DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Responses to Hydro-Québec's Interrogatories

R-3552-2004 – March 9, 2005

Question 1 :

Référence : Rapport de MM. Philippe Dunsky, Eric Belliveau et John Plunkett (ci-après experts communs), *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »,* page 8 de 153.

Préambule :

« Contrary to last year's mandate, the primary objective of this report is not to quantify the savings potential from new opportunities, nor to estimate their costs and benefits. »

Question :

Veuillez confirmer que les experts communs n'ont pas évalué les coûts, les bénéfices dont les économies d'énergie et les impacts tarifaires de leurs recommandations ?

Answer:

As indicated in our report, our recommendations are strictly limited to cost-effective changes that are aimed at maximizing the PGEÉ's net benefits. We adopted different approaches to ensuring that recommended changes are cost-effective:

Firstly, of the 74 recommendations, the vast majority involve no-cost/low-cost strategy improvements. In these cases, costs are either *negligible* (e.g. relocate the audit link to a more prominent place on Hydro-Québec's web page), *nil* (e.g. transfer a greater share of the proposed incentives from buyers to builders) or *negative* (e.g. replace geothermal incentives with a less expensive leasing strategy). For these measures, we did not provide an economic analysis of the proposals because they should not materially affect current cost-effectiveness.

Secondly, in cases where our recommendations involve higher incentives, we *did* assess measure costs and benefits in order to ensure cost-effectiveness. Specifically:

- *Novoclimat social housing segment:* We proposed that Hydro-Québec increase its incentive to social housing new construction from 75% to 100% of incremental costs. We estimated the incremental cost at 1¢/kWh and the total cost at 4.1¢/kWh (for that segment of the program only), generating a total social housing segment benefit/cost ratio of 2.5:1 (see pp. 41-42).

- *EnerGuide for Houses pilot project:* We proposed a limited-scale pilot project to assess the merits of covering a part of the initial audit cost for 'A' level inspections. We estimated the incremental cost at 0.5¢/kWh (see pp. 50-51). This does not materially affect the program's overall cost-effectiveness.

- *Low-Income Direct Install:* We proposed a structural change to the way in which Hydro-Québec pays its delivery agents, in order to allow it to install more cost-effective measures. We estimated the lighting measure – the most likely to receive greater treatment – at 2¢/kWh, or a 4:1 benefit/cost ratio (see p. 59).

- *MC/ES Efficient Products – lighting:* We proposed that Hydro-Québec offer a permanent compact fluorescent lightbulb incentive of $3 on average to complement its (assumed) temporary joint promotions strategy. We estimated this will cost Hydro-Québec 1.5¢/kWh, as compared with avoided costs of 8¢, thus generating a >5:1 benefit/cost ratio (see pp. 71-72).

- *MC/ES Efficient Products – windows:* We proposed the addition of an efficient windows incentive aimed at natural replacement and new construction markets. We recalled that if done correctly, the program should be able to achieve costs on the order of 1¢/kWh, for a ~10:1 benefit/cost ratio (see p. 85).

- *MC/ES Efficient Products – computer transformers:* We proposed that Hydro-Québec join the North American effort at transforming the market for efficient computer transformers. Given current uncertainty, we presented three possible outcome scenarios: 0¢/kWh (program fails), 3¢/kWh (marginal success) and ~0.00005¢/kWh (market transformation) (see pp. 87-88). While we did not indicate it specifically, this would result in a benefit/cost ratio of between 2.6:1 and 1548:1.

- *MC/ES for Business:* We proposed that Hydro-Québec increase its incentive level so that it covers three quarters of incremental costs. We assessed the direct cost of this incentive at 2¢/kWh, as compared with avoided costs ranging from 7.3 to 8.8 ¢/kWh (see p. 132). Thus, while not specified as such, this would result in a benefit/cost ratio on the order of 4:1.

It is important to note that real TRC-level benefit/cost ratios are higher, in some cases substantially, than what we report above, since we have not included non-energy benefits into our equations.

Thirdly, in the case of changes suggested to the CI (and SMI) Initiatives programs, recall that the change is aimed primarily at the incentive structure, not level. Nonetheless, we note that the move to an incremental cost-based incentive must be accompanied by cost-effectiveness screening, as is practiced elsewhere (see pp. 108-109). We also note that this change, as with some others, should result in *less* wasted resources and *cheaper* net ¢/kWh savings for Hydro-Québec. See our response to Régie question 7.1 for more information.

Finally, in a few cases, we are not certain whether changes will be cost-effective, and in those cases, we limit our recommendations to *examining* the pertinence of a given measure. For example, we suggest *considering* use of the community-based home visits approach to target high-use customers *if* the results of the ongoing pilot evaluation are positive (see p. 24). Similarly, we recommend *considering* – i.e. assessing the relative economic merits of – integrating bulk efficient appliance purchasing into the Novoclimat program's social housing component (p. 42), and an appliance replacement component into the SHQ Affordable Housing program (pp. 64-65). We also encourage Hydro-Québec to *investigate* opportunities for adding incentives based on new SEHA Tier-2 appliance ratings (p. 82). Finally, we make our benchmarking recommendation conditional on results from the ongoing cost-effective potential review working group (p. 146).

In all cases, our recommendations are carefully crafted to ensure cost-effectiveness. Most importantly, they propose strategies aimed at addressing market barriers head-on, and are designed to minimize cream skimming, lost opportunities and free riders. In so doing, these recommendations are aimed at *reducing waste* and *increasing net benefits* by getting "more bang for the buck" from Hydro-Québec's proposed PGEÉ investments.

Question 2 :

Référence : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »,* page i de l'introduction, pages 18 et 19 de 153.

Préambule :

« Table 4 provides the results of a recent energy efficiency program evaluation done by RLW Analytics for the Long Island Power Authority. RLW asked groups of market actors to rate a list of market barriers in order of importance. »

Question 2.1 :

Quelle est la marge d’erreur statistique de chacun des sondages présentés au tableau 4 de la page 19 ?

Question 2.2 :

Est-ce que les résultats des sondages du tableau 4 de la page 19 sont transposables dans d'autres régions ou d'autres États ? Quelle est la marge d'erreur de cette transposition, le cas échéant ?

Question 2.3 :

Veuillez déposer des études similaires à celles résumées pour le *Long Island Power Authority* au tableau 4 de la page 19 du présent mémoire, réalisées pour les autres entreprises au Vermont, au Massachusetts, au New Jersey ou au Maryland, tel que présenté à la page i du rapport des experts communs.

Answer:

We do not possess this information for each individual case, although we indicated the sample size within the table. More importantly, we’re unclear as to the interest in this information. As indicated in the text of our report, Table 4 is presented to illustrate a simple point: that market barriers are not only numerous, but affect different market actors to different extents.

In fact, as we wrote, “*The sorted results of this analysis show that the importance of each barrier varied by market actor group*” (p.18). And as we concluded: “*What seemed like a simple set of barriers became geometrically larger as each market actor expressed its opinion. This is further complicated when multiple market actors are working together on one project; in those cases, multiple barriers require multiple strategies*.” Again, the implication is not that the precise ratios apply in Québec, but rather, that market actors display very different barriers, and that recognizing the existence of such differences is essential to designing appropriate programs.

Question 3 :

Référence : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec’s Proposed 2005-2010 Energy Efficiency Plan »,* note de bas de page 7, page 24 de 153.

Préambule :

« For example, assuming Hydro-Québec's 250,000 questionnaire target is reached, we estimate that achieving the same level of participation through home visits would require roughly 1,000 full-time-equivalent dedicated staff. »

Question :

Veuillez détailler le calcul qui mène à cette estimation de 1 000 employés dédiés à temps plein.

Answer:

The "rough estimate" noted in footnote 7 is based on 2 staff members per visit, conducting 2 visits per day on average, five days per week, fifty weeks per year. Thus 250,000 / (2/2*5*50) = 1,000 full-time equivalent staff.

<u>Question 4 :</u>

Référence : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »,* pages 34, 35 et 44 de 153.

Préambule :

Vous faites référence à quatre programmes « *Energy Star for Homes* », soit ceux offerts au New Jersey, au Texas, au Vermont et en Arizona.
Question :

Veuillez préciser les éléments suivants avec référence à l'appui :

a) le nom de l'entreprise responsable de ce programme ;
b) leur nombre de clients résidentiels ;
c) la consommation annuelle électrique moyenne par client de leurs clients ;
d) la principale source de chauffage des locaux utilisée par ces clients ;
e) la part relative du chauffage des locaux sur la consommation annuelle du client résidentiel moyen de chacune de ces entreprises ;
f) l'évolution du prix de la principale source d'énergie utilisée pour le chauffage des locaux dans ces états pendant la durée de chacun de ces programmes ;
g) le pourcentage de réduction de la consommation généré par l'adoption de cette nouvelle norme par rapport à la norme alors en vigueur dans ces marchés pour le chauffage des locaux (si applicable) ;
h) le pourcentage de réduction de la consommation généré par l'adoption de cette nouvelle norme par rapport à la norme alors en vigueur dans ces marchés pour la climatisation ;
i) le surcoût unitaire moyen de ces maisons par rapport aux autres du marché (en dollars et en pourcentage),

j) le gain unitaire annuel moyen observé de ces maisons par rapport aux autres du marché (en pourcentage et en kWh ou kWh équivalents) ; et
k) l'évolution du prix moyen de ces maisons *Energy Star* au début et à la fin de chacun de ces programmes.

Answer:

The table below provides answers to some of the questions. Answering the remaining questions would require far more time and resources than alloted for in this mandate. For example, forecasting electricity, gas and heating oil prices over the coming 5-10 years in each of these regions goes far beyond the purview of our mandate. So too would an assessment of the pre- and post-program home construction costs in each market, especially since programs are still ongoing.

More importantly, we fail to see the pertinence of most of these questions. We understand that many of them attempt to distinguish between heating and cooling loads. However, the new construction programs we've examined are by their very nature comprehensive. As such, these programs focus first and foremost on the same concerns Québec homebuilders have: improving building envelope. This is just as true in Texas – where air-tightness, insulation and high-efficiency windows are needed to keep heat out and retain cold air in – as it is in Vermont and New Jersey (and Québec) where the same measures are needed to keep cold out and heat in. Furthermore, heating and cooling loads are inseparable in new construction programs, as new homes tend to use both in *all* the regions examined (including, again, Québec). Finally, it is worth noting that all the programs we examined are fuel neutral.

That being said, we provide the following information in the table below:

> Names of the companies responsible for the energy efficiency program

> Population and housing starts (number of new homes built every year)

> Percent savings relative to model energy code specifications

> Most recently available market share results

> Additional notes

Finally, we recall that our discussion was based on practice notably in New Jersey, Texas and Vermont, but *not Arizona*. We only mentioned Arizona in passing later in the report as an example of an approach that we *do not* recommend for electrically-heated homes (see p. 39, not 44). For this reason, we do not provide further information here regarding the Arizona example.

Data for Three Referenced New Home Construction Examples			
	New Jersey	**Texas**	**Vermont**
Utility names	All four electric utilities and all four gas utilities have joined forces to provide a single State-wide new home construction program (much as Hydro-Québec and Gaz Métropolitain both contribute to Novoclimat). The utilities are: Public Service Electric and Gas Company, Connectiv Power Delivery, Jersey Central Power and Light, Rockland Electric Company, PSE&G, New Jersey Natural Gas, South Jersey Gas and NUI/Elisabethtown Gas.	TXU Electric Delivery (previously known as Oncor Energy). TXU serves the northeastern part of the State, including the Dallas / Fort Worth area.	Efficiency Vermont (delivers programs on behalf of all 20+ electric utilities in the State).
Population and Housing starts	Population served: ~8.4 million New Homes: ~30,000/year	Population served: ~2.2 million New Homes: ~44,000/year[1]	Population served: 0.6 million New Homes: ~2,500/year
Energy savings relative to baseline	*Comprehensive criterion:* Minimum HERS rating of 86. This implies **min. 30% improvement** over model energy code. *Additional criteria:* Prescriptive requirements for lighting, AC/HP/ducts (where applicable), others.	*Comprehensive criterion:* Minimum HERS rating of 86 *and* min. 15% better than Y2000 IECC code. *Average* HERS rating of 87. Future min. HERS of 88. This implies a current **average 35% improvement** over model energy code, and an anticipated 40% improvement as the future minimum criterion.[2]	*Comprehensive criterion:* Minimum HERS rating of 86. This implies **min. 30% improvement** over model energy code. *Additional criteria:* Prescriptive requirements for lighting, mechanical ventilation systems.
Market share	*35.4%*	50.5%[3]	30% (in 2003)
Add'l notes	*Program faces additional barrier: new homes built in areas not included in the State's "Smart Growth" policy are excluded.*	*The market share noted here was limited due to budgetary constraints (i.e. there were incentive requests for nearly 60% of new housing starts).*	*Efficiency Vermont also delivers a more aggressive program for Vermont Gas Systems, which has achieved market share in the range of 60%.*

[1] From 2001-2004, the program focused on the Dallas/Fort Worth region only. This region has approximately 35,000 new homes built every year.

[2] A study conducted for Oncor Electric in 2004 found that the baseline for new home construction was 80.2 on the HERS scale, thus supporting the use of the model energy code (80.0) as a baseline. By extension, this also supports the 35% improvement achieved, on average, by the approximately 50% of participants.

[3] Applies to the focus region (representing 75% of all new housing starts).

Question 5 :

Référence : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »,* page 83 de 153.

Préambule :

Vous mentionnez que le « *$10/unit spiffs* » du NEEA a doublé la part de marché des lave-linge *Energy Star* en trois ans, *« in conjunction with a full suite of other marketing strategies »* des quatre États qui le composent.

Question :

Veuillez préciser la nature des efforts commerciaux de ces entreprises de service public sur les lave-linge pendant ces trois années, de même que le coût total de la conjonction de ces stratégies marketing ?

Answer:

We begin with two caveats to our answer. First, it is important to understand that one of the hallmarks of the *Northwest Energy Efficiency Alliance (NEEA)* is its nimbleness, i.e. its ability to quickly modify its program strategies to account for experience and market dynamics. As such, the Alliance's strategy was never quite the same from one year to the next. We introduce this as a caveat to the following text, because while the NEEA used all of the strategies indicated below, they were not necessarily used simultaneously nor consistently throughout the 3-year period.

Second, we would like to clarify our recommendation. As indicated in our report (p. 82, from the top), we primarily recommend that Hydro-Québec adopt the same broad approach to clothes washers as we suggested for CFLs. This approach relies primarily on a combination of permanent incentives and temporary joint promotions. However, in the case of appliances, we recommended supplementing this approach with spiffs. In other words, spiffs are not central to – but rather complement – the central rebates and joint promotions strategy.

In the U.S. northwest, spiffs were one component of a multi-pronged strategy. In addition to $10 Spiffs, a major component of the overall effort was rebates and other direct incentives. These incentives were provided by the Bonneville Power Administration (BPA), NEEA, most local distribution utilities (LDCs) and select retailers. For example, a review of incentives offered in Spring, 2003 by the 81 LDCs in the region finds that nearly all utilities offered rebates in the range of $50-$200 per washer. We also note that the most recent independent market evaluation of the NEEA program concludes that incentives were not only a key component of the previous efforts, but will continue to be necessary to uphold and increase achieved market share.[4] Indeed, BPA has established permanent incentives for FY2005.[5]

Another key element of the overall strategy involved leveraging significant advertising efforts by leading retailers (for example, in 2003 NEEA initiatives incited retailers to spend more than $800,000USD to advertize their own sales of Energy Star clothes washers). Finally, the NEEA applied a suite of other outreach efforts – included events, brochures, displays and field staff support – to its overall home products initiative, which of course included washers.

In response to the question of costs, unfortunately most NEEA cost data are program-wide, not disagregated by measure. Since clothes washers were rolled into an appliances program, we do not have the total cost data Hydro-Québec is looking for. However, a recent report does provide Total Resource Cost unit values for clothes washers specifically. The overall TRC cost is estimated at "-6.3¢/kWh". This is a negative number because NEEA appropriately calculates non-energy benefits in its TRC calculation, and washers offer considerable NEBs in addition to energy efficiency savings.

Question 6 :

Référence : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »,* page 105 de 153, Figure 8.

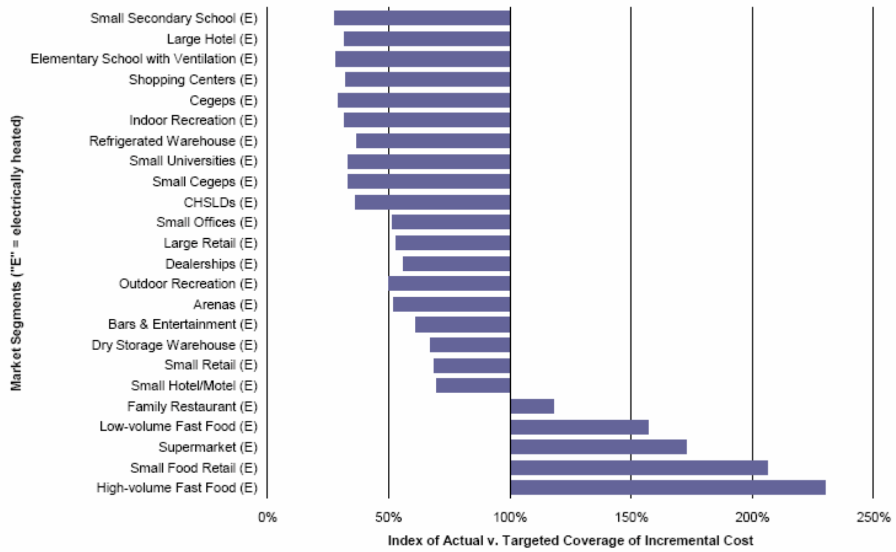
Préambule :

---

[4] Most recent data suggest a 43% market share throughout the Northwest region in 2003. Conclusions in Dethman & Associates, *Energy Star Home Products Program – Market Progress Evaluation Report, No. 2,* August 24th, 2004, 139 p.

[5] These incentives are tiered, a measure we urged Hydro-Québec to consider (using new tiered CEE SEHA specs; see page 82).

Figure 8. **Buildings Initiatives Incentives: Actual vs. Target Share of Incremental Cost**



100% = Hydro-Québec's stated target.
Based on the incremental costs of achieving MNECB+25% in each market segment.

Question :

Veuillez fournir les éléments suivants :

a) les sources des données utilisées
b) le détail des calculs dans un chiffrier en format Excel.

Answers:

a) All of the data sources come from Hydro-Québec's testimony. See appendix A to this document (sixth page).

b) See appendix A to this document (first through fifth pages).

Question 7 :

Référence 1 : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »,* page 111 de 153.

Référence 2 : R-3552-2004, HQD-5, Document 1, question 15.4

Préambule :

Les experts communs recommandent que l'aide financière pour le programme *Appui aux initiatives* pour les marchés CI soit basée sur le surcoût des travaux.

Et

Tel que mentionné dans la réponse du Distributeur à la question 15.4 dans HQD-5, Document 1 :
« [s]uite aux suggestions des participants au programme, le Distributeur a décidé d'utiliser la notion de coût total au lieu de surcoût puisqu'un grand nombre de participants ont de la difficulté à fournir de l'information de qualité portant sur le surcoût des mesures, ce qui n'est pas le cas pour le coût total des mesures. » (HQD-5, Document 1, question 15.4)

Question :

Veuillez expliquer comment la recommandation des experts communs pourrait être implantée compte tenu des difficultés rencontrées par les clients pour fournir de l'information de qualité portant sur les surcoûts.

Answer:

A customer who doesn't know the incremental cost between what they are installing and an acceptable baseline, is most likely a free-rider. Any legitimate program applicant is trying to determine *whether* they should invest in the upgraded equipment or design. This requires having information on both the baseline and the more efficient measure. If they have only determined the cost of the more efficient measure, it would appear they intended to install that measure anyway.

That being said, the structure we recommended does not *require* the customer know the incremental cost of the project or equipment.

There are two fundamental pieces of information required to characterize any energy efficiency measure: savings and costs. To determine savings of a new piece of equipment or an improved design, a baseline comparison must be done. In our program recommendation, utility staff reviews customer applications. They determine whether the customer has enough reliable cost and savings information to determine cost effectiveness. If the project is cost effective, an incentive can be calculated from the cost information provided. Where proposed designs are too complicated for staff to review, an independent third-party Technical Assistance (TA) Contractor, hired by the utility, prepares the cost effectiveness analysis of the project. The TA assistance can also be provided for customers who are unsure what their project will cost or save. The results of this analysis are the foundation of the incentive calculation.

Question 8 :

Référence : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »,* page 132 de 153.

Préambule :

Les experts recommandent que l'aide financière pour le programme *Produits Mieux consommer – Energy Star – marché affaires* soit d'environ 75 % du surcoût.

Question 8.1 :

Veuillez justifier le niveau d'aide financière pour ce programme.

Answer:

First, based on experience elsewhere, 75% is sufficient to generate interest from a considerable share of the medium and large-sized CI market. In our report we cited a paper principally authored by Steve Nadel of ACEEE. In his study of incentive levels, *Nadel et al.* determined that incentives under 50% had little effect on motivating customers to invest in energy efficiency. While there can be some debate as to the ideal level, our primary contention in review of HQ incentives was that the current level of ~27% is inadequate.

Second, we assessed the cost at approximately 2¢/kWh (levelized), which compares favourably with 8¢/kWh avoided costs. Therefore, we have proposed a level of incentive that achieves reasonable penetration in other jurisdictions *and* presents very favourable economics in Québec.

Question 8.2 :

En déterminant ce niveau d'aide financière, est-ce que les experts ont tenu compte des impacts sur le programme *Appui aux initiatives – marchés CI* du Distributeur et le programme proposé par les experts pour les petits CI ? Si oui, de quelle façon ?

Answer:

Yes. We are aware of Hydro-Québec's concern regarding the possibility of higher incentives leading participants to adopt one-off prescriptive measures instead of comprehensive projects.[6] Experience suggests that this concern is not warranted.

In practice, customers have a variety of reasons for investing in energy efficiency upgrades. Those reasons will determine whether the customer is interested in a comprehensive retrofit or replacing a single piece of equipment. For example, a customer whose rooftop HVAC unit (RTU) fails prematurely will choose between the baseline or a more efficient equipment replacement, not between efficient equipment replacement and a comprehensive energy retrofit.

Prescriptive incentives are calculated to provide a percent of the incremental cost of the equipment only, not the wiring, piping, controls, or installation labor common in retrofit projects. Consequently, there is little competition between prescriptive and custom incentives when it comes to energy efficiency retrofit projects; prescriptive incentives are not generally enough to motivate the increased investment.

Lost opportunity projects do require a decision for which program to enter. By basing both the *CI Initiatives* and *MC/ES for Business* incentives on incremental cost, this decision is moot. The customer with the failed RTU who does not have time to perform a cost and savings analysis for the *Initiatives* program takes the incentive for 75% of the incremental cost and gets back to business. If this customer chooses to calculate the costs and savings of additional measures, they can include these costs and receive additional incentive to offset them. In either case, the incentive is based on the same principle.

The small business program we suggested is a direct install program. It deals with retrofit exclusively, and furthermore is limited to small customers. Prescriptive incentives do not provide enough of the installed cost to motivate this customer group. There is therefore it does not compete.

Question 9 :

Référence : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »,* pages 139 à 146 de 153.

Préambule :

« These criteria generate a pool of 15 comparable regions for benchmarking purposes: » (page 140 de 153)

Question :

[6] Alluded to in HQD-5, doc. 8, p. 29, in response to question 3.

Veuillez fournir, dans un tableau sous format Excel avec références à l'appui, les données suivantes concernant ces 14 autres entreprises dont il est fait état, pour les années de 2005 à 2008 inclusivement :

a) les investissements en efficacité énergétique (en millions de dollars) par marché
b) les économies d'énergie projetées (en GWh) par marché
c) les revenus des ventes d'électricité (en millions de dollars) par marché
d) le volume des ventes d'électricité (GWh) par marché, et
e) le nombre de clients par marché

Answer:

As indicated in the report (see page 142), we used the most recent data available for U.S. States, and forward-looking data for Canadian provinces. Given a positive growth trend in energy efficiency spending throughout North America, the likely impact of this discrepancy is to *overstate* the effort of Québec and other Canadian provinces relative to their U.S. counterparts.

We did not benchmark energy savings forecasts, given serious concerns about data quality and the use of strictly forward-looking data. Nor did we adopt a $/population criterion, for the reasons given at the top of page 141.

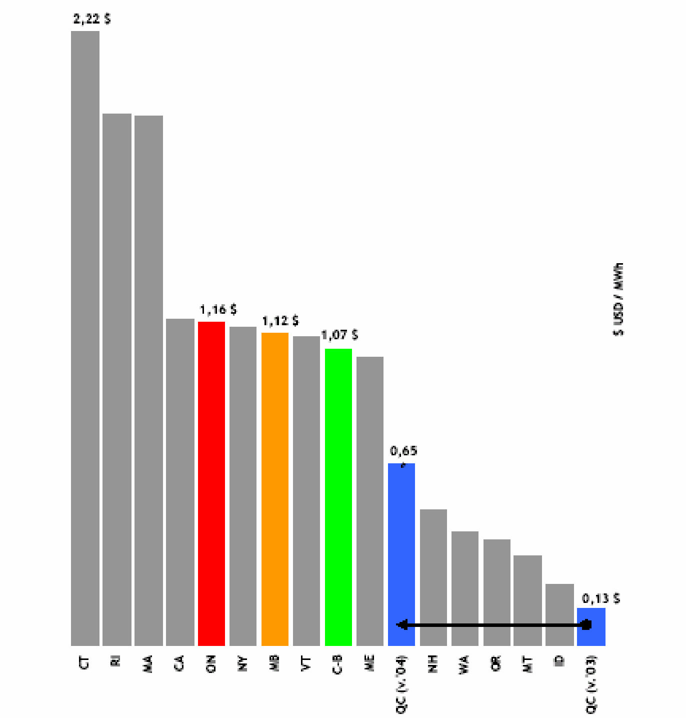
See Appendix B for details.

Question 10 :

Référence 1 : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »,* page 143 de 153, Figure 10.

Préambule :

Figure 10. Québec and 15 Benchmark Regions: DSM Investment / Sales Volume ($/MWh)



Référence 2 : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »,* page 145 de 153.

Préambule :

«One example of "moving goalposts" is Manitoba Hydro. Its 2003 Power Smart plan represented considerable investment – double its previous plan – and resulted in a measured effort 5 times greater than Hydro-Québec's 2003 plan (<u>5¢/MWh</u> investment over sales as compared to Hydro-Québec's <u>1¢/MWh</u>). » (nos soulignés)

Référence 3 : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »,* page 146 de 153.

Préambule :

«Recommendation : Establish as a formal goal that Hydro-Québec's energy efficiency efforts rank among the top 5 of its 15 closest peers within 3 years. »

Question 10.1 :

Veuillez concilier les données citées de la référence 2 avec celles présentées dans la Figure 10 (référence 1).

Question 10.2 :

Veuillez confirmer que votre recommandation que les efforts d'Hydro-Québec Distribution en matière d'économies d'énergie soient parmi les cinq premiers se réfère aux dépenses d'investissement par MWh reproduites à la Figure 10.

Question 10.3 :

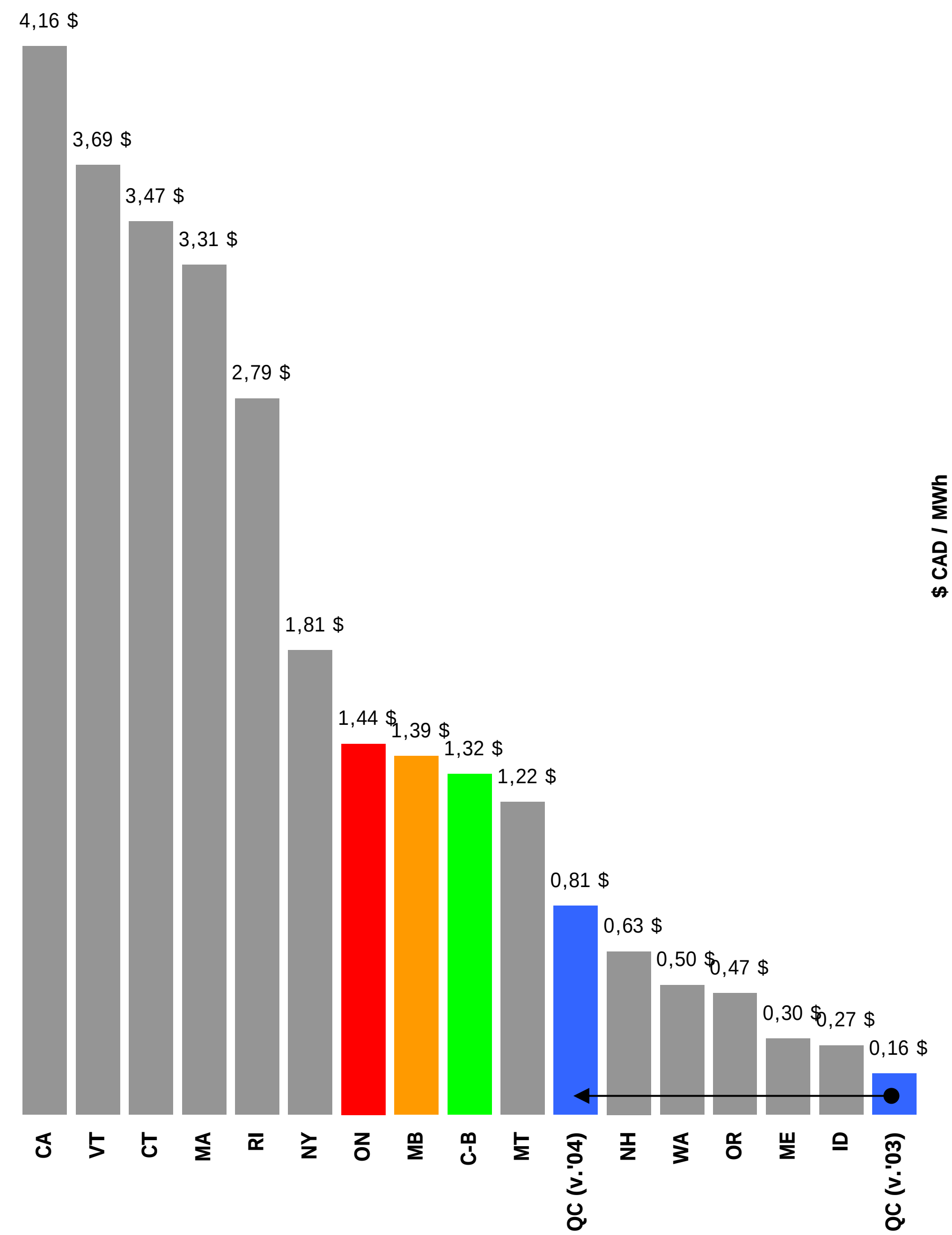
Est-ce que les dépenses d'investissement des cinq entreprises les plus performantes sont approuvées par un organisme de réglementation ? Si oui, est-ce que les impacts tarifaires reliés à ces dépenses d'investissement ont été pris en considération ?

Answers:

10.1 A mistaken link in our spreadsheet led to incorrect results from the $/MWh benchmarking exercise. We apologize for the error. Also, for clarity we have adjusted dollar values into Canadian, instead of U.S. dollars. Below is the corrected graph, which replaces Figure 10 on page 143. Figure 11 remains unchanged.

The sentence should also be corrected, as follows: “One example of ‘moving goalposts’ is Manitoba Hydro. Its 2003 Power Smart plan represented considerable investment – double its previous plan – and resulted in a measured effort 2.5 times greater than Hydro-Québec’s 2003 plan (54¢/MWh investment over sales as compared to Hydro-Québec’s ~~1~~22¢/MWh). Yet while Hydro-Québec was preparing to ~~quadruple~~ triple its own effort, MH was in the process of ~~increasing~~ doubling its effort yet again~~by another 50%~~. Thus the Prairie utility continues to put nearly twice as much resources into its DSM plan, on a per-MWh sales basis, as Hydro-Québec (and~~ nearly 3~~ 2.5 times as much as a percent of sales revenue).”

Figure 10 (corrected)



10.2 Yes, the reference would be to the $/MWh benchmark. However, the correction we bring above may call into question the reasonableness of achieving this goal within the 3 year time frame, given that it implies nearly quadrupling the total PGEÉ budget. As a result, we believe the Régie should rather invite Hydro-Québec to considerably improve its performance on the benchmarking scale presented in Figure 10 in its coming regulatory filings.

10.3 Typically, regulatory agencies similar to the *Régie de l'énergie* review and approve planned DSM program spending and savings. This is the case with the five leaders on the $/MWh benchmark. All five jurisdictions have annual DSM funding levels set on the basis of a fixed public-benefits charge set by statute. Rate impacts were obviously a consideration in the fixing of these surcharges.

In addition, at least the states of California, Vermont, and Connecticut impose additional DSM investment requirements on utilities based on their need for additional supply resources. California regulatory policy now requires that utilities exhaust *all* cost-effective efficiency potential *before* procuring additional supply costing more than demand-side resources. Vermont and Connecticut oblige utilities to pursue additional DSM if it can provide needed transmission and distribution capacity at lower total cost than supply expansion. To some degree rate impacts are always at least an implicit consideration in each jurisdiction mentioned; regulators tend to balance them against the net economic benefits from additional DSM investments, among other considerations (e.g., inter-class distributional equity).

Question 11 :

Référence : Rapport des experts communs, *« Getting Results: Review of Hydro-Québec's Proposed 2005-2010 Energy Efficiency Plan »*.

Question :

Veuillez fournir la référence électronique ou déposer les documents suivants cités en référence :

a) l'étude de J. Plunkett et P. Chernick*, « From Here to Efficiency: Making Efficient Markets. »,* pour *Pennsylvania Energy Office*, Harrisburg, PA, 1993, citée dans la note de bas de page 4, page 16 de 153 ;
b) le rapport d'évaluation préparé par *RLW Analytics* pour *Long Island Power Authority*, cité à la page 18 de 153 ;
c) tous les volumes de l'étude *Quantum Consulting, National Energy Efficiency Best Practices Study,* cités notamment dans les notes de bas de page 8 (page 24), 9 (page 26), 15 (page 28), 30 (page 39) et 45 (page 53) ;
d) les rapports de Oncor Electric (2003 et 2004), les informations provenant de *Public Utilities Commission of Texas*, *TXU Electric Delivery Co.*, the

Electric Utility Marketing Managers of Texas Organization, cités dans la note de bas de page 25, page 35 de 153 ;

e) la présentation de *Megdal & Associates and Opinion Dynamics Corp*., "*Evaluation of the Massachusetts Energy Star Residential Lighting Program – Market Progress as of 2003"*, Presentation slides, 2004, citée dans la note de bas de page 65, page 73 de 153 ;
f) le document de *Ecos Consulting*, *80 Plus Program Utility Prospectus*, November 2004, cité dans la note de bas de page 82, page 87 de 153 ;
g) le document de *UNIES*, *Residential Ground Source Heat Pumps on Urban Lots – Performance and Cost Effectiveness*, October 2003, cité dans la note de bas de page 91, page 95 de 153 ;
h) le rapport de Greg Kats, L. Alevantis, A. Berman, E. Mills, J. Perlman, *The Costs and Financial Benefits of Green Buildings – A Report to California's Sustainable Building Task Force*, October 2003, cité dans la note de bas de page 109, page 117 de 153 ;
i) la présentation de Steve McCarty, "*Demand-Side Portfolio Management*", Presentation to the Midwest Energy Efficiency Alliance Conference, September 27, 2004, citée dans la note de bas de page 111, page 119 de 153 ; et
j) le rapport d'évaluation de *RLW Analytics* sur le programme *LIPA New Construction program,* cité dans la note de bas de page 121, page 133 de 153.

Answers:

a) The **Plunkett & Chernick** report is nearly a thousand pages long, and we do not have an electronic copy of it (it dates back 12 years). If Hydro-Québec and the Régie request it, we can arrange to bring a photocopy with us to the hearings.

b) The **RLW Analytics** report is property of the Long Island Power Authority. We previously requested and received permission to reproduce the table on page 19 as well as some lighting saturation data. We have not received permission, however, to share the full report. We will advise Hydro-Québec and the Régie if we receive such permission prior to the hearings.

c) The **Quantum Consulting** reports are included here as appendices C, D and E.

d) The information referenced in footnote 25 was obtained from three sources: TXU Electric Delivery's 2003 and 2004 Energy Efficiency Reports (provided to me by the Public Utility Commission of Texas), and discussions with TXU's *Energy Smart for Homes* program manager. Note that TXU Electric Delivery was previously known as Oncor Electric, which explains why the attached reports are signed by the latter. The other references were mistakenly included in this footnote.

The **TXU Electric** reports (2003 and 2004) are included here as appendices F and G.

e) The **Megdal & Associates** presentation slides are included here as appendix H.

f) The **Ecos Consulting** prospectus report is included here as appendix I. For more up to date information, see our forthcoming response to question 6 of the Régie de l'énergie. We will be in a position to provide more information still during the hearings.

g) The **UNIES** report is included here as appendix J.

h) The **Kats et al.** report is included here as appendix K.

i) The **Steve McCarty** presentation slides are included here as appendix L.

j) See our response to question 11.b.

Question 12 :

Référence : Mémoire de l'Union des consommateurs, p. 4 de 13

Préambule :

« Plus d'une décennie après sa première implication dans des programmes de ce genre, le Distributeur affirme ne pas disposer des études sérieuses, ni internes ni externes, nécessaires à la compréhension de ces barrières et plus particulièrement de la barrière financière, celle qui pèse le plus lourd dans les choix des consommateurs. »

et

« Les experts Dunsky, Belliveau et Plunkett (ci-après les experts) soulignent d'ailleurs dans leur rapport que tout programme d'économie d'énergie doit être basé sur une connaissance approfondie des barrières à l'efficacité énergétique. »

Question :

Veuillez déposer tous les rapports internes et externes spécifiques au marché du Québec que les experts communs ont utilisés dans le cadre de la rédaction de leur rapport et qui ont servi de base à leurs recommandations (notamment sur le niveau optimal d'aide financière accordée par programme) et propositions de nouveaux programmes.

Answers:

With rare exception, market barriers to energy efficiency do not differ from region to region. Customers are reluctant to pay higher first cost whether they're in Texas or Trois-Rivières. Small municipalities in Québec, Canada and throughout the United States have trouble incorporating energy efficiency specifications into building bid documents. The fact that most customers lack the engineering/economic skills required to calculate future equipment performance and bill savings is not region-specific either. Tenants in Long Beach, Long Island and Longueuil face much the same split incentives. Home Depots, Wal-Marts and Réno-Dépôts all are reluctant to provide prime shelf space to less common, high-efficiency newcomers.

Our recommendation is for Hydro-Québec to "*[u]ndertake a comprehensive review of market barriers in order to inform future program design and ensure maximum effectiveness*". This does not imply reinventing the wheel for Québec. Rather, Hydro-Québec should review the existing body of literature and develop a "map" pinpointing the full breadth of barriers – as they affect various market players – that Hydro-Québec's programs need to overcome. This mapping of barriers will provide the key to ensuring that Hydro-Québec's future efforts use ratepayer funds to maximum effect.

Question 13 :

Référence : Rapport de M. Louis Bolullo, « *Plan global en Efficacité Énergétique 2005-2010. budget 2005* »

Préambule :

« Il nous apparaît également important, qu'à l'instar des pratiques implantées par les gouvernements de la grande majorité des états voisins, le Gouvernement du Québec décrète, pour les programmes d'économie d'énergie, des crédits de taxes, en vue de stimuler encore plus l'adhésion des citoyens. » (page 9 de 10)

Question 13.1 :

Est-ce que les clients des États (ou des régions) où l'on retrouve les meilleures pratiques, bénéficient d'une aide financière autre que les subventions offertes par les entreprises (distributeurs ou autres), tel que des crédits de taxes des gouvernements ?

Question 13.2 :

Si oui, veuillez fournir la liste de ces États (ou des régions) et des taux de crédits qui ont été consentis pour des programmes d'économie d'énergie, de même que leur période d'application. Veuillez spécifier la nature ou la forme de ces crédits de taxes.

13. Tax incentives

Our report addresses utility energy efficiency programs, not tax incentives.

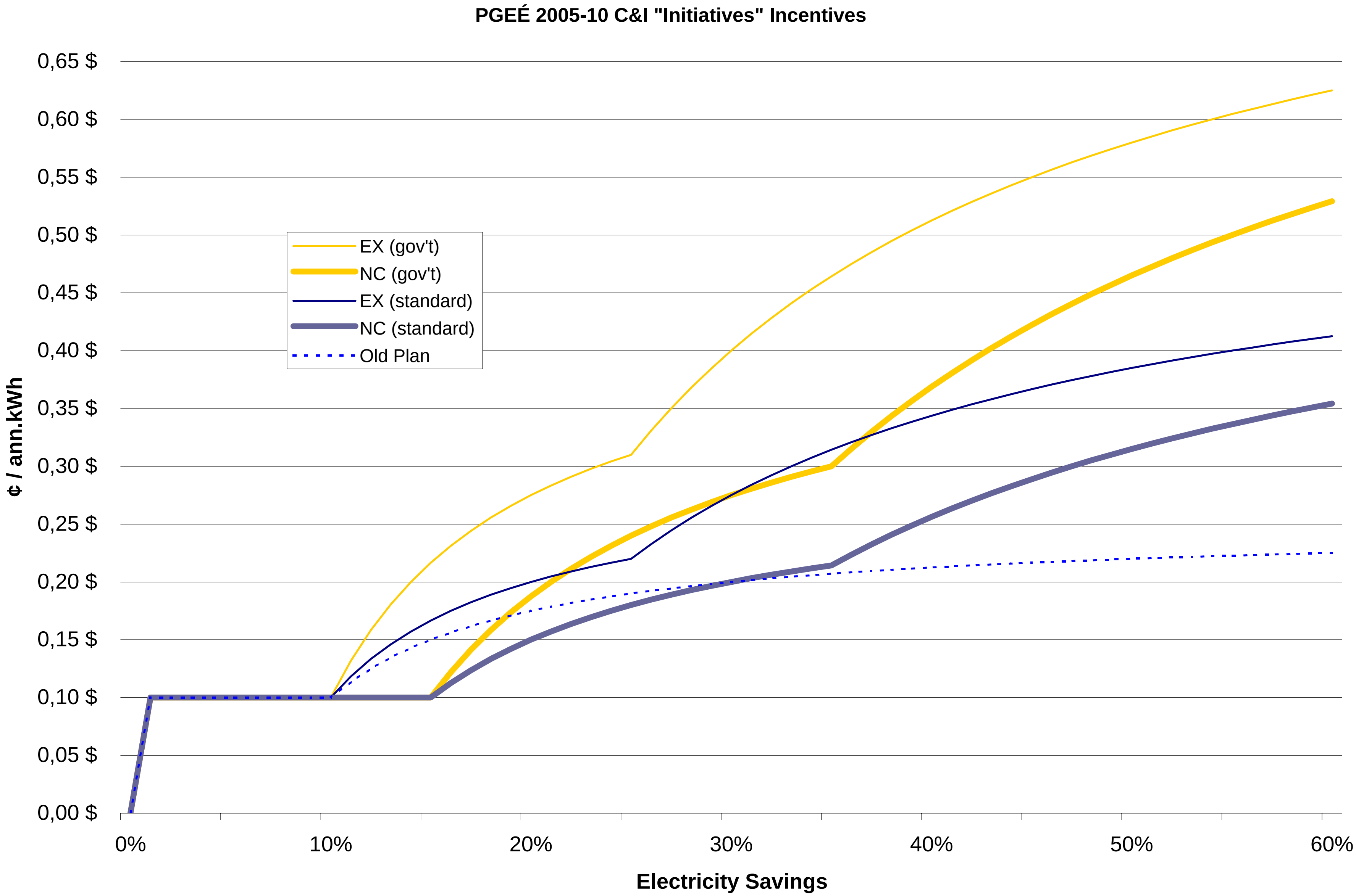
DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix A:
CI Initiatives Real v. Target Calculations (and Sources)

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2		**C&I "Initiatives" Incentives**										
3												
4												
5			**Old Plan**		**New Plan -- Standard**				**New Plan -- Gov't Bldgs**			
6					**Existing**		**New Construction**		**Existing**		**New Construction**	
7			Marginal	Avg.	Marginal	Avg.	Marginal	Avg.	Marginal	Avg.	Marginal	Avg.
8		**0%**	0,00 $	0,00 $	0,00 $	0,00 $	0,00 $	0,00 $	0,00 $	0,00 $	0,00 $	0,00 $
9		**1%**	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $
10		**2%**	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $
11		**3%**	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $
12		**4%**	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $
13		**5%**	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $
14		**6%**	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $
15		**7%**	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $
16		**8%**	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $
17		**9%**	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $
18		**10%**	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $	0,10 $
19		**11%**	0,25 $	0,11 $	0,30 $	0,12 $	0,10 $	0,10 $	0,45 $	0,13 $	0,10 $	0,10 $
20		**12%**	0,25 $	0,13 $	0,30 $	0,13 $	0,10 $	0,10 $	0,45 $	0,16 $	0,10 $	0,10 $
21		**13%**	0,25 $	0,13 $	0,30 $	0,15 $	0,10 $	0,10 $	0,45 $	0,18 $	0,10 $	0,10 $
22		**14%**	0,25 $	0,14 $	0,30 $	0,16 $	0,10 $	0,10 $	0,45 $	0,20 $	0,10 $	0,10 $
23		**15%**	0,25 $	0,15 $	0,30 $	0,17 $	0,10 $	0,10 $	0,45 $	0,22 $	0,10 $	0,10 $
24		**16%**	0,25 $	0,16 $	0,30 $	0,18 $	0,30 $	0,11 $	0,45 $	0,23 $	0,45 $	0,12 $
25		**17%**	0,25 $	0,16 $	0,30 $	0,18 $	0,30 $	0,12 $	0,45 $	0,24 $	0,45 $	0,14 $
26		**18%**	0,25 $	0,17 $	0,30 $	0,19 $	0,30 $	0,13 $	0,45 $	0,26 $	0,45 $	0,16 $
27		**19%**	0,25 $	0,17 $	0,30 $	0,19 $	0,30 $	0,14 $	0,45 $	0,27 $	0,45 $	0,17 $
28		**20%**	0,25 $	0,18 $	0,30 $	0,20 $	0,30 $	0,15 $	0,45 $	0,28 $	0,45 $	0,19 $
29		**21%**	0,25 $	0,18 $	0,30 $	0,20 $	0,30 $	0,16 $	0,45 $	0,28 $	0,45 $	0,20 $
30		**22%**	0,25 $	0,18 $	0,30 $	0,21 $	0,30 $	0,16 $	0,45 $	0,29 $	0,45 $	0,21 $
31		**23%**	0,25 $	0,18 $	0,30 $	0,21 $	0,30 $	0,17 $	0,45 $	0,30 $	0,45 $	0,22 $
32		**24%**	0,25 $	0,19 $	0,30 $	0,22 $	0,30 $	0,18 $	0,45 $	0,30 $	0,45 $	0,23 $
33		**25%**	0,25 $	0,19 $	0,30 $	0,22 $	0,30 $	0,18 $	0,45 $	0,31 $	0,45 $	0,24 $
34		**26%**	0,25 $	0,19 $	0,55 $	0,23 $	0,30 $	0,18 $	0,85 $	0,33 $	0,45 $	0,25 $
35		**27%**	0,25 $	0,19 $	0,55 $	0,24 $	0,30 $	0,19 $	0,85 $	0,35 $	0,45 $	0,26 $
36		**28%**	0,25 $	0,20 $	0,55 $	0,26 $	0,30 $	0,19 $	0,85 $	0,37 $	0,45 $	0,26 $
37		**29%**	0,25 $	0,20 $	0,55 $	0,27 $	0,30 $	0,20 $	0,85 $	0,38 $	0,45 $	0,27 $
38		**30%**	0,25 $	0,20 $	0,55 $	0,28 $	0,30 $	0,20 $	0,85 $	0,40 $	0,45 $	0,28 $
39		**31%**	0,25 $	0,20 $	0,55 $	0,28 $	0,30 $	0,20 $	0,85 $	0,41 $	0,45 $	0,28 $
40		**32%**	0,25 $	0,20 $	0,55 $	0,29 $	0,30 $	0,21 $	0,85 $	0,43 $	0,45 $	0,29 $
41		**33%**	0,25 $	0,20 $	0,55 $	0,30 $	0,30 $	0,21 $	0,85 $	0,44 $	0,45 $	0,29 $
42		**34%**	0,25 $	0,21 $	0,55 $	0,31 $	0,30 $	0,21 $	0,85 $	0,45 $	0,45 $	0,30 $
43		**35%**	0,25 $	0,21 $	0,55 $	0,31 $	0,30 $	0,21 $	0,85 $	0,46 $	0,45 $	0,30 $
44		**36%**	0,25 $	0,21 $	0,55 $	0,32 $	0,55 $	0,22 $	0,85 $	0,48 $	0,85 $	0,32 $
45		**37%**	0,25 $	0,21 $	0,55 $	0,33 $	0,55 $	0,23 $	0,85 $	0,49 $	0,85 $	0,33 $
46		**38%**	0,25 $	0,21 $	0,55 $	0,33 $	0,55 $	0,24 $	0,85 $	0,49 $	0,85 $	0,34 $
47		**39%**	0,25 $	0,21 $	0,55 $	0,34 $	0,55 $	0,25 $	0,85 $	0,50 $	0,85 $	0,36 $
48		**40%**	0,25 $	0,21 $	0,55 $	0,34 $	0,55 $	0,26 $	0,85 $	0,51 $	0,85 $	0,37 $
49		**41%**	0,25 $	0,21 $	0,55 $	0,35 $	0,55 $	0,26 $	0,85 $	0,52 $	0,85 $	0,38 $
50		**42%**	0,25 $	0,21 $	0,55 $	0,35 $	0,55 $	0,27 $	0,85 $	0,53 $	0,85 $	0,39 $

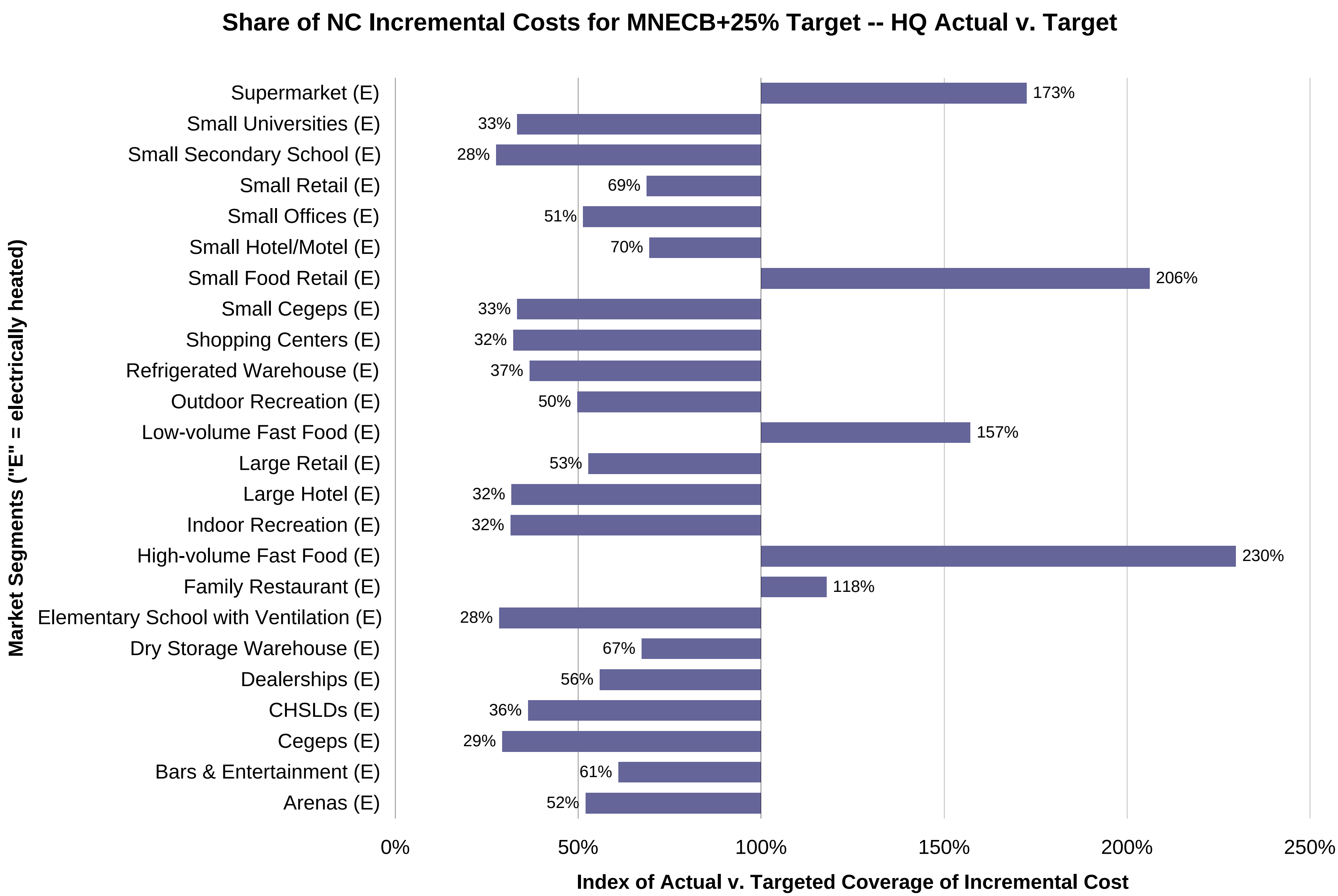
	A	B	C	D	E	F	G	H	I	J	K	L
51		**43%**	0,25 $	0,22 $	0,55 $	0,36 $	0,55 $	0,28 $	0,85 $	0,54 $	0,85 $	0,40 $
52		**44%**	0,25 $	0,22 $	0,55 $	0,36 $	0,55 $	0,28 $	0,85 $	0,54 $	0,85 $	0,41 $
53		**45%**	0,25 $	0,22 $	0,55 $	0,37 $	0,55 $	0,29 $	0,85 $	0,55 $	0,85 $	0,42 $
54		**46%**	0,25 $	0,22 $	0,55 $	0,37 $	0,55 $	0,29 $	0,85 $	0,56 $	0,85 $	0,43 $
55		**47%**	0,25 $	0,22 $	0,55 $	0,37 $	0,55 $	0,30 $	0,85 $	0,56 $	0,85 $	0,44 $
56		**48%**	0,25 $	0,22 $	0,55 $	0,38 $	0,55 $	0,31 $	0,85 $	0,57 $	0,85 $	0,45 $
57		**49%**	0,25 $	0,22 $	0,55 $	0,38 $	0,55 $	0,31 $	0,85 $	0,57 $	0,85 $	0,46 $
58		**50%**	0,25 $	0,22 $	0,55 $	0,39 $	0,55 $	0,32 $	0,85 $	0,58 $	0,85 $	0,47 $
59		**51%**	0,25 $	0,22 $	0,55 $	0,39 $	0,55 $	0,32 $	0,85 $	0,59 $	0,85 $	0,47 $
60		**52%**	0,25 $	0,22 $	0,55 $	0,39 $	0,55 $	0,32 $	0,85 $	0,59 $	0,85 $	0,48 $
61		**53%**	0,25 $	0,22 $	0,55 $	0,39 $	0,55 $	0,33 $	0,85 $	0,60 $	0,85 $	0,49 $
62		**54%**	0,25 $	0,22 $	0,55 $	0,40 $	0,55 $	0,33 $	0,85 $	0,60 $	0,85 $	0,49 $
63		**55%**	0,25 $	0,22 $	0,55 $	0,40 $	0,55 $	0,34 $	0,85 $	0,60 $	0,85 $	0,50 $
64		**56%**	0,25 $	0,22 $	0,55 $	0,40 $	0,55 $	0,34 $	0,85 $	0,61 $	0,85 $	0,51 $
65		**57%**	0,25 $	0,22 $	0,55 $	0,41 $	0,55 $	0,34 $	0,85 $	0,61 $	0,85 $	0,51 $
66		**58%**	0,25 $	0,22 $	0,55 $	0,41 $	0,55 $	0,35 $	0,85 $	0,62 $	0,85 $	0,52 $
67		**59%**	0,25 $	0,22 $	0,55 $	0,41 $	0,55 $	0,35 $	0,85 $	0,62 $	0,85 $	0,52 $
68		**60%**	0,25 $	0,23 $	0,55 $	0,41 $	0,55 $	0,35 $	0,85 $	0,63 $	0,85 $	0,53 $

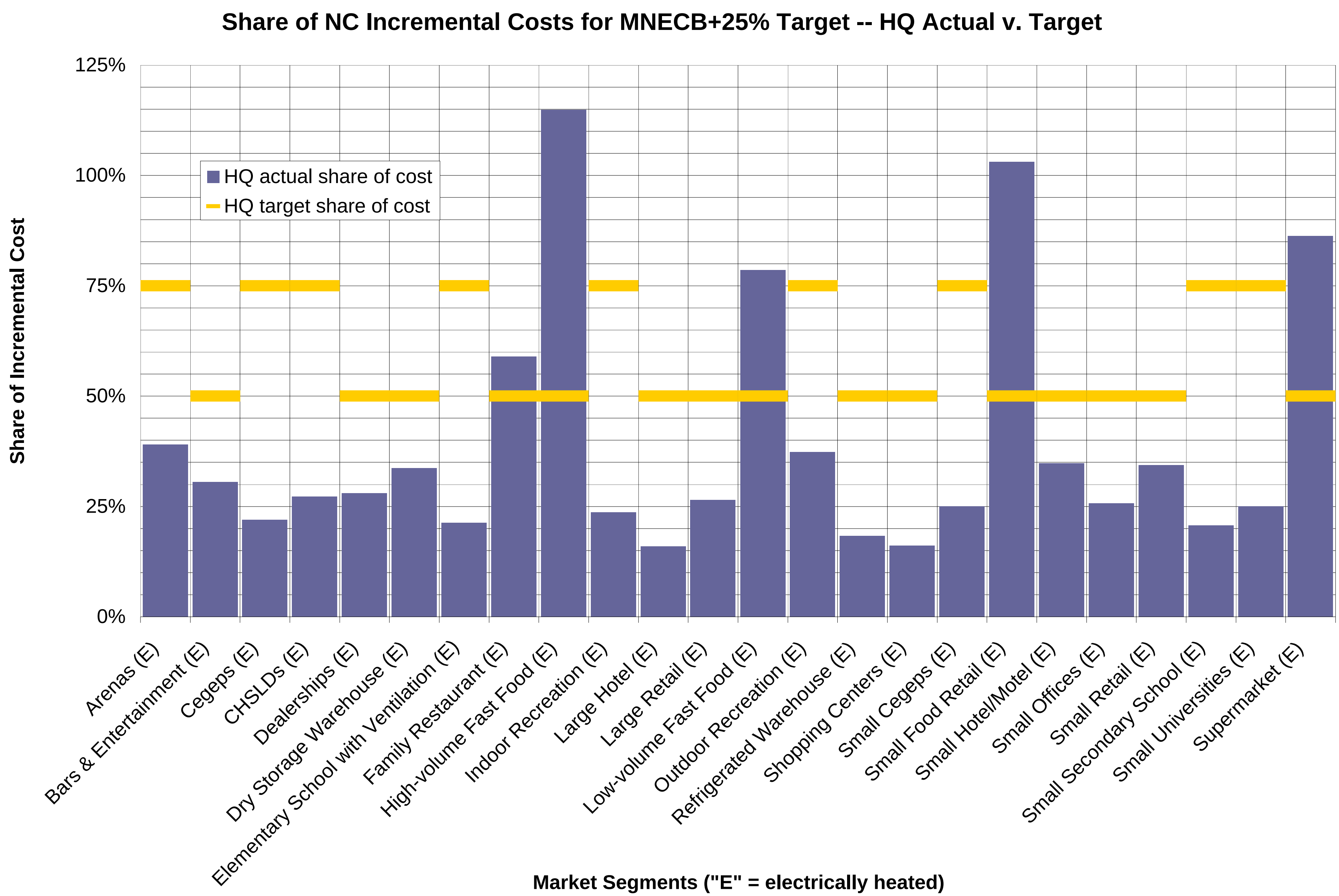

PGEÉ 2005-10 C&I "Initiatives" Incentives
0,65 $
0,60 $
0,55 $
0,50 $
0,45 $
0,40 $
0,35 $
0,30 $
0,25 $
0,20 $
0,15 $
0,10 $
0,05 $
0,00 $
¢ / ann.kWh
0%
10%
20%
30%
40%
50%
60%
Electricity Savings
EX (gov't)
NC (gov't)
EX (standard)
NC (standard)
Old Plan

	A	B	C	D	E	F
1						
2						
3		**New Construction CMNEB+25%**		**Colonnes:**	**A**	**B**
4		**Segment**	**Segment**	**Client**	**Incremental Cost (¢/kWh levelized)**	**Incremental Cost (¢/ann.kWh)**
5		Arena TAE	Arenas (E)	Prov./Muni	0,05 $	0,61 $
6		Bar, salle de réception TAE	Bars & Entertainment (E)	Regular	0,05 $	0,59 $
7		CEGEP TAE	Cegeps (E)	Prov./Muni	0,09 $	1,09 $
8		CHSLD TAE	CHSLDs (E)	Prov./Muni	0,07 $	0,88 $
9		Concessionnaires TAE - UT vol. cst	Dealerships (E)	Regular	0,05 $	0,64 $
10		Entrepôts secs TAE	Dry Storage Warehouse (E)	Regular	0,04 $	0,53 $
11		École primaire avec ventilation TAE	Elementary School with Ventilation (E)	Prov./Muni	0,09 $	1,13 $
12		Restaurant familial TAE	Family Restaurant (E)	Regular	0,02 $	0,31 $
13		Resto rapide haut volume TAE	High-volume Fast Food (E)	Regular	0,01 $	0,16 $
14		Loisir intérieur TAE	Indoor Recreation (E)	Prov./Muni	0,08 $	1,02 $
15		Grand hôtel TAE	Large Hotel (E)	Regular	0,09 $	1,13 $
16		Grand détail TAE	Large Retail (E)	Regular	0,05 $	0,68 $
17		Resto rapide bas volume TAE	Low-volume Fast Food (E)	Regular	0,02 $	0,23 $
18		Loisir extérieur TAE	Outdoor Recreation (E)	Prov./Muni	0,05 $	0,64 $
19		Entrepôts Réfrigérés TAE	Refrigerated Warehouse (E)	Regular	0,08 $	0,98 $
20		Centre commerciaux TAE - UT vol. cst	Shopping Centers (E)	Regular	0,09 $	1,12 $
21		Petit CEGEP TAE	Small Cegeps (E)	Prov./Muni	0,08 $	0,96 $
22		Petit détail alimentaire TAE	Small Food Retail (E)	Regular	0,01 $	0,17 $
23		Petit hôtel/motel TAE	Small Hotel/Motel (E)	Regular	0,04 $	0,52 $
24		Petits bureaux TAE - UT vol. cst	Small Offices (E)	Regular	0,06 $	0,70 $
25		Petit détail TAE	Small Retail (E)	Regular	0,04 $	0,52 $
26		Petite école secondaire TAE	Small Secondary School (E)	Prov./Muni	0,09 $	1,16 $
27		Petit université TAE	Small Universities (E)	Prov./Muni	0,08 $	0,96 $
28		Supermarché TAE	Supermarket (E)	Regular	0,02 $	0,21 $
29						
30						
31				Lifetimes	20	yrs
32						
33						

	G	H	I	J	K	L
1						
2						
3	**C**	**D**	**E**	**F**	**G**	**H**
4	**HQ Incentive (¢/ann.kWh)**	**HQ target share of cost**	**HQ actual share of cost**	**HQ actual v. ideal**	Unit Savings (kWh/yr)	Incremental Cost
5	0,24 $	**75%**	**39%**	**52%**	174 178	107 105 $
6	0,18 $	**50%**	**31%**	**61%**	10 174	5 998 $
7	0,24 $	**75%**	**22%**	**29%**	406 265	444 275 $
8	0,24 $	**75%**	**27%**	**36%**	340 076	299 871 $
9	0,18 $	**50%**	**28%**	**56%**	64 840	41 756 $
10	0,18 $	**50%**	**34%**	**67%**	6 146	3 284 $
11	0,24 $	**75%**	**21%**	**28%**	70 974	79 949 $
12	0,18 $	**50%**	**59%**	**118%**	56 050	17 121 $
13	0,18 $	**50%**	**115%**	**230%**	56 854	8 908 $
14	0,24 $	**75%**	**24%**	**32%**	26 602	27 014 $
15	0,18 $	**50%**	**16%**	**32%**	369 475	418 424 $
16	0,18 $	**50%**	**26%**	**53%**	216 037	147 114 $
17	0,18 $	**50%**	**79%**	**157%**	26 053	5 968 $
18	0,24 $	**75%**	**37%**	**50%**	7 468	4 798 $
19	0,18 $	**50%**	**18%**	**37%**	80 751	79 102 $
20	0,18 $	**50%**	**16%**	**32%**	456 683	509 559 $
21	0,24 $	**75%**	**25%**	**33%**	83 810	80 439 $
22	0,18 $	**50%**	**103%**	**206%**	20 365	3 556 $
23	0,18 $	**50%**	**35%**	**70%**	44 794	23 201 $
24	0,18 $	**50%**	**26%**	**51%**	7 647	5 356 $
25	0,18 $	**50%**	**34%**	**69%**	8 904	4 660 $
26	0,24 $	**75%**	**21%**	**28%**	141 686	164 170 $
27	0,24 $	**75%**	**25%**	**33%**	83 810	80 439 $
28	0,18 $	**50%**	**86%**	**173%**	397 449	82 926 $
29						
30		HQ Stated Target Share of Incr.Cost				
31		Regular:	50%			
32		Prov/Muni:	75%			
33						

	A	B	C	D	E	F
34		**Sources des données**				
35		Colonne A	HQD-5, doc. 8, p. 32 (fichier annexé)			
36		Colonne B	calcul: colonne H / colonne G			
37		Colonne C	tableau de l'onglet "*CI Initiat's (calcul incitatif)*" (calculé à partir de HQD-1, doc. 1, p.57)			
38		Colonne D	HQD-5, doc. 8, p. 34.			
39		Colonne E	calcul: colonne C / colonne B			
40		Colonne F	calcul: colonne E / colonne D			
41		Colonne G	HQD-5, doc. 8, p. 32 (fichier annexé)			
42		Colonne H	HQD-5, doc. 8, p. 32 (fichier annexé)			


Share of NC Incremental Costs for MNECB+25% Target -- HQ Actual v. Target
Market Segments ("E" = electrically heated)
Supermarket (E) 173%
Small Universities (E) 33%
Small Secondary School (E) 28%
Small Retail (E) 69%
Small Offices (E) 51%
Small Hotel/Motel (E) 70%
Small Food Retail (E) 206%
Small Cegeps (E) 33%
Shopping Centers (E) 32%
Refrigerated Warehouse (E) 37%
Outdoor Recreation (E) 50%
Low-volume Fast Food (E) 157%
Large Retail (E) 53%
Large Hotel (E) 32%
Indoor Recreation (E) 32%
High-volume Fast Food (E) 230%
Family Restaurant (E) 118%
Elementary School with Ventilation (E) 28%
Dry Storage Warehouse (E) 67%
Dealerships (E) 56%
CHSLDs (E) 36%
Cegeps (E) 29%
Bars & Entertainment (E) 61%
Arenas (E) 52%
0%
50%
100%
150%
200%
250%
Index of Actual v. Targeted Coverage of Incremental Cost


Share of NC Incremental Costs for MNECB+25% Target -- HQ Actual v. Target
HQ actual share of cost
HQ target share of cost
Share of Incremental Cost
125%
100%
75%
50%
25%
0%
Arenas (E)
Bars & Entertainment (E)
Cegeps (E)
CHSLDs (E)
Dealerships (E)
Dry Storage Warehouse (E)
Elementary School with Ventilation (E)
Family Restaurant (E)
High-volume Fast Food (E)
Indoor Recreation (E)
Large Hotel (E)
Large Retail (E)
Low-volume Fast Food (E)
Outdoor Recreation (E)
Refrigerated Warehouse (E)
Shopping Centers (E)
Small Cegeps (E)
Small Food Retail (E)
Small Hotel/Motel (E)
Small Offices (E)
Small Retail (E)
Small Secondary School (E)
Small Universities (E)
Supermarket (E)
Market Segments ("E" = electrically heated)

DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix B:
Benchmarking Data

Balisage -- Hydro-Québec et Quinze pairs comparables

		(a) Investissements (K$CAD/an)	(b) Économies (MWh/an)	(c) Revenus de vente (K$CAD/an)	(d) Volume des ventes (MWh/an)	(e) Population (milliers)
California	CA	1 014 320 $	11 375 000	28 650 587 $	244 057 000	34 000
Manitoba	MB	30 681 $	366 625	891 000 $	22 000 000	1 163
Connecticut	CT	104 038 $	2 034 000	3 536 845 $	29 952 000	3 410
Vermont	VT	20 832 $	173 000	718 068 $	5 639 000	610
Massachusetts	MA	171 120 $	2 053 000	6 093 375 $	51 773 000	6 357
British Columbia	C.-B.	65 675 $	2 162 000	2 694 000 $	49 600 000	4 168
Rhode Island	RI	20 336 $	374 000	921 298 $	7 301 000	1 050
Montana	MT	17 732 $	262 000	903 728 $	14 580 000	903
Ontario	ON	225 000 $	???	13 000 000 $	156 000 000	11 410
QC (H-Q '05-10)	QC (v.'04)	**144 050 $**	**1 701 333**	**10 438 950 $**	**177 463 210**	**7 487**
New York	NY	256 568 $	3 213 000	20 046 608 $	142 027 000	18 989
Washington	WA	48 707 $	3 567 000	5 182 863 $	96 511 000	5 980
Oregon	OR	23 684 $	1 806 000	3 050 686 $	50 330 000	3 429
Idaho	ID	6 133 $	535 000	1 181 970 $	22 834 000	1 299
New Hampshire	NH	6 448 $	163 000	1 417 383 $	10 159 000	1 240
QC (H-Q '04-06)	QC (v.'03)	28 350 $	763 429	10 062 490 $	177 463 210	7 487
Maine	ME	3 596 $	51 000	1 461 311 $	12 163 000	1 277

		Indicateur investissement ($CAD)			Indicateur Gains d'EÉ projetés		
		$/MWh (a) / (d)	$/$ (a) / (c)	$/cap. (a) / (e)	MWh/K$ (b) / (c)	MWh/MWh (b) / (d)	MWh/cap. (b) / (e)
California	CA	4,16 $	3,5%	30 $	0,4	4,7%	0,3
Manitoba	MB	1,39 $	3,4%	26 $	0,4	1,7%	0,3
Connecticut	CT	3,47 $	2,9%	31 $	0,6	6,8%	0,6
Vermont	VT	3,69 $	2,9%	34 $	0,2	3,1%	0,3
Massachusetts	MA	3,31 $	2,8%	27 $	0,3	4,0%	0,3
British Columbia	C.-B.	1,32 $	2,4%	16 $	0,8	4,4%	0,5
Rhode Island	RI	2,79 $	2,2%	19 $	0,4	5,1%	0,4
Montana	MT	1,22 $	2,0%	20 $	0,3	1,8%	0,3
New York	NY	1,81 $	1,3%	14 $	0,2	2,3%	0,2
Ontario	ON	1,44 $	1,7%	20 $	not available	not available	not available
QC (H-Q '05-10)	QC (v.'04)	**0,81 $**	**1,4%**	**19 $**	**0,2**	**1,0%**	**0,2**
New Hampshire	NH	0,63 $	0,5%	5 $	0,1	1,6%	0,1
Washington	WA	0,50 $	0,9%	8 $	0,7	3,7%	0,6
Oregon	OR	0,47 $	0,8%	7 $	0,6	3,6%	0,5
Maine	ME	0,30 $	0,2%	3 $	0,0	0,4%	0,0
Idaho	ID	0,27 $	0,5%	5 $	0,5	2,3%	0,4
QC (H-Q '04-06)	QC (v.'03)	**0,16 $**	**0,3%**	**4 $**	**0,1**	**0,4%**	**0,1**

HQ 2004 PGEÉ Rank (v. 15)	**11**	**10**	**9**	**12**	**14**	**12**
HQ 2003 PGEÉ Rank (v. 15)	**16**	**15**	**15**	**14**	**14**	**14**

Notes

We **strongly advise *against* using the $/capita criterion.** We believe the $/MWh criterion is preferable for benchmarking purposes.
We also **strongly advise against using projected MWh savings** (the last three indicators) for benchmarking purposes.

DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix C:
Quantum Report: Home Audits

QUANTUM CONSULTING

NATIONAL ENERGY EFFICIENCY BEST PRACTICES STUDY

VOLUME R7 – RESIDENTIAL AUDIT PROGRAMS BEST PRACTICES REPORT

Submitted to

California Best Practices Project Advisory Committee
Kenneth James
Contract Manager
Pacific Gas and Electric Company
P.O. Box 770000,N6G
San Francisco, CA 94177

Submitted by

PRIME CONTRACTOR
QUANTUM CONSULTING INC.
2001 Addison St, Suite 300
Berkeley, CA 94704

Volume R7 Report Contractor – Quantum Consulting Inc.

December 2004

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The Best Practices Study team would like to gratefully acknowledge the participation of the following individuals and their organizations in this report:

- Albert Chiu – Pacific Gas and Electric
- Tom Conlon – GeoPraxis
- Janice Erickson – Sacramento Municipal Utility District
- Andrew Fisk – New York State Energy Research and Development Administration
- Laurie Gomez – Sempra Utilities
- Jerome Hanna – National Grid
- Taffy Miller – KEMA-Xenergy
- Rick Ridge – Ridge and Associates
- Shahana Samiullah – Southern California Edison
- Jennifer Shen – Southern California Edison
- Cheryl Wynn – Southern California Edison
- Carol Yin – Southern California Edison
- Deb Young – NorthWestern Energy

These individuals participated in lengthy interviews in which they generously shared their expertise and lessons learned in program design, management, implementation, and evaluation. Without their participation and the support of their organizations this report would not have been possible.

In addition, we thank the many individuals that participated in the user needs focus groups conducted at the outset of the project.

We also thank the members of the Best Practices Study's Project Advisory Committee for their inspiration, insights, tireless review and thoughtful direction throughout the project:

- Kenneth James – Pacific Gas & Electric Company
- Pierre Landry – Southern California Edison Company
- Rob Rubin – Sempra Utilities
- Jay Luboff – California Public Utilities Commission, Energy Division
- Eli Kollman – California Public Utilities Commission, Energy Division
- Sylvia Bender – California Energy Commission

Finally, these reports benefited greatly from the diligent technical editing of Betsy Wilkins and the tireless production efforts of Alex Kang.

CONTACT INFORMATION

Kenneth James
Best Practices Study Contract Manager
Pacific Gas & Electric Company
P.O. Box 770000,N6G
San Francisco, CA 94177
415-973-0246
klj1@pge.com

Michael W. Rufo
Best Practices Study Prime Contractor Lead
Quantum Consulting, Inc.
2001 Addison Street, Suite 300
Berkeley, California 94704
510-540-7200, ext. 2037
mrufo@qcworld.com

Phil Willems
R7 Residential Audit Chapter Lead
Quantum Consulting, Inc.
2001 Addison Street, Suite 300
Berkeley, California 94704
301-762-3494
pwillems@qcworld.com

ES. EXECUTIVE SUMMARY FOR RESIDENTIAL AUDITS PROGRAM AREA (R7)

ES.1 INTRODUCTION

This volume presents results of a comparative analysis of residential audit programs included in the National Energy Efficiency Best Practices Study ("Best Practices Study"). The overall Best Practices Study objectives, scope, and methodology are briefly outlined in Appendix R7A of this report. More details on methods and cross-program findings are provided in separate report volumes.

The Best Practices Study team ("Best Practices Team") reviewed six residential audit programs for this program area study ("R7 Programs" and "R7 Study," respectively), each of which focused on or included residential audits and targeted opportunities for retrofits as well as behavioral changes among residential customers in existing homes. Their scope varied widely: from the provision of information only to a more comprehensive approach to help residential customers identify and implement energy efficiency measures, including insulation, lighting, HVAC, appliances, and others. Some programs had energy savings goals; others explicitly excluded such goals to focus exclusively on the provision of information. The mix of program goals and approaches means that programs are not directly comparable, and it is not the goal of this report to judge one program as superior in design or execution to another. Instead, the focus is on identifying best practices from a variety of programs that have audits as a key component. The R7 Programs are listed in Exhibit R7-E1 below and presented in the body of this report. A discussion of the program selection process is provided in Appendix R7A.

ES.2 KEY CATEGORY THEMES

Four key crosscutting issues that affect multiple program components were identified for the R7 Programs.

One of the key differentiating features among R7 programs was the extent to which audits led to implementation of recommended measures. In some cases program managers see this issue as outside the scope of program goals, since some programs were designed to provide information and education only, and program goals were set and their achievement measured in terms of customers contacted and audits conducted. For these programs, direct impacts associated with or attributable to the audits were not expressed as an explicit part of the program goals.

Other programs were more concerned with measuring or estimating energy savings that could be directly attributed to the program. This was done through follow-up telephone surveys or through the direct involvement of a contractor who visited the customer and installed recommended measures (in a few instances on-site audits included direct installation of low-cost measures). This direct link typically led to higher estimated program impacts.

Finally, some audit programs were explicitly seen as feeder programs for the utility (or other agency) rebate programs. The audits identified promising links between customer needs and available programs and encouraged the customer to participate in the program. In this case, however, the audit program did not share in the impacts from installation of those measures, since the utility attributed them to the rebate program and could not double count the impacts by also assigning them to the audit program.

Program philosophies often were not spelled out in program plans or statements of intent. Sometimes they were articulated by program managers, sometimes they were the result of a sort of evolution, whereby programs were shaped by a combination of formal and informal evaluation, political pressures (explicit or subtle) to provide high-visibility services to residential customers, and inertia. Similarly, and in part because predecessor residential audit programs had been running for such a long time, R7 programs often lacked a detailed description of program flows. (Few of the program managers interviewed had been involved with the design and initial fielding of predecessors to their programs; instead, most had "inherited" a non-documented institutional memory of program flow.)

A suite of well-designed, field-tested audit tools is available to support almost any level of analysis of residential audit programs due to the maturity of these programs. The tools used to gather and analyze audit data from residential customers have grown dramatically in power, ease of use, and quality of presentation, comprising not only traditional on-site audits, but also computer-based and, increasingly, Internet-based applications.

Comprehensive, easily accessible tracking systems are critical to a complete understanding of audit program success. Since the extent to which audit programs can "claim" energy savings often depends on their role as feeders for other residential programs, it is important to track the timing of audits as well as the measures recommended and implemented – preferably with easy-to-use electronic systems. Moreover, the growing role of online audits means that existing tracking systems should be adapted to the task of linking Web site audits directly to customer data in the CIS.

ES.3 BEST PRACTICES SUMMARY

Best practices are identified in this study for each of the four major program components used to organize data collection and analysis. These program components are Program Design (including program theory), Program Management (including reporting and tracking, quality control and verification), Program Implementation (including participation process, incentive strategies, and marketing and outreach) and Program Evaluation. Best practices were developed by analyzing information across programs developed from detailed interviews of program sponsors and administrators, implementing agencies, and implementation or evaluation contractors, and thorough review of all relevant secondary sources such as program filings and evaluations. Clearly, not all best practices will be relevant for all audit programs, since some program components are not applicable for certain types of programs. Exhibit R7-E2 presents the list of best practices developed from the analysis of R7 programs. Exhibit R7-E3 provides the rationales associated with each best practice. The remainder of this report provides detailed analysis and discussion of program features and best practice rationales.

The scope of this study also includes a California gap analysis. A comparison of the best practices presented in this report with the practices employed in California's Statewide Standard Performance Contract Program is in progress and will be published when complete in a separate document.

Exhibit R7-E1
R7 Programs: Residential Audit Programs In R7 Study

Program Name	Implementer/s	Abbreviation for R7 Report
2002 Home Performance with ENERGY STAR Program	New York State Energy Research Development Association (NYSERDA)	Home Performance with ENERGY STAR
2000 Time-of-Sale Home Inspection Program	Sponsor: Southern California Edison Implementer: GeoPraxis, Inc.	TOS Inspection
2002 Residential Conservation Services (RCS) Audit Program	National Grid	RCS Audit
2002 E+ Energy Audit for Your Home Program	Northwestern Energy	E+ Energy Audit
2002 Residential Energy Advisory Services Program	Sacramento Municipal Utility District (SMUD)	SMUD Audit
2002 California Statewide Home Energy Efficiency Program	Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas Company (SCG), and San Diego Gas & Electric Company (SDG&E)	CA SW HEES

Exhibit R7-E2
Summary List of Best Practices for Residential Audit Programs

Program Theory and Design
• Articulate a program theory that clearly states the target for the program, program timing and the strategic approach whether resource acquisition, market transformation, or referral to other programs • Link the mix of on-site, online, and mail-in audits for each targeted market segment to policy objectives and resource constraints • Adopt a multi-year planning approach when possible • Use a collaborative or coordinated planning approach
Program Management: Project Management
• Utilize electronic project management • Make customer follow-up part of the implementation contractor's responsibility • Actively involve leading businesses in the segment targeted for transformation • Use a single prime contractor as the point of contact with the utility • Support program managers with accurate information about market conditions and market segments
Program Management: Reporting and Tracking
• Integrate marketing, customer, audit, and impact data • Make the audit recommendations, including energy saving potential, part of the program tracking database • Design the program tracking system to support the requirements of evaluators as well as program staff • Utilize databases that fully integrate audit participation and results with other energy efficiency program information systems • Track vendor activity and measure volume where relevant
Program Management: Quality Control and Verification
• Conduct on-site post-installation inspections by a third party where appropriate • Conduct follow-up telephone calls to provide an accurate estimate of the number of measures installed • Use audit tools to check for the reasonableness of savings and payback estimates
Program Implementation: Participation Process
• Provide a range of options • Make program participation part of an existing, routine transaction such as the purchase of a home or the installation of a heating or cooling system • Provide vendors with an economic incentive to participate, as well as an easy, simplified participation process where appropriate • Make the audit flow seamlessly into the adoption of recommended measures • Use rebates primarily to support market transformation strategies • It is not necessary to offer free measures for a program to succeed, although installation of low-cost measures does ensure that every audit delivers at least some energy savings • Use incentives to promote a specific technology or target a specific segment

Exhibit R7-E2 (Continued)
Summary List of Best Practices for Residential Audit Programs

Program Implementation: Marketing and Outreach
• Provide customers with a single statewide point of contact • Feature links to residential audits prominently on utility Web sites • Combine outreach to vendor partners with mass marketing efforts to raise consumer awareness and demand when appropriate • Use target marketing strategies to ensure that hard-to-reach (HTR) populations are informed about available audit program • Make marketing materials (as well as the audit instruments themselves) multi-lingual • Provide contractors or inspectors used to deliver programs with training and resources to enable them to market effectively • Take advantage of external factors such as heat waves to enhance marketing effectiveness • For mail-based audits, include the audit form with the audit offer and make the offer letter succinct and compelling
Program Evaluation
• Integrate impact evaluation and measure verification • Regularly assess program performance and success, such as measuring the level of energy and peak demand savings achieved • Periodically verify that the audit software is correctly calculating potential impacts • Conduct detailed impact evaluations that include measurement routinely, though not annually • Perform market assessments for those programs that have a market transformation component • Conduct process evaluations closer to the time of the audit than the impact evaluation • Conduct evaluations in a timely way, or concurrent with programs • Systematically update measure life every 2-3 years • Engage the implementation team in evaluation process • Present actionable findings to program staff both in real time and at the conclusion of study

Exhibit R7-E3
Summary of Best Practices Rationale for Residential Audit Programs

Best Practice	Rationale
Program Theory and Design	
Articulate a program theory that clearly states the target for the program, program timing and the strategic approach whether resource acquisition, market transformation, or referral to other programs	Sound program theory enables the program administrator to think through likely program outcomes and ensure the strategic and tactical approaches will lead to the desired results.
Link the mix of on-site, online, and mail-in audits for each targeted market segment to policy objectives and resource constraints	
Adopt a multi-year planning approach when possible	For programs that seek to transform a market by influencing the behavior of supply-side market actors with incentives, disruptions in funding can undermine otherwise significant gains. Securing funding for several years is more likely to enable program managers to first induce and then sustain changes in the market.
Use a collaborative or coordinated planning approach	In lieu of a competitive solicitation to select audit programs, such a process would encourage better integration of various audit programs that co-exist within a given state or region.
Program Management: Project Management	
Utilize electronic project management	Best-of-class IT solutions for end-to-end business process automation improve access to information for enhanced productivity and cost savings.
Make customer follow-up part of the implementation contractor's responsibility	Extending the implementation team's scope beyond audits alone should encourage greater emphasis on spurring customers to take action.

Best Practice	Rationale
Actively involve leading businesses in the segment targeted for transformation	Ensuring that for-profit parties are allowed an opportunity to realize benefits beyond those provided solely by the direct program management contract or incentives encourages additional private investments, support of upper management, and the creation of private sector stakeholders who have a long term interest in the success of the program objectives.
Use a single prime contractor as the point of contact with the utility	Coordination within and across programs can also be effectively attained through in-house program management, but using multiple contractors to implement different audit programs makes coordination more difficult.
Support program managers with accurate information about market conditions and market segments	Rigorous market research in advance of program design and continuous program evaluation can help ensure customer and trade ally satisfaction and maximize overall cost effectiveness.
Program Management: Reporting and Tracking	
Integrate marketing, customer, audit, and impact data	This will support tracking the effectiveness of marketing efforts, analysis of audit customer demographics, and extent to which various categories of residential customers (including HTR customers) are successfully reached by the program.
Make the audit recommendations, including energy saving potential, part of the program tracking database	A knowledge not just of what specific measures were recommended, but also what kinds of measures were installed and what kinds were rejected can be very helpful in designing follow-up strategies or marketing approaches for other residential programs.
Design the program tracking system to support the requirements of evaluators as well as program staff	This ensures that the kinds of information sought by each group can be readily obtained from the program database.
Utilize databases that fully integrate audit participation and results with other energy efficiency program information systems	This facilitates management review and tracking the effectiveness of the audit program in directing customers to rebate programs.

Best Practice	Rationale
Track vendor activity and measure volume where relevant	Helpful in assessing relative vendor effectiveness.
Program Management: Quality Control and Verification	
Conduct on-site post-installation inspections by a third party where appropriate	Random inspections of 10 to 20 percent of projects discourage vendors from failing to fully and properly install all rebated measures.
Conduct follow-up telephone calls to provide an accurate estimate of the number of measures installed	This can be done as part of the evaluation function, but should be done in a timely manner to provide program managers with relatively quick feedback on the percentage of audits that lead to action being taken.
Use audit tools to check for the reasonableness of savings and payback estimates	Catching "outliers" through an automated process allows implementation staff to identify shortcomings in the quality of the audit and recommendations.
Program Management: Participation Process	
Provide a range of options	Offering participants a choice of audit paths can hold down the cost per audit.
Make program participation part of an existing, routine transaction such as the purchase of a home or the installation of a heating or cooling system	This makes audits more likely to become a permanent part of the market.
Provide vendors with an economic incentive to participate, as well as an easy, simplified participation process where appropriate	For those programs were vendors are the most important actor in the prospecting and delivery mechanism, success depends on a process that facilitates participation and keeps contractor costs modest.
Make the audit flow seamlessly into the adoption of recommended measures	Linking audit results to specific actions increases the likelihood of installation and associated impacts.
Use upstream or midstream market actor incentives primarily to support market transformation strategies	Vendors face higher costs to modify their business practices.
It is not necessary to offer free measures for a program to succeed, although installation of low-cost measures does ensure that every audit delivers at least some energy savings	Programs with free measures do not have substantially higher installation rates or impacts than do programs without them.

Best Practice	Rationale
Use customer rebates to promote a specific technology or target a specific segment	Rebates may be an appropriate strategy for encouraging greater participation among HTR customers, if that is deemed to be an explicit program goal.
Program Management: Marketing and Outreach	
Provide customers with a single statewide point of contact	Use of an 800 number that can direct customers to the appropriate utility or other organization depending on their location or need makes it easy for consumers to respond to marketing initiatives.
Feature links to residential audits prominently on utility Web sites	Online audit participation improves when links to the online audits are moved to the home page of utility Web site instead of being located several layers down.
Use target marketing strategies to ensure that HTR populations are informed about available audit program	Sending direct mail to targeted markets helps ensure HTR customers have access to audits.
Make marketing materials (as well as the audit instruments themselves) multi-lingual	This will help make audits available to a broader range of potential respondents, including those in the HTR population.
Provide contractors or inspectors used to deliver programs with training and resources to enable them to market effectively	Vendors who deliver program-related service may not have any training or background in marketing, yet their ability to market the program can be crucial.
Take advantage of external factors to enhance marketing effectiveness	Utilities and audit program managers report an upswing in interest following heat waves or energy shortages. Marketing efforts should be tied to such events where possible (and consistent with the program's ability to respond to the demand).
For mail-based audits, include the audit form with the audit offer and make the offer letter succinct and compelling	Participation rates in mail-in audits with compelling offer letters can be as high as 20 percent or more in some segments. The offer part of the letter should be no more than one page. Including examples of audit reports and emphasizing that the results will be truly customized to the unique characteristics of the participant has also been shown to be effective.

Best Practice	Rationale
Program Management: Program Evaluation	
Integrate impact evaluation and measure verification	The verification of measures installed (including comparison of actual installations to those that were recommended) should be a basis for more robust estimates of program impacts. This would also allow evaluators to address persistence issues.
Regularly assess program performance and success, such as measuring the level of energy and peak demand savings achieved	Performance assessment is high priority.
Periodically verify that the audit software is correctly calculating potential impacts	A 2002 study found that audit software over- or under-estimated measure impacts by as much as 50%; moreover, there is always a risk that either the customer or the auditor enters data incorrectly; while internal validation routines will capture most such problems, evaluators should periodically examine a few audits in great detail.
Conduct detailed impact evaluations that include measurement routinely, though not annually	While audit programs have not been required to demonstrate impacts, they will increasingly be called on to do so if emphasis shifts to resource acquisition.
Perform market assessments for those programs that have a market transformation component	By using established indicators to verify the extent of market transformation, program effectiveness can be measured.
Conduct process evaluations closer to the time of the audit than the impact evaluation	While it is appropriate to wait a year before conducting follow-up contacts to determine installed measures, questions regarding customer satisfaction and the effectiveness of program delivery should be addressed using data collected within a few months of the audit.
Conduct evaluations in a timely way, or concurrent with programs	Timely evaluations give real-time feedback to program staff and contribute to program planning.

Best Practice	Rationale
Systematically update measure life effectiveness every 2-3 years	Measure life is a key parameter in estimating the lifecycle benefits of audit-recommended measures and therefore program cost. Measure life studies using a panel of program participants that are visited or interviewed every 2 to 3 years over the study life greatly enhances the accuracy of program assumptions, minimizing customer attrition and allowing the evaluators to better pin point the time at which measures fail.
Engage the implementation team in evaluation process	Involving program staff encourages their buy-in, and encourages them to express research issues and their perspective on program activities.
Present actionable findings to program staff both in real time and at the conclusion of study	Key findings from evaluations should be well-distilled and disseminated (i.e., via workshops, good executive summaries, two-page briefs).

1. OVERVIEW OF REVIEWED PROGRAMS

The R7 Programs targeted opportunities for retrofits as well as behavioral changes among residential customers in existing homes. Their scope ranged from the provision of information only to a more comprehensive approach to help homeowners identify and implement energy efficiency measures, including insulation, lighting, HVAC, appliances, and others.

- **The 2002 Home Performance with ENERGY STAR Homeowners Program implemented by NYSERDA (Home Performance with ENERGY STAR)** provided on-site Comprehensive Home Assessments (CHA) as the first stage in a one-stop shopping experience for customers in existing one - four family residences in New York. To meet its market transformation goals, Home Performance with ENERGY STAR created consumer demand for CHAs and treatments through an aggressive multi-media marketing campaign while also stimulating infrastructure development through the use of financial incentives targeted to mid-stream market participants such as contractors. Customers who complete home performance work can take advantage of low-interest financing options such as Fannie Mae's Home improvement Loan, a New York Energy $martSM Loan, or a 10 percent Homeowner Financing Incentive. The primary goal of the program is to have comprehensive home improvement work completed by trained and certified professionals. In 2002 approximately 2,000 households received home energy assessments, and 1,025 households installed energy-efficient equipment through the program.

- **The 2000 Time-of-Sale Home Inspection Program sponsored by Southern California Edison and implemented by GeoPraxis, Inc**. **(TOS Inspection)** trained and equipped home inspectors to identify energy-saving opportunities in existing residential homes in Southern California during a traditional time-of-sale (TOS) home inspection as part of its market transformation activities. To promote resource acquisition, TOS Inspection provided incentives to inspectors to perform a free comprehensive home energy rating audit (EnergyCheckup™) which qualified homeowners to receive rebates, free energy-saving measures, and Energy-Efficient Mortgage (EEM) financing to make home improvements, purchase energy-efficient appliances, or stretch the maximum loan amount. In 2000, 4,170 customers in the SCE service territory participated in TOS Inspection.

- **The 2002 Residential Conservation Services Audit Program implemented by National Grid (RCS Audit)** was a statewide mandated fuel-blind audit program which provides one-stop shopping to Massachusetts residential utility customers for energy efficiency and renewable energy services. RCS offers two tiers of service; Tier One customers receive low-cost educational assistance, access to technical information, self-audit tools, and online resources. Tier Two customers receive an on-site Home Energy Assessment (HEA) and are eligible for incentives up to 50 percent of the cost of allowable measures up to a maximum of $1,000 (plus $300 to replace inefficient refrigerators). In 2002, over 6,250 customers participated in the RCS Audit.

- **The 2002 E+ Energy Audit for Your Home Program implemented by Northwestern Energy (E+ Energy Audit)** was an on-site energy audit program for residential customers whose space and/or water heating fuels were delivered by Northwestern Energy. The audit included the installation of water measures, a gas appliance inspection, and customer education supported through a blower door analysis of air infiltration. Customers received a bill disaggregation as well as an analysis of recommended major measures with a payback of less than seven years. The goal was to achieve cost-effective energy savings in residential facilities on Northwestern Energy's system. In 2002, 3,500 on-site audits and 2,500 mail-in audits were completed through the program.

- **The 2002 Residential Energy Advisory Services Program implemented by the Sacramento Municipal Utility District (SMUD Audit)** was designed to help residential customers improve the energy efficiency of their homes. Customers received a choice of three relatively low-cost energy survey products: an online survey on SMUD's Web site, a survey on CD that was mailed out to customers, or a mail-in questionnaire. Customers who had significantly high bills or other special needs were eligible for the more costly in-home audit. In 2002 1,500 in-home audits and 6,000 self-audits were completed through the program.

- **The 2002 California Statewide Home Energy Efficiency Survey Program (CA SW HEES)** was implemented by the four largest investor-owned utilities (IOUs) in California: Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas Company (SCG), and San Diego Gas & Electric Company (SDG&E). The statewide program provided multi-lingual mail-in and on-line audits to help customers better understand and manage energy use in their homes, recognizing that customers have distinct needs that may make one type of delivery channel more appealing than another. The HEES program was positioned to reach the largest number of customers possible, including hard-to-reach (HTR) customers who in the past have had less access and fewer program alternatives. Both mail-in and on-line audits used sophisticated software tools to disaggregate customer bills, produce customized reports of energy usage, and provide recommendations on measures to install. Links to available rebates and incentive programs were also provided. In 2002, the program delivered 48,590 mail-in and 22,431 online audits.

Summary program characteristics are presented in Exhibit R7-1.

Exhibit R7-1
Summary of R7 Programs

	Home Performance with ENERGY STAR	**CA SW HEES**	**TOS Inspection**	**RCS Audit**	**E+ Energy Audit**	**SMUD Audit**
Period Reviewed	2002	2002	2000	2002	2002	2002
Cost						
Average retail price of electricity	$0.12	$0.16	$0.16	$0.10	$0.07	$0.10
Program budget	$4,000,000	$2,014,000	$282,000	$2,815,000	$1,300,000	$1,052,000
Total Incentives Paid	$1,200,000	$0	$146,000*	$987,000	$0	$0
Participation						
Eligible Participants	Single-family and 1-4 unit residences	All residential customers	Existing homes (single & multi-family, mobile homes, low income). Some geographical limitations depending on program sponsor.	All residential customers	All residential customers in homes more than 5 years old	All residential single-family customers (detached, duplex and mobile homes with either gas- or electric-heat)
Eligible Measures	Building Envelope, HVAC, Lighting, Water Heating, Appliances	Building Envelope, HVAC, Lighting, Water Heating, Appliances	Building Envelope, HVAC, Lighting, Water Heating, Appliances	Insulation, HVAC, Water Heating, Appliances	Building Envelope, HVAC, Lighting, Water Heating, Appliances	Building Envelope, HVAC, Lighting, Water Heating, Appliances
Number of Audits/Sites	About 2,000 audits, 1025 that led to action	48,590 Mail-in 22,431 Online	4,170	6,251	3,500 onsites 2,500 mail-in	7,500
Energy Savings Accomplishments						
MWh achieved (net)	741	8,770**	1,974	2,677	4,713	400
kW achieved	80	4,190**	Not reported	406	884	70

* $35 inspector incentive per audit

** Based on 2001 SCE Residential Audit Evaluation net impact estimates of 123 kWh and .06 kW per site for both mail-in and online audits

2. CONTEXT

2.1 POLICY ENVIRONMENT

Utilities and other program administrators and energy efficiency policy makers have fielded a variety of audit programs for the residential market over the past 25 years. Over that time, both the regulatory environment and the technology available to support residential audits have changed substantially. Predecessors to the R7 Programs were in operation from a few years to more than two decades. As a result, they reflect the evolution of both the policy environment and the technology base. A thumbnail summary of the history of policy changes in California is provided below:

- **1980s** – Early conservation programs focused on providing energy audits and other information aimed at encouraging residential customers to turn off lights when not in use, set back thermostats, increase insulation levels, and install high-efficiency heating and cooling systems. Rebates were also used increasingly in the latter half of the 1980s to support the installation of high-efficiency HVAC systems and appliances.

- **Early- to mid-1990s** – With the shift from "conservation" to "resource planning" paradigm for justifying and evaluating programs as part of integrated resource planning, investor-owned utilities in California operated under direct financial incentives to achieve and measure program savings. Overall funding for energy efficiency increased significantly during this period. Audit and information programs continued but incentive programs became more aggressive.

- **Late-1990s** – In the late 1990s, recognizing their long-term value, California held programs and funding in place during restructuring, at a time when some other states completely eliminated programs and funding. Nonetheless, programs in the late 1990s faced several challenges: funding levels were lower than during the earlier part of the decade, policy objectives shifted from resource acquisition to market transformation, and program oversight shifted temporarily to the California Board for Energy Efficiency (CBEE).

- **2000 to 2003** – Beginning in 2000, energy efficiency in California began a quick and dramatic shift back toward a stronger focus on resource acquisition to achieve immediate, cost-effective energy and peak demand savings in response to the state's restructuring-related energy crisis. Another important event during this period was the CPUC's decision to fund approximately $100 million worth of efficiency programs for the 2002-2003 period from new locally-oriented programs (approximately two-thirds of which were administered by non-utilities). The CPUC selected many of these programs with the expectation that they would provide marketing services or impacts in HTR segments or geographic areas that had not participated extensively in the IOUs' statewide programs (for example, the CPUC funding SCE's local in-home audit program specifically to target HTR customers) or had newly identified, untapped efficiency potential (for example, the incorporation of energy audits into standard time-of-sale home inspections). These types of selections were based in part on concerns about the equitable distribution of public benefits funds to segments that contributed funds, but that did not tend to participate at proportionate levels. Of particular relevance to the R7 Study is the CPUC's decisions to promote a statewide residential audit program targeted to HTR customers. In addition, as a means of investigating the effectiveness of online audits, in 2001 the CPUC authorized a pilot program to provide interactive consumption and cost information to residential and small business customers. An evaluation found that the resulting California Energy Connection Web site was visited by up to 2,700 unique visitors per month from late 2002 to early 2004. While users found the site easy to navigate, content was found to overlap with the online audit tools provided by individual utilities. (Quantum Consulting 2004)[1] The policy and funding history described above for California is somewhat indicative of the patterns that played out in other regions of the country, though often not as dramatically and without the direct energy crisis experience. Other contextual factors to consider with respect to the R7 Programs follow.

- Like other audit programs, **SMUD Audit** sought to balance limited funds against the high cost of in-home audits by moving to other, less expensive alternatives such as online and mail-in audit data collection.

- As a utility-sponsored third-party program, **TOS Inspection** emerged from the trend to local programs described above. Since it sought to incorporate energy audits into standard time-of-sale home inspections, the program was strongly oriented toward market transformation, although it also strove to deliver cost-effective energy savings. This program and its predecessors illustrate the uncertainty of the regulatory climate. Since 1999, predecessor programs had been run under "third-party initiative" funding from SCG, SCE and the CPUC. Based on the initial success, SCG increased funding in 1999 and renewed the program in 2000. Also in 2000, SCE adopted the program for delivery in their service area and subsequently approved a modified program design that was implemented under Summer Demand Initiative funding for 2001. In 2002, the CPUC authorized the program's introduction to the PG&E service area through 2004 as a training and information program, with a free low-cost measure distribution element, but without any incentives paid directly to inspectors.

- Like other programs, **E+ Energy Audit** and its predecessors have been in place over more than a decade of major changes in the regulatory and economic environment facing the implementing utility. Initially launched in the early 1990s by Montana Power as a program mandated by regulators and paid for by cost-recovery through rates, the program remained in place both as the region moved through deregulation and as Montana Power was first acquired by Northwestern Energy and subsequently went into bankruptcy. Since 1999 the audit program has been funded by a universal systems benefits (USB) charge as a local conservation program, but the program's initial goals, implementation contractor, and methods employed to deliver audits and information to Northwestern Energy's customers have remained the same.

[1] Interactive Consumption And Cost Information For Small Customers – Program Process/Customer Response Evaluation – Program Year 2003, Quantum Consulting, February 2004

- **RCS Audit** was a statewide mandated program that traced its origins both to the Federal Residential Conservation Service (RCS) law (established by the federal National Energy Conservation Policy Act of 1978) and to a 1980 state law requiring Massachusetts electric and gas utilities to provide home energy audits to customers on demand, paid for by a surcharge on energy bills. When the federal RCS requirement expired in 1990, most states abandoned the mandated audits, but Massachusetts, with its own law still on the books, kept its program. As in other parts of the country, Massachusetts' 1997 restructuring act put pressure on the state's electric utilities to keep prices low and forced a review of free or low-cost home energy audits and their $160 per home price tag, (exclusive of administrative and other overhead costs.) Despite relatively low adoption rates among audit customers, a decision was made to continue the program using public benefits funds to cover not only the cost of the audit, but also, in an effort to encourage adoption, up to 50 percent of the cost of installed measures.

- **Home Performance with ENERGY STAR** was one of a portfolio of market transformation-oriented programs developed in New York for both residential and non-residential customers. The program was designed by NYSERDA to focus on the 1-4 family residential marketplace and develop a competent home performance contractor infrastructure to service the demand created by the program's marketing efforts. The program also utilizes the expertise of contractors certified and accredited from the Building Performance Institute (BPI) - a national association for building science technology that sets the standards for assessing and improving the energy performance of homes - to transform the way homeowners buy and contractors sell and implement energy-related home improvements. While in the past the individual New York utilities fielded residential audit programs, the emergence of NYSERDA as the primary organization to design and implement energy efficiency programs meant that Home Performance with ENERGY STAR could be developed from scratch in a way that was consistent with NYSERDA's market transformation focus. As a result, Home Performance with ENERGY STAR has much less of the "history" associated with some other residential audit programs.

A few important contextual conclusions relevant to the R7 Study can be drawn from the summary and secondary sources cited above:

- Traditional residential audit programs have been influenced by a variety of trends in energy efficiency policy and politics, and have been fielded for decades with the primary goal of providing customer education. Only some of the more recently initiated programs have explicitly incorporated market transformation into program goals.

- The tension between the customer education, market transformation, and resource acquisition aspects of residential audit programs continues, as evidenced by the recent reversals within California on the appropriate role (or lack thereof) of these kinds of programs.

- Rebates have always played at least a supporting role in most residential audit programs, either through direct installation of low-cost measures, to help fund recommended measures, or as a means of directing residential customers to other programs with associated incentives.

- The longevity of some of these programs means that program theories and even procedures often predate current program managers, and are not always well documented.

- Similarly, the longevity of many residential audit programs has led to diminishing returns from marketing and audit efforts for some programs as the more receptive customers have all been reached, making the programs less cost-effective.

- Online audits have attracted significant attention as a possible means of delivering very low-cost customized audits. However, they have not yet achieved the level of market penetration as have well-executed mail audits.

2.2 PROGRAM STRATEGY AND GOALS

The R7 Programs focused primarily on customer education and market transformation to achieve energy efficiency, with less emphasis on actually verifying demand and energy savings, as illustrated in Exhibit R7-2.

As discussed above, ensuring the equitable distribution of public goods funds among different customer classes has affected the design of a number of residential programs in recent years. While most of these programs are open to all residential customers, there are more specific requirements for some. TOS Inspection, for example, focuses on energy audits conducted as part of the home inspection process. Other programs are available to all residential customers, but seek to minimize the number of customers who receive the highest-cost in-person audits. Some of these programs focus on HTR customers, defined as those with a specific house type, rural locations, income level, or membership in a population where language barriers limit program participation. Specifically, HEES was explicitly required by the CPUC to mail at least 50 percent of mail-in audit solicitation packages to HTR customers (English, Spanish, and Chinese). National Grid’s program, while not focused on HTR customers, reflected a concern with equitable distribution of public benefits revenues that caused it to continue its RCS program despite relatively low implementation rates.

Exhibit R7-2
Program Goals and Approaches

Program	Type of Measure	Customer Size	Program Strategy	Incentive
Home Performance with ENERGY STAR	Building Envelope, HVAC, Lighting, Water Heating, Appliances	1-4 family residences	Market Transformation	Financing, 10% Rebate in Lieu of Financing, General Education & Trade Ally Training
CA SW HEES	Building Envelope, HVAC, Lighting, Water Heating, Appliances, Pool and Spa	All	Increase Consumer Awareness and Encourage Customer Adoption; Focus on HTR	Free Audits
TOS Inspection	HVAC, Lighting, Water Heating, Appliances, Building Envelope	Residential Existing Homes (SF, MF, Mobile Homes, Low Income)	Resource Acquisition & Market Transformation	Free Audits, Trade Ally Training, Inspector Incentives
RCS Audit	HVAC, Water Heating, Appliances, Insulation	All	Provide One-stop Shopping	Prescriptive, General Education & Free Audits
E+ Energy Audit	Building Envelope, HVAC, Lighting, Water Heating, Appliances	All	Cost-effective Energy Savings	Free Measures & Audits
SMUD Audit	Building Envelope, HVAC, Lighting, Water Heating, Appliances	All Residential Single-Family Customers	Reduce Energy Costs and Peak Load	Free Audits

3. COMPARISON OF PROGRAM COMPONENTS

This section compares the R7 Programs across the four major program components used to organize data collection and analysis. These program components are Program Design (including program theory), Program Management (including project management, reporting and tracking, and quality control and verification), Program Implementation (including participation process and marketing and outreach) and Program Evaluation.

3.1 PROGRAM THEORY AND DESIGN

The findings of extensive research on home energy performance and bill disaggregation techniques have, over the years, created a body of knowledge that allows the energy usage of an individual home to be analyzed and the effect of changes in measures or behavior to be predicted and quantified. The overall theory behind all residential audit programs is that it is possible to conduct such an analysis for a specific home with relatively limited input regarding the home's characteristics and the behavior of its occupants. The amount of data and the cost of collecting it vary according to the type of audit conducted. On-site audits have traditionally been conducted by trained auditors who have the time and ability to collect data on a wider range of variables. In contrast, mail-in, telephone, and online audits that rely on customer input limit the amount of data required from customers in order to encourage participation. The potentially greater accuracy of the on-site audit must be balanced against the lower cost of alternative types of audits. (In SCE's 2002-2003 program implementation plan program budget, for example, per audit costs were budgeted at $91 for in-home, $36 for telephone, $25 for mail-in, and $2 for online – exclusive of administrative, marketing, and other program costs.)

For the most part, the R7 Programs did not develop formal program theories as part of their design or evaluation processes. Program theories have been relatively common only since the late 1990s when a justification of how a given set of actions would transform the targeted market became required for some programs. This was particularly important as programs were in competition for a fixed "pot" of public goods money, and those that could better defend market transformation claims had a better chance of winning. As a result, the programs with the most clearly developed theoretical basis are the newer ones with an explicit market transformation emphasis. For several of the longer-standing audit programs, any formal theory behind the programs was developed years ago by people no longer associated with the program.

Nevertheless, all of the program managers interviewed were able to articulate a rationale for their program's design logic that was based on hypotheses about the barriers to energy efficiency among residential customers. In particular, all of the California programs followed the CPUC's proposal requirements for 2002-2003 programs which included a specification of market barriers, a discussion of HTR goals and objectives, and an explanation of how the proposed program approaches would achieve the overall program goals.

The R7 Programs can be categorized according to three models: Market Transformation Programs, Information/Education Programs, and Rebate-linked Programs. While most program incorporate elements of more than one model, they are characterized here according to the dominant program theme.

- **Market Transformation Programs** are designed to bring about fundamental changes in aspects of the residential market that influence the extent to which energy efficiency is incorporated into relatively common transactions. Such programs may include incentives as transitional measures to encourage both residential customers and other market actors to take a broader view.

The goal of **Home Performance with ENERGY STAR** was to create a network of contractors who built their business around a “whole-house” approach to energy efficiency – whether they were working with HVAC systems/ducts, windows, or insulation. To facilitate this development, the program paid incentives to contractors for training, BPI certification/accreditation, diagnostic equipment, and whole-house projects completed or referred to other contractors.

TOS Inspection aimed to make it standard practice for home inspectors to identify energy saving opportunities in existing homes during a traditional time-of-sale home inspection. Incentives were offered to home inspectors for each home energy rating they performed.

- **Information/Education Programs** fundamentally address the information barrier as the main reason residential customers do not install optimum levels of energy efficiency measures. By providing detailed, accurate information and specific recommendations, along with costs and expected returns, it is believed audit programs will enable consumers to make informed decisions. Both **CA SW HEES** and **Energy E+ Audit** took this approach. Based on the assumption that information alone would drive customers to action, neither program offered direct incentives (although **Energy E+ Audit** did provide some free low-cost measures). The percentage of customers who have actually taken action as a result of information-only programs has typically ranged from 15-50 percent based on years of data. When audit-based information is derived from costly on-site audits, these numbers limit the cost-effectiveness of such an approach when measured in terms of energy savings. If the information is developed through a lower cost online or mail-in audit, however, it can be a relatively cost-effective means of generating energy savings, although confirming the level of savings adds significantly to program cost.

- **Rebate-linked Programs** pay rebates directly to customers who install recommended measures or direct customers to other programs that offer incentives**.** In the latter case, the audit program may be seen as part of an integrated residential program portfolio, with the stated purpose of directing customers to appropriate programs. As discussed elsewhere, one of the drawbacks of viewing audit programs in this light is the difficulty of attributing savings to the audit, since most savings are attributed to the program that pays the rebate, making audits appear to have very limited impacts. Several R7 Programs employed this model.

Both **SMUD Audit** and **CA SW HEES** used referrals to other residential programs as one of their strategies. In contrast, **RCS Audit** sought to motivate customers to take actions directly by offering rebates of up to 50 percent of the installed cost of recommended measures.

The mix of market transformation, information-only, or rebated-linked approaches employed by a program tends to be shaped by the policy environment and the specific requirements of the funding organization. Traditional IOU audit programs resulted from external pressure to provide services and/or information to the politically important residential customer base, and some of the R7 Programs seemed to be guided by such considerations. Similar pressures have led to the use of audits as referral tools, which has enabled utilities to, in essence, enhance the cost-effectiveness of their (typically higher impact) rebate programs. Finally, audit programs have either been designed or have evolved in response to demands by market transformation-oriented funding sources. As these sources increasingly integrate resource acquisition strategies into their overall portfolios, audit programs will probably evolve further to address specific requirements of funding sources. This can be seen already in the requirement that California utilities explicitly target HTR customers and in the growing trend toward lower cost online and mail-in audits to replace site visits.

There are several program design implications of the above. First, the cost of providing information-only audits must be kept down by limiting the number of on-site audits and increasingly relying on mail-in and online audits. Second, audit programs that seek to encourage more lasting changes in the market for residential energy efficiency will probably require incentives for some time to support supply-side actors (contractors and inspectors) who will drive such changes. Third, to the extent that audit programs are a highly visible intervention on behalf of residential customers, funding sources (utilities, public goods funds administrators, regulators) will continue to press for an equitable distribution of funds that ensures participation beyond the traditional "typical" audit customer: a relatively affluent, older, highly-educated consumer in a single-family detached home.

Best Practices

Program Theory and Design
• Articulate a program theory that clearly states the target for the program, program timing and the strategic approach whether resource acquisition, market transformation, or referral to other programs. • Link the mix of on-site, online, and mail-in audits for each targeted market segment to policy objectives and resource constraints. • Adopt a multi-year planning approach when possible. • Use a collaborative or coordinated planning approach.

- **Articulate a program theory that clearly states the target for the program, program timing and the strategic approach whether resource acquisition, market transformation, or referral to other programs.** Even a relatively simple statement of program logic can reveal gaps in program focus or effort and assure that everyone involved knows what the program seeks to accomplish and why. This is particularly important for long-established programs that may have restated their goals in response to the changing policy environment without revisiting the logic behind their program approach. In addition, it is critical to determine whether program success will be defined in terms of the numbers of customer contacts, audits completed, awareness or knowledge levels, measures installed, or energy savings.

- **Link the mix of on-site, online, and mail-in audits for each targeted market segment to policy objectives and resource constraints.** For example, a program that uses on-site audits, rebates for installed measures, and follow-up phone calls may be desirable when the primary goal is to maximize installation of recommended measures among customers who are difficult to motivate or have special issues like high bill complaints. By contrast, a mail-in or online audit with no incentives is far superior at maximizing the number of participants reached per program dollar. In general, on-site audits should be restricted to a narrow niche and minority role in the audit portfolio as they are much less cost-effective than mail and online delivery in the residential sector. An exception may be designs that bundle the audit with delivery of another service, like a home inspection, that results in a lower marginal cost for the audit portion of the visit. While this reduces the number of potential audits, the number of home inspections in California alone tops 500,000 a year, according to the National Association of Realtors.

- **Adopt a multi-year planning approach when possible.** For programs that seek to transform a market by influencing the behavior of supply-side market actors with incentives, disruptions in funding can undermine otherwise significant gains. Securing funding for several years is more likely to enable program managers to first induce and then sustain changes in the market.

- **Use a collaborative or coordinated planning approach.** Use of such an approach in lieu of a competitive solicitation to select audit programs encourages better integration of various audit programs that co-exist within a given state or region.

Program design must be responsive to the policy goals and resource constraints within which the program will be judged. In addition, a sound program theory or design rationale enables the program administrator to think through the likely outputs and outcomes from the program and to ensure that the strategic approach taken will lead to the anticipated results.

3.2 PROGRAM MANAGEMENT: PROJECT MANAGEMENT

Exhibit R7-3 summarizes the project management structure of the R7 Programs, including roles for overall management and audit implementation.

Exhibit R7-3
Program Management Roles

Program	Audit Implementer	Management Approach
Home Performance with ENERGY STAR	Primarily Turnkey Contractor	• Program managed by NYSERDA (1.5 FTE), but implemented by a turnkey non-profit contractor: the Conservation Services Group (10FTE)
CA SW HEES	Primarily Turnkey Contractor, with some In-house Personnel	• Program managers at each IOU coordinate program planning and design and manage contracts with KEMA-XENERGY, a private firm that implements the statewide mail-in audits • Individual IOUs maintain their own online audit tools (KEMA for SCE; Nexus for PG&E; Enercom for SDG&E and SCG)
TOS Inspection	Primarily Turnkey Contractor	• Program managed by GeoPraxis • India-based Web consulting firm also provides IT services as subcontractor • Designed/implemented in partnership with third-party real estate market leader
RCS Audit	Primarily Turnkey Contractor	• The National Grid program manager spends about half his time managing 3 or 4 implementation contractors selected to implement the RCS program
E+ Energy Audit	Primarily Turnkey Contractor	• A project manager at Northwestern Energy manages the contract with KEMA-XENERGY, a private firm that implements the program • There are 8 auditors, plus office staff, plus project managers at K-X and Northwestern Energy
SMUD Audit	Primarily In-house Personnel	• The project is managed and implemented in-house • A team of managers of other residential programs is also involved in program planning

Note that most implementing organizations (e.g., utilities) relied on turnkey contractors to deliver residential audit services as "implementation contractors," with only a single program (SMUD Audit) using primarily in-house personnel to conduct audits. One contractor (KEMA-XENERGY) was responsible for implementing both E+ Energy Audit and much of CA SW HEES, while another (Conservation Services Group) was the primary implementation contractor for both RCS Audit and Home Performance with ENERGY STAR. CA SW HEES program managers note, however, that the IOUs typically handle program design, develop mailing schedules, and implement and coordinate marketing/promotion activities.

Those implementation contractors who were responsible for delivering audits for a program typically designated a single project manager to interact directly and frequently with the utility program manager. This provided the utility with on-going knowledge of program operations and allowed the utility program manager to quickly approve any mid-course corrections that were needed. The implementation contractors for the R7 Programs all had multi-year working relationships with the implementing organization, and communications were consistently described as excellent.

SMUD Audit used in-house program staff to handle all aspects of the program, from marketing and outreach to the actual performance of the audits. Other members of the SMUD residential team were also involved in tracking the project's progress and ensuring smooth interaction with rebate and other programs. For the CD and online audits, SMUD used Nexus software.

Coordination of a single contractor for a statewide multi-utility effort raised management challenges for CA SW HEES in that KEMA-XENERGY was responsible for the mail-in audits for all four participating IOUs, but for only SCE's online audits, which used the KEMA-XENERGY RECAP audit tool. The other utilities used different audit "engines" for their online audits – Nexus for PG&E and Enercom for SDG&E and SCG. The extent to which the online audit captured information about the customer largely determined whether any follow-up activities were possible (either to encourage installation of measures or for evaluation purposes). There was some interest in moving the non-RECAP utilities to the RECAP platform in the interest of consistency. However, this was resisted by the other utilities, who had invested substantial time and money in buying and implementing other online audit tools and argued that climate and territory-specific concerns dictated the use of utility-tailored audit tools.

One of the key functions contributing to audit program success is a follow-up with customers after they have received audit results, regardless of what type of audit was conducted. Unfortunately, this function is rarely explicitly assigned to implementation contractors and most participants receive follow-up phone calls only as part of a program evaluation, if at all. Two programs incorporated follow-up in program design. Home Performance with ENERGY STAR did so by relying on the contractors who conducted the whole house inspection (contractors received an incentive for installed measures or for referral to another contractor who installed them). RCS Audit had the auditor provide a direct link to one of the Tier 2 contractors who could actually install measures. Some programs such as the CA SW HEES were clearly discouraged from providing follow-up by their inability to claim energy savings for the program by the CPUC.

Use of a single implementation contractor appears to be the most effective way of ensuring coordination across various types of audits. Having an effective program database (as discussed below) also adds to the ability of program manager to track audit requests, status, and outcome.

Best Practices

Program Management: Project Management
• Utilize electronic project management. • Make customer follow-up part of the implementation contractor's responsibility. • Actively involve leading businesses in the segment targeted for transformation. • Use a single prime contractor as the point of contact with the utility. • Support program managers with accurate information about market conditions and market segments.

- **Utilize electronic project management.** Specify best-of-class IT solutions for end-to-end business process automation and thus improved access to information for enhanced productivity and cost savings. TOS Inspection attempted to do this through the use of a sophisticated database and a team of IT vendors.

- **Make customer follow-up part of the implementation contractor's responsibility.** Extending the implementation team's scope beyond audits alone should encourage greater emphasis on spurring customers to take action. Home Performance with ENERGY STAR did this by offering incentives to the auditing contractors. Alternative approaches include lower cost follow-up phone calls, postcards, or e-mails.

- **Actively involve leading businesses in the segment targeted for transformation**. Ensuring that for-profit parties are allowed an opportunity to realize benefits beyond those provided solely by the direct program management contract or incentives encourages additional private investments, support of upper management, and the creation of private sector stakeholders who have a long term interest in the success of the program objectives.

- **Use a single prime contractor as the point of contact with the utility**. Coordination within and across programs can also be effectively attained through in-house program management, but using multiple contractors to implement different audit programs make coordination more difficult.

- **Support program managers with accurate information about market conditions and market segments**. Rigorous market research in advance of program design and continuous program evaluation can help ensure customer and trade ally satisfaction and maximize overall cost effectiveness.

3.3 PROGRAM MANAGEMENT: REPORTING AND TRACKING

All of the R7 Programs had some process for reporting and tracking the progress and/or impact of program activities. For most programs, the emphasis was on tracking activities (i.e., the number of audits) rather than results (i.e., energy savings). All sponsors/administrators, and implementing contractors tracked project-level information, but often took different approaches to database management. A variety of project-specific indicators were used for internal project management and regulatory reporting. Tracking typically involved fairly detailed monitoring of activities, especially progress toward goals and project status.

Program staff acknowledged the importance of computer databases to automate tasks, reduce data entry demands, generate reports easily and ensure quality control of data inputting. Key tracking indicators for this program area and their uses are shown in Exhibit R7-4. The number of audits performed was reported to be the key indicator tracked, however, a number of implementers found value in tracking other indicators as well, in particular, the number of phone calls expressing interest in an audit, the number of mail-in audits sent out, recommendations made and associated energy savings, measures implemented, and customer characteristics.

Exhibit R7-4
Key Reporting and Tracking Indicators

Program	Key Tracking Indicators	Purpose
Home Performance with ENERGY STAR	• Number of reporting contractors • Number of homes assessed and treated • Measure costs and paybacks • Amount of financing provided	• Track the performance of individual contractors to see who is active and who is doing a good job • The contractors generate a computerized analysis of the home's performance and identify measure costs and paybacks. These reports are included in the tracking system • Tracking system helped NYSERDA see that many small jobs were not being reported, which led to introduction of incentives in lieu of financing
CA SW HEES	• Number of m ail-in audits sent out (by language) • Number of mail-in audits returned (by language) • Number of online audits • % HTR mailed and returned • audit results, recommendations, savings	• Track overall progress against goals • Determine whether HTR percentage is being met • Support impact and process evaluations
TOS Inspection	• Number of inspectors trained • Number of audits • Customers • Measure recommendations • Savings (estimates)	• Data provided to contract managers and used to improve program design/performance

Program	Key Tracking Indicators	Purpose
RCS Audit	• % of customers installing measures • Number of audits • Outcomes • Individual measures installed	• For reporting to the DOER • To determine how well the program is doing • To follow up on customers who claim rebate checks but do not install recommended measures • To determine if the portion of rebate paid by the utility should be increased
E+ Energy Audit	• Customer contacts, customer characteristics • Number of audits, measures recommended	• Northwestern uses the results to prepare reports on the disposition of USB funds • To determine the status of any request or job in the system at any time • Keeps utility informed both in talking to the customer and in preparing audit reports
SMUD Audit	• Number of training sessions • Energy efficiency initiatives • Number of energy audits by type (in-home, mail-in, CDROM, online) • Number of energy audits in comparison to goal • Customers who have participated through various types of audits	• Used in program manager's monthly report to track progress

In designing tracking systems, implementers must balance the need to capture important program and customer information against the significant extra cost of follow-up contacts. Follow-up is primarily used to determine whether recommended measures have been installed so that savings can be estimated. Most implementers of information-oriented programs tend not to track the actions of every audited customer, relying instead on follow-up with a sample of participants for evaluation purposes. Since the program tracking goals of information programs are typically based on the number of audits conducted rather than kW savings, the extra time and cost associated with tracking installed measures is difficult to justify.

Tracking the *potential* impact of audits, on the other hand, is something to which the audit tools used by all the R7 Programs are ideally suited. Since the audit –whether conducted in person, by mail, or over the Internet – captures detailed baseline data, energy savings that the homeowner would be likely to realize if the recommendations were followed could have been calculated easily using engineering algorithms in the audit software. Among the R7 Programs, only the TOS program tracked and reported those potential savings, and at least one program manager lamented the failure of evaluators and funding sources to tap this rich source of data.

The array of information recorded supported a number of purposes. The standard functions were regulatory reporting, internal performance monitoring and project status tracking. For example, Home Performance with ENERGY STAR tracked the performance of individual contractors "to see who is active and is doing a good job." (Fisk, 2003) The tracking system also helped Home Performance with ENERGY STAR program managers see that many small jobs were not being reported by contractors (who did not finance them or seek incentives), which led to introduction of incentives in lieu of financing for small jobs.

Among the more sophisticated tracking systems are the following:

- For TOS Inspection, GeoPraxis used a fully Web-based Home Energy Rating Services (HERS) Server (residential audit application based on IDEA Server™ and DOE-2. The HERS Server used a SQL Server database, and provided MS Access and MS Excel data extracts for third-party evaluation, measurement and verification (EM&V) consultants. The database was remotely hosted (in Virginia), and was accessible over the Internet by IT staff (in India and California), program management contractor staff (in Virginia, Georgia, and California), sub-consultants (in California), trade allies (in California), and consumers (in California).

- Several of the online audit tools used for CA SW HEES captured and stored all the data collected during the audit, as well as the recommendations made, including costs and expected measure level energy savings associated with each. However, these data were not routinely reported in regulatory filings because it was not a requirement for CA HEES.

A few program implementers noted the limitations of their current or previous systems and described recent upgrades or interest in expanding the functionality of their tracking systems.

- After many years of using an internally developed database developed in the mid-1980s, KEMA-XENERGY moved to a sophisticated relational database for CA SW HEES.

- For E+ Energy Audit, KEMA-XENERGY tracked every step of a customer's interaction with the program using an Access database. However, the actual audit results, recommendations, and estimated costs and savings were tracked separately by the RECAP audit software.

- SMUD Audit used a stand-alone database developed in-house for tracking. While this database was useful for determining how many people had received various kinds of audits, the dedicated program database did not integrate with other SMUD programs, which complicated reporting efforts – particularly since one of the goals of the audit program was to direct customers to other programs. SMUD is moving to an integrated database in 2004 to facilitate the reporting process.

Best Practices

Program Management: Reporting and Tracking
• Integrate marketing, customer, audit, and impact data. • Make the audit recommendations, including energy saving potential, part of the program tracking database. • Design the program tracking system to support the requirements of evaluators as well as program staff. • Utilize databases that fully integrate audit participation and results with other energy efficiency program information systems. • Track vendor activity and measure volume where relevant.

- **Integrate marketing, customer, audit, and impact data.** This will support tracking the effectiveness of marketing efforts, analysis of audit customer demographics, and the extent to which various categories of residential customers (including HTR customers) are successfully reached by the program.

- **Make the audit recommendations, including energy saving potential, part of the program tracking database.** Knowledge not just of what measures were recommended, but also what kinds of measures were installed and what kinds were rejected can be very helpful in designing follow-up strategies or marketing approaches for other residential programs.

- **Design the program tracking system to support the requirements of evaluators as well as program staff** so that the kinds of information sought by each group can be readily obtained from the program database.

- **Utilize databases that fully integrate audit participation and results with other energy efficiency program information systems.** This facilitates management review and tracking the effectiveness of the audit program in directing customers to rebate programs.

- **Track vendor activity and measure volume where relevant** to assess relative vendor effectiveness.

3.4 PROGRAM MANAGEMENT: QUALITY CONTROL AND VERIFICATION

The extent to which the R7 Programs used verification protocols varied with the degree of program involvement in measure installation. Programs like CA SW HEES, SMUD Audit, TOS Inspection and E+ Energy Audit limited verification to phone calls or follow-up letters asking customers about the measures they had installed, either as part of the program process or as part of the evaluation. Programs involving contractors who installed recommended measures, on the other hand, conducted verification inspections of a percentage of installations.

Measurement and verification (M&V) requirements of the R7 Programs are summarized in Exhibit R7-5. Home Performance with ENERGY STAR had the most thorough inspection regime, inspecting 15 percent of all sites after measure installation by the contractor. These inspections are conducted by NYSERDA's Program Implementation Contractor (CSG). BPI conducts an additional level of inspections beyond NYSERDA's. Program managers noted that the percentage of sites inspected was higher for new contractors and for contractors who had had problems in the past. In the past (including the year analyzed for this review), National Grid relied on the implementation contractors to self-inspect installations for their audit programs. After several customer complaints, however, program managers instituted a third-party inspection process.

Exhibit R7-5
Measurement and Verification (M&V) Requirements

Program	M&V Requirements
Home Performance with ENERGY STAR	• Random inspections of 15% of completed improvements, plus additional random inspections by the Building Performance Institute • Results of testing are verified to determine if recommendations were sound, and then installation of the measures themselves is verified • Start with a higher percentage of inspections for new contractors, and also increase the percentage if problems are found with a certain contractor, and may go down below that once contractor has a proven track record • For home inspections, measure installation quality, failure rates, implementation quality, and adherence to process • On other jobs, results are reviewed through the program database, which provides information on measures installed for each job
CA SW HEES	• RECAP software for mail-in has built in internal validation routines for reporting results • Follow-up phone calls conducted as part of the evaluation are the only method used to verify installation (education/information only program)
TOS Inspection	• Installation of measures verified by 3rd party evaluator telephone survey • Quality control (QC) of inspectors required by Residential Energy Services Network (RESNET) standards, including observation in field of inspector prior to certification; followup QC • Automated QC procedures in software seek out outliers in all audit reports • All reports receive QC review by specially trained QC auditor • Feedback to inspector if outlier reports are identified
RCS Audit	• Third party verification process to ensure measure installation
E+ Energy Audit	• No verification that measures are installed (other than the direct install measures) but, customers receive a 6 week follow up letter to see if measures have been installed for any recommended major measure with less than 7 year payback • QC includes auditors handing out cards where customers rate the job they did; as well as about 160 follow-up phone calls a year where customers are asked about the process and the results

Program	M&V Requirements
SMUD Audit	• Verification is limited to calling customers and asking if they have installed measures and if they were satisfied with the audit process

In addition to verification of installed measures, several respondents cited a broad range of other quality control measures used to ensure the effectiveness of program delivery. NYSERDA, for example, verified measure installation quality, failure rates, implementation quality, and adherence to process for Home Performance with ENERGY STAR. For TOS Inspection, GeoPraxis mentioned using automated quality control procedures in their audit software that highlighted outliers in audit reports, as well as a certification process for home inspectors required by Residential Energy Services Network (RESNET) standards. SMUD evaluated the quality of SMUD Audit training, and Northwestern Energy reported having auditors hand out cards for customers to rate the quality of the audit, as well as make 160 follow-up phone calls a year in which customers were asked about the process and the results of E+ Energy Audit. All of the online audit tools used by the audit programs reviewed also included internal automated quality control processes based on where actual results fall on a log-normal distribution of expected results, allowing outliers to be identified for follow up (e.g., review for data entry errors, follow-up phone calls).

Best Practices

Program Management: Quality Control and Verification
• Conduct on-site post-installation inspections by a third party where appropriate. • Conduct follow-up telephone calls to provide an accurate estimate of the number of measures installed. • Use audit tools to check for the reasonableness of savings and payback estimates.

- **Conduct on-site post-installation inspections by a third party where appropriate** to discourage vendors from failing to fully and properly install all rebated measures. Random inspections of 10 to 20 percent of projects are usually adequate, but the percentage should be higher for newer contractors.

- **Conduct follow-up telephone calls to provide an accurate estimate of the number of measures installed.** This can be done as part of the evaluation function, but should be done in a timely manner to provide program managers with relatively quick feedback on the percentage of audits that lead to action being taken – recognizing that there is a lag between audits and measure installation.

- **Use audit tools to check for the reasonableness of savings and payback estimates.** Catching "outliers" through an automated process allows implementation staff to identify shortcomings in the quality of the audit and recommendations.

3.5 PROGRAM IMPLEMENTATION: PARTICIPATION PROCESS

For many programs, including the R7 Programs, a tradeoff exists between the goals of simplicity (making participation easy for customers and contractors) and accountability (ensuring funds are paid only for proper installations and savings are calculated accurately). Exhibit R7-6 describes the steps involved in participating in the R7 Programs. All of the programs assessed recognize the importance of simplicity and have streamlined participation, while maintaining the information necessary for tracking and verification.

Determining customer eligibility is usually simple for audit programs; the exception is programs that have requirements regarding the age of the home to be audited or the fact that a home can only have one audit (this limit usually does not apply to online audits). Programs that target HTR customers usually do so through marketing efforts rather than by limiting participation of non-HTR customers.

Exhibit R7-6
Participation Process

Program	Participation Process
Home Performance with ENERGY STAR	1. Customers contact a participating Building Performance Institute certified contractor 2. Contractor performs an audit and provides recommendations for energy improvements, including itemized cost estimates for each suggested improvement, a report outlining energy savings for each improvement, and financing options to get the job done 3. If the homeowner proceeds with the improvements, the $100 cost of the audit is deducted from the total cost
CA SW HEES	1. Utilities mass-mail mail-in audit forms to 100% HTR customers, who complete and return, then receive audit report with recommendations; customers can also call and request a mail-in audit form 2. Alternatively, customers can go to their IOUs website and complete and online audit form, which generates an immediate audit report with recommendations 3. All audit recommendations include links to other EE programs and services
TOS Inspection	1. Home inspectors are informed of upcoming training seminars via trade association monthly meetings 2. Inspectors are trained (technical and sales training) and certified (after 3 successful supervised audits) 3. Inspectors begin offering service (included in regular fee or as up-sell option) 4. Inspectors receive per audit incentive based on number of completed audits submitted to server
RCS Audit	1. Any residential customer in the state may call Mass Electric through a statewide 800 number, which forwards those calls to the program's energy efficiency advisor vendor 2. The customer can answer specific questions from the energy advisor or fill out the Nexus ENERGYgram self qualifying form 3. Based on the answers, the ENERGYgram or the energy advisor offers energy efficiency tips and determines whether an on-site audit might be beneficial 4. If an onsite audit is performed, the program offers residential customers an incentive that will cover up to 50% of the cost of all allowable measures, up to a maximum of $1,000

Program	Participation Process
E+ Energy Audit	1. Customers call in and ask for an audit 2. Utility determines whether customers qualify for the on-site audit and if they do, schedule the audit 3. The audit is performed and free measures are installed (water heater blanket, up to 10' pipe insulation, low-flow showerheads and aerators) 4. Results and recommendations are sent out about 5-10 days later, including bill disaggregation and recommendations of measures with paybacks of less than 7 years 5. Customers who have no space or water heat fuels delivered by NorthWestern Energy (or whose homes are less than 5 years old) are sent the E+ Energy Survey, a mail-in audit
SMUD Audit	1. When they contact SMUD, most customers receive a choice of three low-cost energy survey products: online survey on SMUD's website, CD with a Nexus product, or mail in questionnaire for people who do not have a computer 2. Customers who have significantly high bills or other special needs may receive the more costly in-home audit

Incentive Approaches

The R7 Study revealed the importance of incentive approaches as part of the participation process for residential audit programs. Exhibit R7-7 summarizes information collected on R7 Program incentives. For all programs except Home Performance with Energy Star, the basic incentive was the availability of a no-cost audit. However, several of the R7 Programs offered further incentives to encourage measures installation — payments of up to 50 percent of installed measure cost – as part of the program itself. In addition, some programs provided 100 percent incentives in the form of free low-cost measures such as low-flow showerheads and CFLs, while others offered miscellaneous incentives to vendors (home inspectors and contractors) to encourage their participation. These audit programs sometimes also made recommendations for measures offered through other rebate programs offered by the sponsoring utility.

While incentives offered for the installation of recommended measures are beyond the scope of "pure" audits and could be considered separate elements in the residential portfolio, they are included here because the audits are central elements of these programs, and it is not possible to separate the management, delivery, tracking, and evaluation of the different program components.

Exhibit R7-7
Incentive Approaches

Program	Incentive Approach	Level of Incentive
Home Performance with ENERGY STAR	• Customer pays for audit, but $100 cost is deducted from total cost if customer adopts recommended improvements • The program offers incentives to ensure that all available cost-effective energy efficiency opportunities are captured. This includes referral incentives because different trades have traditionally operated in isolation, which meant that an HVAC contractor had no reason to address insulation or ducts, for example. The referral incentive was designed to address that • Incentives designed to encourage contractors to pursue whole house opportunities	• Customers have access to low interest financing or can take the 10% financing incentive if they self-finance the work (up to $2000). • NYSERDA pays contractors an incentive equal to 5% of the value of work contracted and completed as a result of a proposal made using a whole house approach. • Contractors are also eligible for a referral incentive of 5% of the value of referred work when and if the referral turns into a contract.
CA SW HEES	• Free audits	• 100% of audit cost
TOS Inspection	• Free audit • Free measures kit	• Per audit incentive of $35 for inspectors (full incremental cost of energy audit) • Free measures kits (2 CFLs, 1 showerhead, 2 aerators, $25 value) mailed to consumer after audit (PY2002-04 only)
RCS Audit	• Free audit • Program provides incentives to encourage customers to install measures	• 100% of audit cost • Rebates of up to 50% of installed cost for qualifying measures, mostly for heating, hot water, insulation, and appliance
E+ Energy Audit	• Free audits • Free measures with on-site audits	• 100% of audit cost • On-site audit customers receive free measures: water heater blanket, pipe insulation, low-flow showerheads; bathroom and kitchen sink faucet aerators
SMUD Audit	• Free audits	• 100% of audit cost

GeoPraxis' experience using or trying to use incentives as part of TOS Inspection illustrates some of the difficulties associated with rebates. When the TOS Inspection predecessor program was rolled out in 2001 by SCG, it paid a $35/audit incentive to inspectors. This proved so successful (27,000+ audits) that SCG declared the market "transformed" and did not renew funding. Since the market clearly had not been transformed, numerous inspectors who had made efforts to begin offering energy inspections on a fee for service basis were left stranded until the program was re-launched by GeoPraxis in 2002[2].

Some R7 Programs adjusted incentive levels during the course of the program to better meet goals. NYSERDA added a 10 percent incentive to Home Performance with ENERGY STAR as an alternative to low-cost financing for smaller jobs that were being self-financed by the homeowner. National Grid consciously used rebate levels as a means of increasing the percentage of measures installed. When installation levels fell below 20 percent early in the 2003 program year, program managers increased rebate levels to bring installations back to historical averages. It should be noted, however, that EM&V of the CA SW HEES (and before that the audits programs offered individually by the IOUs) reported installation rates higher than this without offering any incentives beyond the free audit.

Best Practices

Program Implementation: Participation Process
• Provide a range of options. • Make program participation part of an existing, routine transaction such as the purchase of a home or the installation of a heating or cooling system. • For market transformation strategies, provide vendors with an economic incentive to participate, as well as an easy, simplified participation process where appropriate. • Make the audit flow seamlessly into the adoption of recommended measures. • Use rebates primarily to support market transformation strategies. • It is not necessary to offer free measures for a program to succeed, although installation of low-cost measures does ensure that every audit delivers at least some energy savings. • Use incentives to promote a specific technology or target a specific segment.

- **<u>Provide a range of options</u>** to offer participants a choice of audit paths and hold down the cost per audit. Online audits offer excellent potential for low-cost audits, assuming participants can be adequately screened for eligibility and provided enough support. However, it is much more difficult to achieve significant participation through online audits than with mail-in audits.

- **<u>Make program participation part of an existing, routine transaction such as the purchase of a home or the installation of a heating or cooling system</u>**. This makes audits more likely to become a permanent part of the market.

---

[2] When GeoPraxis proposed a similar program for Northern California in 2003, the CPUC authorized it as a training and information program, with a free low-cost measure distribution element, but without any incentives paid directly to inspectors – apparently because the funds for inspector incentives were quickly depleted..

- **For market transformation strategies, provide vendors them with an economic incentive to participate, as well as an easy, simplified participation process where appropriate**. For those programs were vendors are the most important actor in the prospecting and delivery mechanism, success depends on a process that facilitates participation and keeps contractor costs modest.

- **Make the audit flow seamlessly into the adoption of recommended measures**, for example by providing model numbers of qualifying measures. Linking audit results to specific actions increases the likelihood of installation and associated impacts. This can be facilitated by providing detailed information regarding available rebates and qualifying measures or equipment, including specific model numbers, or other criteria.

- **Use incentives primarily to support market transformation strategies**. Short-term incentives can help vendors offset higher costs associated with modifying their business practices. However, incentives should be used sparingly.

- **It is not necessary to offer free measures for a program to succeed, although installation of low-cost measures does ensure that every audit delivers at least some energy savings**. Programs with free measures do not have substantially higher installation rates or impacts than do programs without them.

- **Use incentives to promote a specific technology or target a specific segment**. Rebates may be an appropriate strategy for encouraging greater participation among HTR customers, if that is deemed to be an explicit program goal.

3.6 PROGRAM IMPLEMENTATION: MARKETING AND OUTREACH

Since most of the R7 Programs targeted a very broadly defined population, a mass marketing and outreach approach was used. Direct mail pieces and bill stuffers were by far the most common types of marketing materials used by the R7 Programs.

- RCS Audit's statewide marketing efforts encouraged people to call a toll-free number, which subsequently directed them to the appropriate utility's audit program.

- For CA SW HEES and other mail-in audit programs (i.e., SMUD Audit and the mail-in component of E+ Energy Audit), the direct mail piece often **was** the audit form. In 2002, approximately 440,000 audits were sent out by the four California IOUs, and approximately 12 percent of those were completed and returned.

- For CA SW HEES, the direct mail effort was modified by the requirement that at least half of the marketing be targeted to HTR segments, defined according to the following criteria:
  - Primary language spoken is other than English
  - Income is in the moderate level
  - Multi-family and mobile home tenants

- Geographic areas other than San Francisco Bay area, San Diego area, Los Angeles Basin, or Sacramento
- Renters

To reach these HTR segments, mailings were produced in multiple languages (in English and Spanish for all four IOUs, also in Chinese for PG&E, SCG and SCE, and in Vietnamese for SDG&E) and targeted to the geographic areas described above. Unfortunately, the definitions of HTR that lend themselves readily to direct marketing are all geographically based, which is only a single dimension of the HTR definition, and not a very effective one at that, since many "rural" zip codes are, in fact, relatively affluent "outer suburbs." While the CA IOUs succeeded in achieving their goal of sending more than half their mailings to the targeted segments, the 2002 program evaluation findings suggest that HTR customers were still not fully represented in the mail-in program. (Ridge, 2004) Specifically, the evaluation found that people with a college or graduate degree were overrepresented in the program, while the following were underrepresented:

- Apartment dwellers (nearly 87 percent of participants lived in single-family detached dwellings)
- Households with incomes of less than $50,000/year
- Hispanics and Asian-Americans
- Online audits were marketed using bills stuffers and direct mail, and also via the Internet itself. In addition to online advertising, the audits were promoted by more prominently featuring links to the residential audits on the home pages of the utility Web sites, and at least some of the utilities also utilized an e-mail "blast," a message broadly distributed to a third-party list to inform customers in their territories about the online audit.

For programs that used other market actors – contractors and home inspectors - to deliver the audits, mass marketing was significantly less important. TOS Inspection initially (and effectively) focused its marketing on recruiting inspectors, but later began to focus on helping home inspectors market the program to consumers.

Home Performance with ENERGY STAR relied on contractors for marketing, but supplemented that with a mass market outreach effort designed to increase awareness of the program among homeowners. The comprehensive consumer and contractor awareness/education campaign was focused on "call to action" marketing, creating both consumer demand and contractor participation. The goal of increasing consumer demand was based on the belief that this is the true driver of market transformation. Homeowners received information on the program by accessing the NYSERDA Web site or by calling a toll-free number. As a result of their inquiry, homeowners received an information packet, a video and a list of participating contractors in their area. Providing a homeowner with a list of participating, certified contractors not only served to boost the homeowner's comfort and confidence level in the program, but also generated qualified leads for the contractor.

Best Practices

Program Implementation: Marketing and Outreach
• Provide customers with a single statewide point of contact. • Feature links to residential audits prominently on utility Web sites. • Combine outreach to vendor partners with mass marketing efforts to raise consumer awareness and demand when appropriate. • Use target marketing strategies to ensure that hard-to-reach (HTR) populations are informed about available audit programs. • Make marketing materials (as well as the audit instruments themselves) multi-lingual. • Provide contractors or inspectors used to deliver programs with training and resources to enable them to market effectively. • Take advantage of external factors such as heat waves to enhance marketing effectiveness. • For mail-based audits, include the audit form with the audit offer and make the offer letter succinct and compelling.

- **Provide customers with a single statewide point of contact**. For all types of audits, use of an 800 number that can direct customers to the appropriate utility or other organization depending on their location or need makes it easy for consumers to respond to marketing initiatives.

- **Feature links to residential audits prominently on utility Web sites.** For CA SW HEES, online audit participation improved when links to the online audits were moved to the utility's Web site home page instead of being located several layers down. In addition, the evaluation of the Internet information pilot cited previously (Quantum Consulting 2004) found that the number of Web site hits increased with the offer of an amazon.com gift certificate as an incentive, but that the number of site visits dropped sharply when the incentive period ended.

- **Combine outreach to vendor partners with mass marketing efforts to raise consumer awareness and demand when appropriate.** This strategy was used effectively by Home Performance with ENERGY STAR to recruit new contractors while making residents aware of the program.

- **Use target marketing strategies to ensure that hard-to-reach (HTR) populations are informed about available audit programs.** Sophisticated tools (such as Donnelly and Microvision codes) are currently being used in California to target mail audits to customers who truly meet the HTR criteria.

- **Make marketing materials (as well as the audit instruments themselves) multi-lingual**. This will help make audits available to a broader range of potential respondents, including those in the HTR population. This is especially important if reaching non-English speaking populations is a goal.

- **Provide contractors or inspectors used to deliver programs with training and resources to enable them to market effectively.** Vendors who deliver program related services may not have any training or background in marketing, yet their ability to market the program can be crucial.

- **Take advantage of external factors to enhance marketing effectiveness.** Heat waves, the energy crisis, and other high-visibility events or trends increase the number of customers interested in residential audits. Marketing efforts should leverage such events wherever possible (and consistent with the program's ability to respond to the demand).

- **For mail-based audits, include the audit form with the audit offer and make the offer letter succinct and compelling.** Participation rates in mail-in audits with compelling offer letters can be as high as 20 percent or more in some segments. The offer part of the letter should be no more than one page. Including examples of audit reports and emphasizing that the results will be truly customized to the unique characteristics of the participant has also been shown to be effective.

3.7 PROGRAM EVALUATION

The history of evaluations of audit programs has varied as widely as the goals of the programs themselves. When audits were funded by IOUs as part of commission-mandated conservation efforts, significant resources were devoted to developing impact estimates using engineering algorithms, modeling, and/or billing analysis. When market transformation became the dominant paradigm, evaluators looked for evidence of reduction in market barriers and other indicators of permanent changes in the marketplace (this remains true for several MT-oriented programs, including those of NYSERDA[3], GeoPraxis[4], and CA SW HEES).

Most of the R7 Programs were funded using public benefits charges, and therefore had to demonstrate that money was effectively spent. Formal evaluations for the R7 Programs typically encompassed program accomplishments in terms of customers reached and audits completed, but not necessarily in terms of impacts achieved, since few of the programs defined their goals in terms of kWh savings. For programs such as CA SW HEES, this created a dilemma in that impacts have not been an explicitly tracked goal for this and other audit programs in the past, but the growing emphasis on resource acquisition forced program managers and evaluators to take a second look at impacts that could be directly tied to the money spent on residential audit programs.

[3] While a thorough evaluation of NYSERDA's 2002 program had not been done at the time of this report, some evaluation results are now available on NYSERDA's website through 2003. These results incorporate market characterization and causality, M&V, and process evaluation metrics.

[4] A process and impact evaluation of the TOS program (2002-2003, no inspector incentives) is available at www. Calmac.org.

The CPUC mandated that audit-recommended installed measures be assumed to have measure lives of just two years – a reasonable assumption for behavioral actions taken (such as setting back thermostats), but unduly conservative for equipment measures such as CFLs, insulation, or HVAC upgrades. Both the evaluation of the 2001 SCE audit program (Ridge, 2002) and the evaluation of the 2002 program (Ridge, 2004) found that installed measures typically have a significantly longer life, and that per-home impacts can be estimated to average about 300 kWh annually – not high, but more than the zero impacts assumed by the CPUC Energy Efficiency Policy Manual. The 2002 SCE evaluation found that estimated useful life averaged about 3.5-4.5 years for online, mail-in, in-home and telephone audits, while measures installed as a result of time-of-sale audits were estimated to have a useful life of more than 13 years.

This general level of impacts has been confirmed in a number of evaluations that show savings of 2-5 percent of annual usage, which is consistent with the 300 kWh estimated cited above. Examples include an average of 343 net kWh for the 1995 SCE in-home audit program; 391 kWh for the 1997 SDG&E Residential Energy Management Services program; 156 kWh for in-home and 67 kWh for telephone and mail-in audits for the 1997 PG&E Residential Energy Management Services programs; 432 kWh for in-home and 154 kWh for telephone audits for the 2001 SCE Residential Audit programs; and 473 net kWh for the 2000 GeoPraxis TOS program.

Exhibit R7-8
Types of Residential Audit Program Evaluation

Program	Last Major Evaluation	Type of Evaluation
NYSERDA	2003	Process Impact
California IOUs	2002 program	Impact Process
GeoPraxis, Inc.	2002-2003 program	Process Impact
National Grid	2002	Impact
Northwestern Energy	1990s	Impact
	Yearly	Informal customer surveys
SMUD	2004	Informal customer surveys

Beyond traditional impact and process evaluation objectives, recent evaluations of programs with HTR goals sometimes involve assessment of how a program is meeting equity concerns. For instance, equity was an explicit goal of CA SW HEES, which set a 50 percent HTR goal, as described earlier. The evaluation of the program found it met its HTR requirements, with over half of the customers who completed mail-in audits in populations defined as HTR.

One worthwhile practice that was raised across programs is to *closely* involve program implementers in the evaluation process. Both NYSERDA and the California IOUs had implementation staff participate in evaluation kick-off meetings and made them available to be interviewed by the evaluation team. Not only does this practice encourage implementers to buy-in to the evaluation process, it also gives them an opportunity to pose questions and bring their research needs to the evaluation study. In addition, evaluators can brief the implementation team on high level, actionable findings in the draft stage and take consideration of their feedback and perspective before finalizing reports.

Despite good progress in this regard, the evaluator for CA SW HEES would like to see even closer working ties for future programs, creating the ability to provide more rapid feedback to the program managers. Having evaluators provide input into the design of databases, for example, would help ensure that data could be made readily available in a format that would support subsequent analysis.

There are indications that the impacts associated with recommended measures may be miscalculated by some online audit programs. A 2002 paper in Building Energy reviewed more than 50 online and disk-based audit programs, and found that some of the most widely used overestimated impacts by as much as 52 percent (Mills 2002). In addition, interactive effects are not always adequately addressed by such software tools.

A significant issue regarding impact evaluations of residential audit programs is the need to wait a substantial amount of time to allow owners of audited homes to take action. Managers of the reviewed programs reported waiting from six months to a year before following up with customers to determine what measures they had installed. Ridge & Associates, in evaluating the 2000 SCE audit program, recommended that "it would be imprudent not to wait until at least a full year after the end of the program year to assess the full impact of the audit." (Ridge, 2002)

Of course the need to wait for a year for impact results conflicts with the desirability of contacting program participants for process-related questions when the audit is still fresh in their minds. Process evaluations are common for these programs but the level of effort and depth varies. Key process findings from these process evaluations include:

- Customers generally have high levels of satisfaction with the audit, regardless of whether it is delivered in person, by mail, by phone, or electronically.

- Reports are generally considered easy to read and interpret.

- In the evaluation of CA SW HEES, 85 percent of respondents said they were aware of the benefits of energy efficiency measures before they received the audit.

Best Practices

Program Evaluation
• Integrate impact evaluation and measure verification. • Regularly assess program performance and success, such as measuring the level of energy and peak demand savings achieved. • Periodically verify that the audit software is correctly calculating potential impacts. • Conduct detailed impact evaluations that include measurement routinely, though not annually. • Perform market assessments for those programs that have a market transformation component. • Conduct process evaluations closer to the time of the audit than the impact evaluation. • Conduct evaluations in a timely way, or concurrent with programs. • Systematically update measure life every 2-3 years. • Engage the implementation team in evaluation process. • Present actionable findings to program staff both in real time and at the conclusion of study.

- **Integrate impact evaluation and measure verification**. Most impact estimates currently rely on self-reported data obtained through telephone verification interviews, and apply engineering estimates of per-measure impacts to those measures. The onsite verification of measures installed (including comparison of actual installations to those that were recommended) should be a basis for more robust estimates of program impacts. This would also allow evaluators to address persistence issues such as first-year failures (burn outs) and removals for lighting measures.

- **Regularly assess program performance and success, such as measuring the level of energy and peak demand savings achieved.**

- **Periodically verify that the audit software is correctly calculating potential impacts**. As reported in the 2002 study (Mills, 2002), some algorithms appear to have been programmed incorrectly. Moreover, there is always a risk that either the customer or the auditor enters data incorrectly. While internal validation routines will capture most such problems, evaluators should periodically examine a few audits in great detail.

- **Conduct detailed impact evaluations that include measurement routinely, though not annually**. While audit programs have not been required to demonstrate impacts, they will increasingly be called on to do so in jurisdictions like that of the California IOU's that emphasize energy efficiency as part of an overall resource procurement process.

- **Perform market assessments for those programs that have a market transformation component**. By using established indicators (for example, awareness and knowledge of efficiency measures for customers; use of a whole-house approach for contractors; incorporation of energy efficiency by home inspectors) to verify the extent of market transformation, program effectiveness can be measured.

- **Conduct process evaluations closer to the time of the audit than the impact evaluation**. While it is appropriate to wait for a year before conducting follow-up contacts to determine installed measures, questions regarding customer satisfaction and the effectiveness of program delivery should be addressed using data collected within a few months of the audit.
  - For those programs where vendors are integral to program delivery, process evaluations should include vendor satisfaction, and obtaining vendor input on the program process and on rebate levels.
  - For online audits, special care must be taken to identify the customer actually conducting the audit and then gathering information from them regarding issues like perceptions of using the site, and the quality/usefulness of the report. It may be worth asking a sample of online customers to conduct a brief process-related online survey immediately upon completing the audit.
- **Conduct evaluations in a timely way, or concurrent with programs**. Timely evaluations give real-time feedback to program staff and contribute to program planning.

- **Systematically update measure life every 2-3 years.** Measure life is a key parameter in estimating the lifecycle benefits of audit-recommended measures and therefore program cost-effectiveness. Measure life studies using a panel of program participants that are visited or interviewed every 2 to 3 years over the study life greatly enhances the accuracy of program assumptions, minimizing customer attrition and allowing the evaluators to better pin point the time at which measures fail.

- **Engage the implementation team in evaluation process.** Involving program staff early and throughout the evaluation is important to obtain their buy-in to the evaluation process, encourage them to develop research issues, solicit their perspective on program activities, and increase the likelihood they will review and utilize the evaluation results.

- **Present actionable findings to program staff both in real time and at the conclusion of study.** Focusing on actionable findings and recommendations is critical to engaging program implementers' attention, obtaining feedback on the findings and recommendations in draft form, and challenging them to act on study recommendations or create their own alternative approaches to achieving similar ends.

4. COMPARISON OF OUTCOMES

Energy efficiency programs and portfolios are often designed with specific policy objectives in mind, and those objectives can often impact the outcome of a program. For example, programs that target hard-to-reach areas may not exhibit the same rates of participation as those that do not. Key factors that affect cost effectiveness and program outcomes include:

- **Energy efficiency policy objectives –** policies that emphasize different goals such as market transformation, resource acquisition, equity, etc. will drive different program designs and program objectives.

- **Market barriers addressed** – programs that seek to mitigate difficult barriers may have poorer performance-related metrics because they attack tough problems, in contrast to programs that may have excellent ostensible metrics because of cream skimming.

- **Measure mix** – the mix of measures installed in a program can significantly affect a program's cost-effectiveness.

- **Demand/energy** – the extent of peak demand versus energy focus of the program can, by definition, affect the cost-effectiveness of the indicator in question (e.g., a peak demand oriented program may score poorly on an $/kWh metric). This can be considered a part of the measure mix factor listed above.

- **Multi-year policy objectives** – if consistent, help programs to achieve goals that require medium to long-term market presence and extensive program infrastructure; if inconsistent, make achievement of such goals more difficult.

- **Multi-year funding levels** – if consistent, allow programs to set multi-year goals and maintain consistent presence and messages among end-users and supply-side market actors; if inconsistent, makes maintaining a stable market presence more difficult.

- **Program/Market Lifecycle** – where a program or key measure is in its product lifecycle will affect its cost-effectiveness. For example, a program seeking impacts from the last 50 percent of the market to adopt a product that has penetrated the first 50 percent of the market should be expected to be more costly than one attacking a market with a low or insignificant saturation level.[5]

- **Climate** – for example, HVAC measures are more cost-effective in severe climates than in mild climates because absolute savings are strongly a function of base usage levels.

---

[5] There are at least two reasons for this. First, in more highly saturated markets, it is more difficult to find the remaining measure opportunities and, second, the remaining market is typically characterized by late majority and laggard organizations that are more resistant to adopting new products and practices. In addition, a program in the first-year of a multi-year plan to impact a market may have poor first-year metrics because of the associated startup costs and time it takes to create awareness and other program effects.

- **Customer/target market actor mix** – the mix of customers and trade allies often plays a role in cost-effectiveness, for example, a program in a market with larger commercial customers will tend to be more cost effective than an identical program in a market of smaller commercial customers, all other things being equal; similarly, programs with customer segments with longer full-load equivalent hours will be more cost-effective than those with lower average full-load hours of operation (also related to climate).

- **Customer density** – delivering an energy efficiency program to a relatively dense population base will be less costly than delivering to a sparser population, all other things being equal.

- **Customer Energy Rates** – higher electricity rates should lead to higher levels of measure adoption, all else being equal.

- **Economic Conditions** – willingness to invest in new products and practices changes in response to short-term economic and market conditions, which may vary across regions.

- **Customer Values** – efficiency program effectiveness can vary as a function of differences in customer values, again, all else being equal.

Because a number of the R7 Programs had educational and market transformation goals rather than resource acquisition targets, it is difficult to compare their outcomes.

Information is presented on the Total Resource Cost (TRC) test, the associated discount rate and the average measure life, where available. Also shown are non-incentive dollars spent per kWh, which offers an indication of the cost to market and administer. Incentive dollars per kWh shows the overall average incentive amount per unit of estimated first-year net impact. Cost-effectiveness data made available to the Best Practices Team for the R7 Study are displayed in Exhibit R7-9.

Program planning assumptions can create large variations in both total resource benefit-cost ratios and program costs per unit of impact. Cost-effectiveness is driven by a set of assumptions about measure cost, measure life, per unit savings, savings per application, net-to-gross and other factors. The benefit side of cost-effectiveness is based on avoided cost, which differs substantially across service territories. Furthermore, measure mix also affects cost-effectiveness. The exact measure mix was not made available to the Best Practices Team for all of the R7 Programs, although some qualitative information was available (e.g., TOS Inspection tended to recommend higher cost, longer lifetime measures than CA SW HEES).

The TRC test is one of the most commonly used metrics to determine if a program is cost-effective. Essentially the TRC is calculated as the ratio of the lifecycle avoided cost benefit of all the energy and demand savings, divided by all of the associated program and measure costs (specifically, full measure costs, not just those covered by incentives). Unfortunately, TRC values are not directly comparable across jurisdictions because of the variations in avoided costs, measure cost estimates, measure life estimates, and discount rates mentioned above.

Exhibit R7-9
Cost Effectiveness

Program	Home Performance with ENERGY STAR	CA SW HEES	TOS Inspection	RCS Audit	E+ Energy Audit	SMUD Audit
kWh saved per incentive paid (kWh/$)	0.62	*	13.53	2.71	*	*
kWh saved per non-incentive $ (kWh/$)	0.26	4.08	14.51	1.46	3.63	0.38
Net to Gross Ratio	1	72%	72%	1	1	1
Total Resource Cost/Societal test	NA	NA	1.27	0.61	NA	NA
Utility cost test	NA	NA	NA	0.76	NA	NA
Average measure lifetime	NA	4.6	13.3	7.7	NA	NA
Real discount rate	NA	NA	NA	NA	NA	NA

Data Sources/Notes:

NA: Not available
*: No incentives paid, information only program
NYSERDA: c/b data not available for individual programs, only aggregate
California Statewide HEES: Interview with program evaluator, Ridge and Associates
GeoPraxis, Inc.: Ridge, 2002 (Note: inspector, not customer incentives)
National Grid: 2002 DSM Performance Measurement Report
Northwestern Energy: Annual Report of NorthWestern Energy Electric Utility - 2002
SMUD: Interview with program manager

In addition, a number of utilities/jurisdictions either did not have TRC and other benefit-cost data or were unable to provide it to the Best Practices Team – in some cases because program managers recognized the difficulty of accurately attributing measure installations and associated savings either to an audit-only program or to the audit component of a broader program. To the extent that such data exist but were not made available, it becomes more difficult to develop meaningful comparisons of various approaches to delivering and measuring the results of residential audit programs.

5. SOURCES

Building Performance Institute website, http://www.bpi.org.

Conlon, Tom (Vice President, GeoPraxis, Inc.) 2003. Best Practices In-Depth Interview, EnergyCheck Time of Sale Home Inspection Program, October 31.

Erickson, Janis (Energy Star Project Manager, Sacramento Municipal Utility District). 2003. Best Practices In-Depth Interview, SMU Residential Audit Program. December 22.

Fisk, Andrew (Senior Project Manager, NYSERDA). 2003. Best Practices In-Depth Interview, NYSERSDA Home Performance with EnergyStar Program. October 24.

Hagler-Bailly Consulting and Xenergy Consulting. 1999. *Impact Evaluation of Pacific Gas and Electric Company's 1997 Residential Energy Management Services Programs*, Prepared for Pacific Gas & Electric Company.

Hanna, Jerome (RCS Program Manager, NGRID). 2003. Best Practices In-Depth Interview, National Grid Residential Conservation Services Program. December 16.

KVR Research Consulting. 2004. *Final Report for the Measurement and Evaluation Study of Southern California Edison Company's PY2002 Local In-Home Audit Program.* Prepared for Southern California Edison.

Miller, Taffy (Director/Project Manager, KEMA-Xenergy). 2003. Best Practices In-Depth Interview, Northwestern Energy E+ Energy Audit for Your Home. October 16.

Mills, Evan. 2002. *Review and Comparison of Web- and Disk-based Tools for Residential Energy Analysis*. Lawrence Berkeley National Laboratory.

National Grid. 2002. *2003 Energy Efficiency Plan, Massachusetts Electric And Nantucket Electric*.

National Grid. 2002. *2001 DSM Performance Measurement Report, Massachusetts Electric and Nantucket Electric.* submitted to Massachusetts Department of Telecommunications and Energy.

National Grid. 2003. *2002 DSM Performance Measurement Report, Massachusetts Electric and Nantucket Electric*. submitted to Massachusetts Department of Telecommunications and Energy

Northwestern Energy. 2002. *Annual Report of Northwestern Electric Utility to the Public Service Commission, State of Montana - Year 2001.* http://psc.state.mt.us/scripts/annualreports2001/

Northwestern Energy. 2002. *Annual Report of Northwestern Gas Utility to the Public Service Commission, State of Montana - Year 2001.* http://psc.state.mt.us/scripts/annualreports2001/

Northwestern Energy. 2003. *Annual Report of Northwestern Electric Utility to the Public Service Commission, State of Montana - Year 2002.* http://psc.state.mt.us/scripts/annualreports2002/

Northwestern Energy. 2003. *Annual Report of Northwestern Gas Utility to the Public Service Commission, State of Montana - Year 2002.* http://psc.state.mt.us/scripts/annualreports2002/

NYSERDA. *New York Energy $martSM Program Evaluation and Status Report - Quarterly Report - March 2003.* http://www.nyserda.org/sbcmar2003.pdf

NYSERDA. *New York Energy $martSM Program Evaluation and Status Report - Quarterly Report - September 2002.* http://www.nyserda.org/sbcsep2002.pdf

NYSERDA. *New York Energy $martSM Program Evaluation and Status Report - Quarterly Report - June 2002*. http://www.nyserda.org/sbcjun2002.pdf

NYSERDA. *New York Energy $mart Program Evaluation and Status Report - Report to the System Benefits Charge Advisory Group* - May 2003, http://www.nyserda.org/sbcadvisorymay2003.pdf

NYSERDA. 2003. *System Benefits Charge - Revised Operating Plan for New York Energy $martSM Programs (2001-2006*). http://www.nyserda.org/sbcadvisorymay2003.pdf

Quantum Consulting. 2002. *"Interactive Consumption And Cost Information For Small Customers"*. Prepared for Pacific Gas & Electric Company.

______________. 2004. "California Statewide Home Energy Efficiency Surveys Program Summary Profile." Prepared for Pacific Gas & Electric.

______________. 2004. "GeoPraxis Time of Sale EnergyCheck Program Summary Profile." Prepared for Pacific Gas & Electric.

______________. 2004. "National Grid Residential Conservation Services Program Summary Profile." Prepared for Pacific Gas & Electric.

______________. 2004. "Northwestern Energy E+ Energy Audit for Your Home Program Summary Profile." Prepared for Pacific Gas & Electric.

______________. 2004. "NYSERDA Home Performance with Energy Star Program Summary Profile." Prepared for Pacific Gas & Electric.

______________. 2004. "Sacramento Municipal Utility District Residential Audit Program Summary Profile." Prepared for Pacific Gas & Electric.

RLW Analytics. 2003. *Final Report, Measurement and Evaluation Study of the 2002 SDG&E Residential In-Home Audits Program*, Prepared for San Diego Gas and Electric.

Ridge and Associates. 2002. *Evaluation of Southern California Edison's (2001) Residential Audit Programs: Final Report.* Prepared for Southern California Edison.

Ridge, Rick, (Program Evaluation Contractor, Ridge and Associates). 2004. Best Practices In-Depth Interview, California Statewide Home Energy Efficiency Surveys Program. March 25.

Sacramento Municipal Utility District. 2003. *Residential Energy Advisory Services Program Plan*.

Young, Deb (Program Manager, Northwestern Energy). 2003. Best Practices In-Depth Interview, Northwestern Energy E+ Energy Audit for Your Home. November 3.

APPENDIX R7A – BRIEF INTRODUCTION TO THE NATIONAL ENERGY EFFICIENCY BEST PRACTICES STUDY

INTRODUCTION

This report presents results of a comparative analysis of residential audit programs included in the National Energy Efficiency Best Practices Study ("Best Practices Study"). The overall Best Practices Study objectives, scope, and methodology are briefly outlined in this Appendix. More details on methods and cross-program findings are provided in separate report volumes.

OBJECTIVE AND SCOPE

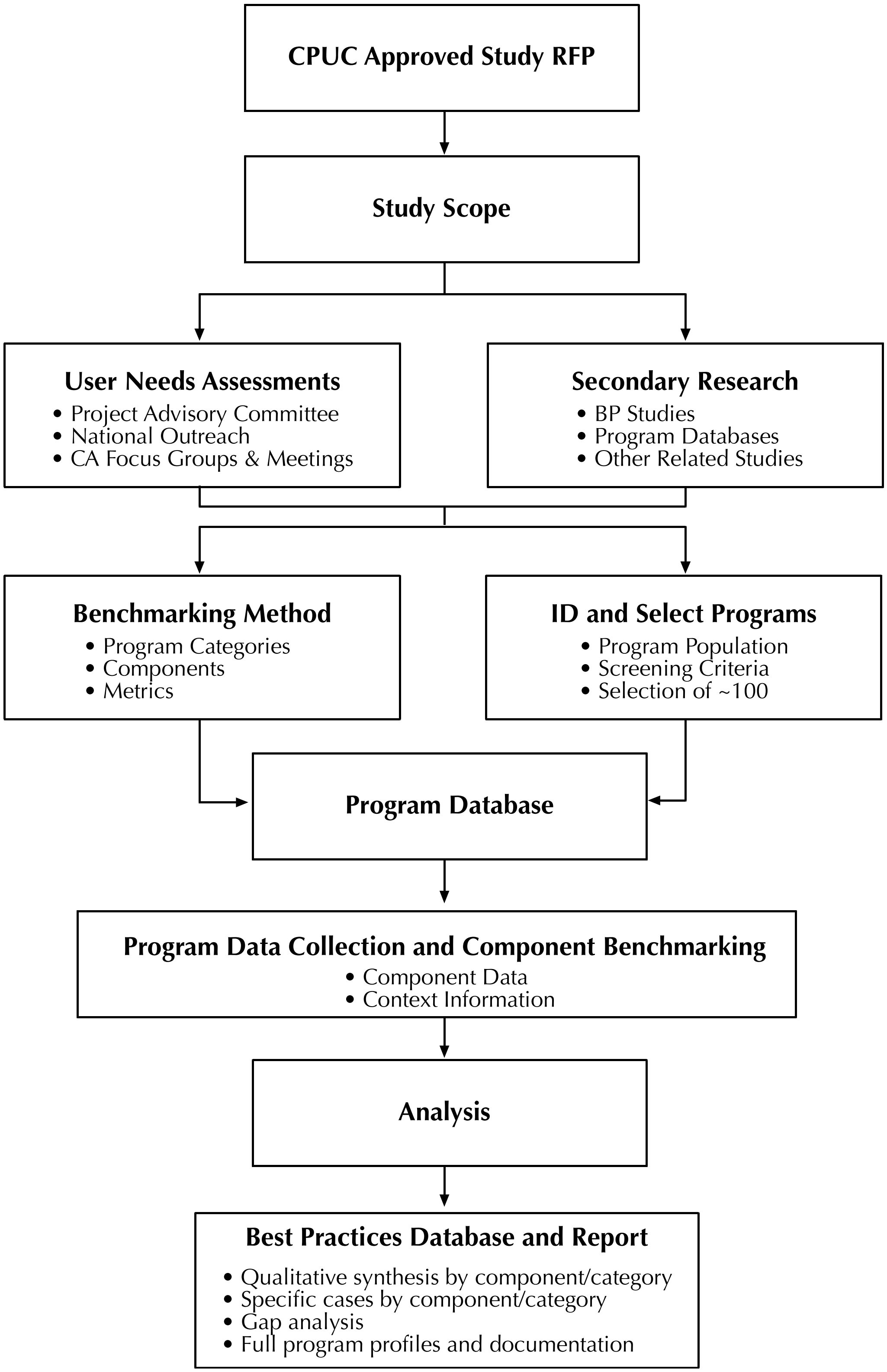
The overall goal of the Best Practices Study is to develop and implement a method to identify and communicate excellent energy efficiency program practices nationwide in order to enhance the design of such programs in California. In particular, program implementers supported through public goods funds are encouraged to use the Best Practices Study's products, along with other resources and their own knowledge and experience, to develop and refine energy efficiency programs.

The Best Practices Study is intended as a first-order effort to identify successful program approaches through systematic cross-program data collection and comparative analyses. It is not intended to produce a census of best practices across all types of programs. Such an approach would be neither practical nor useful given the number of programs that exist; the many differences in policies, goals, and market conditions around the country; the unique needs and market conditions in California; and the importance of encouraging innovation, which by its nature sometimes requires attempting approaches that are not yet proven. If the framework and results of the Best Practices Study prove useful, future phases of the work can expand the number and types of programs covered.

METHODOLOGY

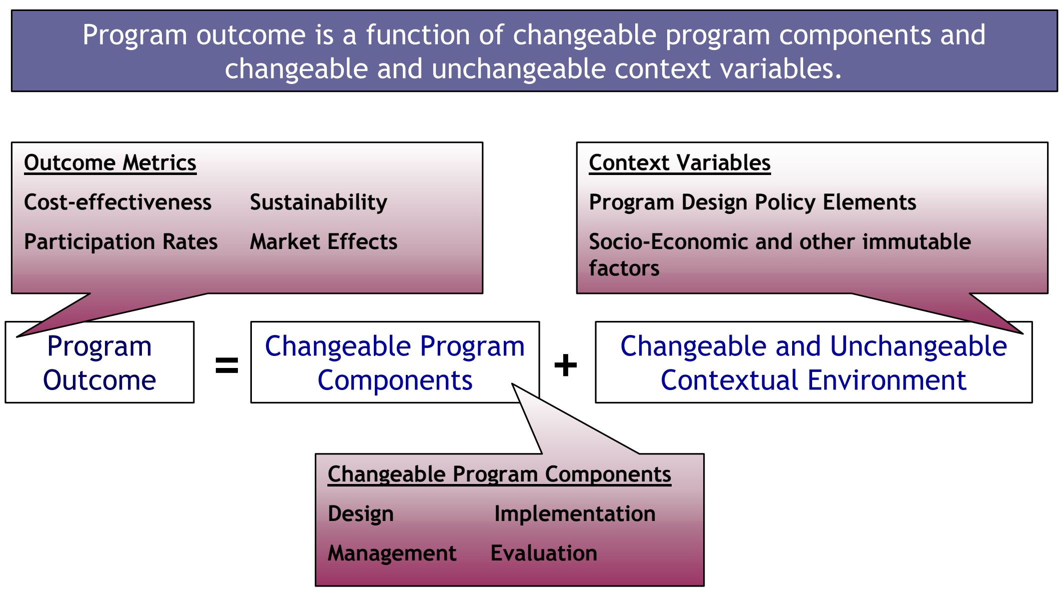
Key aspects of the Best Practices Study include a user needs assessment, secondary research, development of the benchmarking methods, identification and selection of programs to benchmark, development of the program database, data collection and program benchmarking, analysis, and preparation of the best practices report and final database. In addition, outcome metrics will be tracked. An overview of the Best Practices Study key activities is shown in Exhibit R7-10 below.

Exhibit R7-10
Overview of Energy Efficiency Best Practices Study



As shown below in Exhibit R7-11, the outcome of a program – as measured by $ per kWh saved, market penetration or sustainability – can be thought to be a function of changeable program elements, changeable portfolio-level design and programmatic policy decisions, and unchangeable social, economic, demographic, climate, and other factors. All of these factors can influence the ultimate success of an energy efficiency program. Some program elements (such as marketing, tracking or customer service) are directly controllable at the program level and can be modified to affect the success of the program. Other elements (such as the program policy objectives and whether the program has a single- or multi-year funding commitment) may not be changeable at the program level but may be changeable at a policy level. Other elements (such as the physical climate or density of the customer base) are not changeable and cannot be affected by program managers, implementers, or policy-makers.

Exhibit R7-11
Relationship Among Program Outcomes, Components, and Context



PROGRAM CATEGORIES

A program category is defined for the Best Practices Study as the basis for grouping "like" programs to compare across components and sub-components. Program categories may be defined in any number of ways, for example, as a function of target market (e.g., sector, vintage, segment, end use, value chain, urban/rural); approach (e.g., information-focused, incentive-focused [prescriptive; custom/performance based]); objective (e.g., resource acquisition, market transformation, equity), and geographic scope (e.g., local, utility service territory, state, region, nation); among other possible dimensions.

A number of criteria a good program categorization strategy should address were identified and include user accessibility, benchmarking compatibility, potential, compatibility with policy guidelines, and compatibility with scope directives. The number of program categories was limited to approximately 17 to conform to resource constraints. These are shown in Exhibit R7-12 below. The final scheme separates residential from non-residential programs, and distinguishes between incentive programs, information and training programs and new construction programs. Programs are also segregated based on targeted end-use and customer type. A Crosscutting section is included to address comprehensive programs that do not cleanly fall within the other 16 categories. Each program category has an associated code, which is used throughout the Best Practices Study for identification purposes (e.g., R7 Programs = Residential Audit R7 Programs for the Best Practices Study).

Exhibit R7-12
Program Categories & Related Codes

<table>
<tr><th colspan="3">Program Category</th><th>Code</th></tr>
<tr><td rowspan="8">Residential</td><td rowspan="5">Incentives</td><td>Lighting</td><td>R1</td></tr>
<tr><td>Air Conditioning</td><td>R2</td></tr>
<tr><td>Appliance and Plug Load</td><td>R3</td></tr>
<tr><td>Single-Family Comprehensive</td><td>R4</td></tr>
<tr><td>Multi-Family Comprehensive</td><td>R5</td></tr>
<tr><td rowspan="2">Information & Training</td><td>Whole House Audit with no/minimal incentive</td><td>R6</td></tr>
<tr><td>General & Other Comprehensive</td><td>R7</td></tr>
<tr><td colspan="2">New Construction Information & Incentives</td><td>R8</td></tr>
<tr><td rowspan="8">Non-Residential</td><td rowspan="5">Incentives</td><td>Lighting</td><td>NR1</td></tr>
<tr><td>HVAC</td><td>NR2</td></tr>
<tr><td>Refrigeration, Motors, Compressed Air, Process</td><td>NR3</td></tr>
<tr><td>Small Comprehensive</td><td>NR4</td></tr>
<tr><td>Large Comprehensive</td><td>NR5</td></tr>
<tr><td rowspan="2">Information & Training</td><td>End-Users</td><td>NR6</td></tr>
<tr><td>Trade Allies</td><td>NR7</td></tr>
<tr><td colspan="2">New Construction Information & Incentives</td><td>NR8</td></tr>
<tr><td>Other</td><td colspan="2">Cross Cutting</td><td>O1</td></tr>
</table>

PROGRAM SELECTION

Programs for each of the program categories in the Best Practices Study were selected through a three step process. First, programs were nominated using recent best practice studies, team member recommendations. Next programs were randomly selected from published data on energy programs to complete the roster. The third step involved conducting outreach interviews with the staff of nominated programs to determine if sufficient information was available to conduct the research. With the final set of programs determined, in-depth interviews were conducted.

PROGRAM COMPONENTS

The Best Practices Study approach focuses on analyzing programs primarily from the perspective of their changeable program characteristics. The Best Practices Team developed a method for breaking programs down into components and sub-components in order to systematically identify and compare specific program features of importance to overall program success. The four primary program components are program design, program management, program implementation, and program evaluation. These components and their associated sub-components are briefly summarized below.

- **Program Design** provides the initial foundation for a successful program. The program design category has two sub-components: **program theory** and **program structure** (which includes policies and procedures). Good program design begins with good program theory and a complete understanding of the marketplace. Good program structure, policies and procedures are necessary to translate program design theories and goals into practical and effective management and implementation actions.

- **Program Management** is the command and control center that drives the implementation process, and may be broken down into the sub-components of **project management**, **reporting and tracking**, and **quality control and verification**. Project management includes the structure and relationship among responsible parties. Reporting and tracking focuses on approaches to identifying and tracking useful and appropriate metrics that can be translated efficiently into reporting effective information. Quality control and verification includes accountability and improvement processes that are typically carried out through implementation and evaluation activities.

- **Program Implementation** is defined by the actual activities carried out in the marketplace to increase adoption of energy efficiency products and practices. Its sub-components include **outreach, marketing, and advertising**, the **participation process**, and **installation and incentive** mechanisms. Good outreach, marketing and advertising efforts should result in relatively high program awareness, knowledge of program specifics, and participation levels. The participation process is a critically important element of a program's ultimate success. Standard measures of market penetration and customer satisfaction provide one indication of a program's effectiveness at enrolling customers and processing their applications. Installation and incentives should demonstrate evidence of installation and delivery follow-through on marketing and outreach efforts.

- **Evaluation and Adaptability** of programs should also be analyzed. The Best Practices Study assesses the adequacy of evaluation efforts and how programs use evaluation results or other feedback mechanisms to improve over time.

DATA COLLECTION

Program information was gathered using primary and secondary sources. Primary data was collected largely through surveys of program managers and review of regulatory filings, annual reports, and program evaluations. The Best Practices Team conducted extensive interviews with program managers using a detailed survey instrument to guide the conversations. The survey instrument collected information on three main areas: policy context and environment, outcome metrics, and information about program components. The first set of questions elicited responses on how the program might have been affected by the broader context in which it operates. Next, respondents provided information on outcome metrics, such as program impacts and costs. The remainder of the instrument was devoted to collecting detailed program information for each program component. For each component, respondents were asked to provide factual information on how the program addressed each issue and qualitative judgments about what practices they felt contributed to the success of this program and what practices should have been avoided or could be improved.

STRUCTURE OF REPORTING

Complete project results are provided in project reports and a Web site that allows users to access information at varying levels of depth, including top-line summaries by program type or component, stand-alone chapters on best practices by program area, documentation of project methods, and individual program profiles.

DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix D:
Quantum Report: New Construction

BEST PRACTICES BENCHMARKING FOR ENERGY EFFICIENCY PROGRAMS

NATIONAL ENERGY EFFICIENCY BEST PRACTICES STUDY

VOLUME R8 – RESIDENTIAL NEW CONSTRUCTION BEST PRACTICES REPORT

Submitted to

California Best Practices Project Advisory Committee
Kenneth James
Contract Manager
Pacific Gas and Electric Company
P.O. Box 770000, N6G
San Francisco, CA 94177

Submitted by

PRIME CONTRACTOR
QUANTUM CONSULTING INC.
2001 Addison St, Suite 300
Berkeley, CA 94704

Volume R8 Report Contractor – Frontier Associates, LLC

December 2004

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The Best Practices Study team would like to gratefully acknowledge the participation of the following individuals and their organizations in this report:

- Mike Baker, TXU Electric Delivery
- Cece Barros, Pacific Gas and Electric Company
- David Blanke, Sempra Utilities
- Linda Douglas, Tucson Electric Power
- Steve Ellison, TXU Electric Delivery
- Mary Kay Gobris, Pacific Gas and Electric Company
- Pat Haller, Efficiency Vermont (VEIC)
- Richard Morgan, Austin Energy
- Greg Nahn, Wisconsin Energy Conservation Corporation
- Sue Ringhof, Clean Energy for New Jersey
- Michelle Thomas, Southern California Edison Company

These individuals participated in lengthy interviews in which they generously shared their expertise and lessons learned in program design, management, implementation, and evaluation. Without their participation and the support of their organizations this report would not have been possible.

In addition, we thank the many individuals that participated in the user needs focus groups conducted at the outset of the project.

We also thank the members of the Best Practices Study's Project Advisory Committee for their inspiration, insights, tireless review and thoughtful direction throughout the project:

- Kenneth James – Pacific Gas & Electric Company
- Pierre Landry – Southern California Edison Company
- Rob Rubin – Sempra Utilities
- Jay Luboff – California Public Utilities Commission, Energy Division
- Eli Kollman – California Public Utilities Commission, Energy Division
- Sylvia Bender – California Energy Commission

Finally, these reports benefited greatly from the diligent technical editing of Betsy Wilkins and the tireless production efforts of Alex Kang.

CONTACT INFORMATION

Kenneth James
Best Practices Study Contract Manager
Pacific Gas & Electric Company
P.O. Box 770000,N6G
San Francisco, CA 94177
415-973-0246
klj1@pge.com

Michael W. Rufo
Best Practices Study Prime Contractor Lead
Quantum Consulting Inc.
2001 Addison Street, Suite 300
Berkeley, California 94704
510-540-7200, ext. 2037
mrufo@qcworld.com

Bruce Mast
R8 – Residential New Construction Report Lead
Frontier Associates
610 16th Street, #412
Oakland, CA 94612
510-271-4785
510-271-0880 fax
bmast@frontierassoc.com

ES. EXECUTIVE SUMMARY FOR RESIDENTIAL NEW CONSTRUCTION PROGRAM AREA (R8)

ES.1 INTRODUCTION

This volume presents results of a comparative analysis of residential new construction programs included in the National Energy Efficiency Best Practices Study ("Best Practices Study"). The overall Best Practices Study objectives, scope, and methodology are briefly outlined in Appendix R8A of this report. More details on methods and cross-program findings are provided in separate report volumes.

The Best Practices Study team ("Best Practices Team") reviewed seven residential new construction programs for this program area study ("R8 Programs" and "R8 Study," respectively), each of which has the goal of capturing energy efficiency gains through increased attention to integrated design and overall construction quality. All R8 Programs focused on whole-building performance, though several programs also included technology-specific requirements or incentives.

The R8 Programs are listed in Exhibit R8-E1 below and presented in the body of this report. A discussion of the program selection process is provided in Appendix R8A.

ES.2 KEY CATEGORY THEMES

The R8 Programs all focused on whole-building performance. This focus reflects the fact that new construction presents a unique opportunity to capture energy efficiency gains through increased attention to integrated design and overall construction quality. Once a home is built, further cost-effective energy efficiency opportunities are limited to select technology upgrades, either as retrofits or as part of routine replacement.

Energy efficiency in new construction is a particular challenge to program designers because of the pervasive split incentive barrier (i.e., the party responsible for energy efficiency decisions is not the one who will ultimately reap related benefits). Most homes are built "on-spec" and sold to the eventual resident at or near completion. The home builder has no long-term interest in energy efficiency because he does not pay the energy bills. The occupant has an interest in energy efficiency but lacks a substantive role in the construction process. In principle, the split incentive could be bridged if the home builder were able to recoup the energy efficiency investment in the form of a higher sales price. But the home buyer generally lacks the technical skills to evaluate energy efficiency claims – and value - and must consider them in the context of a number of bundled home attributes that are usually more important to her.

In this context, the R8 Programs all adopted a strong market transformation emphasis, even when quantifying and offering incentives for direct energy impacts for resource acquisition purposes. The market transformation focus led to several program themes that transect program components: private sector support, combined supply-side/demand-side strategy, and program brand equity.

Private Sector Support - Active support from private sector stakeholders and trade allies was essential. Program managers emphasized the role of builders, contractors, and trade associations in designing programs, crafting marketing messages, and selling energy efficiency to home buyers.

Combined Supply-side / Demand-side Strategy - Program staff members worked closely with builders and contractors to improve the quality and availability of energy-efficient homes. They also offered extensive consumer education resources to stimulate market demand and help bridge the split incentive gap. A key component of the demand-side strategy was a high-profile market brand (usually ENERGY STAR®) that allowed home buyers to identify energy-efficient homes without first developing the technical expertise to evaluate builder claims.

Program Brand Equity - Perhaps the most valuable program asset was the credibility of the program's market brand as an indicator of trustworthy and accurate information. The need to develop and protect brand equity drove project documentation requirements, the site inspection process, quality-control measures at all phases of program implementation, and impact evaluation objectives.

ES.3 BEST PRACTICES SUMMARY

Best practices are identified in the R8 Study for each of the four major program components used to organize data collection and analysis. These program components are Program Design (including program theory), Program Management (including project management, reporting and tracking, and quality control and verification), Program Implementation (including participation process and marketing and outreach) and Program Evaluation. Best practices were developed by analyzing information across programs developed from detailed interviews of program managers and thorough review of all relevant secondary sources such as program filings and evaluations. Exhibit R8-E2 presents the list of best practices developed from the analysis of R8 Programs. For this program area, some specific lessons learned around the program participation process were also identified. These lessons are provided in Exhibit R8-E3. Exhibit R8-E4 provides the rationales associated with each best practice. The remainder of this report provides detailed analysis and discussion of program features and best practice rationales.

The scope of this study also includes a California gap analysis. A comparison of the best practices presented in this report with the practices employed in California's Statewide Residential New Construction Program is in progress and will be published when complete in a separate document.

Exhibit R8-E1
R8 Programs: Residential New Construction Programs Reviewed For R8 Study

Program Name	Implementer/s	Abbreviation for R8 Report
2001-2002 Austin Green Building Program	Austin Energy	Austin Green Building
2002 California ENERGY STAR New Homes Program	Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas Company (SCG), and San Diego Gas & Electric Company (SDG&E)	CA ENERGY STAR New Homes
2002 New Jersey ENERGY STAR Homes	Clean Energy for New Jersey	NJ ENERGY STAR Homes
2002 Texas ENERGY STAR Homes Program	Oncor	TX ENERGY STAR Homes
2002 Tucson Guarantee Home Program	Tucson Electric Power	Tucson Guarantee Home
2001 Vermont ENERGY STAR Homes	Efficiency Vermont	VT ENERGY STAR Homes
2001-2002 Wisconsin ENERGY STAR Program	Wisconsin Energy Conservation Corporation (WECC)	WI ENERGY STAR

Exhibit R8-E2
Summary List of Best Practices for Residential New Construction Programs

Program Theory and Design
• Have a well-articulated theory or program logic • Link program tactics to the stated theory • Plan thoroughly • Involve multiple stakeholders • Build feedback loops into the program design • Maintain program design flexibility • Understand local market conditions • Use targeted incentives • Focus first on developing supply-side capacity • Do not over-promise results
Program Management: Project Management
• Include stakeholders in developing a program process or operational plan • Put the process plan in writing • Keep management teams small • Maintain good staff morale • Make sure at least some of the institutional memory resides in-house, not with subcontractors • Avoid giving a single contractor exclusive responsibility for program implementation • Provide staff with good training that matches skill needs • Reward high performing staff and link performance evaluations to tangible measures which are known in advance and developed together jointly by the manager and employee • Match staff decision-making authority to responsibilities and delegate responsibility and authority to avoid institutionalized bottlenecks • Get upper management buy-in
Program Management: Reporting and Tracking
• Define and identify the key information needed to track and report early in the program development process • Minimize duplicative data entry; link databases to exchange information dynamically • Track market transformation program qualitative benefits and measures related to spillover effects, along with direct savings impacts • Develop accurate algorithms and assumptions on which to base estimates of savings • Design databases to be scalable to accommodate changes in program scope • Use the Internet to facilitate data entry and reporting • Automate routine functions such as monthly reports • Build in rigorous quality control screens for data entry • Document the tracking system carefully

Program Management: Quality Control and Verification
• Treat inspection visits as partnership-building & learning events rather than just regulatory enforcement activities • Require builder or builder's representative to be on-site during inspection • Plan to rely on third-party inspectors for quality control over the long-term • Encourage home inspectors to organize their own professional organization • Provide timely feedback to builders, home inspectors, and other parties • Ensure that inspectors have plenty of hands-on construction experience • Establish a streamlined inspection scheduling process • Recognize the different inspection needs of experienced builders and builders who are new to the program • Host pre-construction meetings with the builder, key subcontractors, and suppliers to review project specifications and program requirements
Program Implementation: Participation Process
• Establish a robust program brand to differentiate energy-efficient homes from conventional homes • Offer assistance in preparing and submitting program applications • Minimize documentation requirements that would entail preparing new documents not already developed in the course of project permitting • Use targeted incentives • Link incentives to building performance requirements • Establish minimum requirements for builders • Build strategic alliances with equipment manufacturers and encourage them to add their own incentives • Target measure incentives to home buyers to encourage them to ask for the higher efficiency equipment • Solicit home inspector input when developing ethics guideline and customer service standards • Encourage home inspectors to take over training functions • Develop a technical and procedural manual for builders • Avoid vague or inconsistent technical standards that do not take into account broader building performance implications • Offer a bill guarantee • Extend program construction standards beyond energy features
Program Implementation: Marketing and Outreach
• Market to multiple departments within volume builder organizations • Take information to builders – use a "push" rather than "pull" marketing approach • Know your target consumer demographic, tailor your message to the audience and develop effective cross-marketing strategies • Combine point-of-sale marketing via builder sales agents with direct marketing to home buyers • Give builders an opportunity to participate in developing marketing messages
Program Evaluation
• Support program review and assessment at the most comprehensive level possible • Ensure that evaluation metrics are in-line with program goals • Clearly explain evaluation roles and responsibilities to participants in advance • Select an evaluator who has a detailed understanding of the market context in which a program operates • Allow for plenty of interaction between evaluators and implementation staff • Ensure the clarity of the evaluation document • Periodically review and update market-level information about construction practices and energy efficiency measure adoption • Periodically review and update algorithms for calculating project savings

Exhibit R8-E3
Residential New Construction Programs Lessons Learned – Participation Tactics

Participation Tactic	Lessons Learned
Financial Incentives	• Useful for overcoming builder resistance but not absolutely required • Most useful for off-setting financial impacts of inspection requirements • More mature programs can reduce incentive levels, based on demonstrated market value of homes built and certified to program standards
Program Membership	• Builder participation is key • Participation from architects and contractors also useful
Membership Requirements	• Require builder to sign ENERGY STAR Partnership Agreement or other pledge to build to program standards • On-going training requirements for builders, architects, and contractors add value
Design Review	• Offer design assistance to help builders trouble-shoot problematic designs and improve overall home performance at a stage where changes are still cost-effective • Assist with building energy simulations, life cycle cost analysis, Manual J calculations
On-site Inspections	• Inspect mechanical rough-in and final for sampled projects • Design sampling protocol to ease inspection burden on experienced builders with demonstrated track record of performance • Include performance tests, i.e., duct test, pressure test, blower door test
Cooperative Advertising	• Promote program builders by name • Solicit builder input on marketing messages and strategy • Train builder's sales staff
Certification Requirements	• Home certification and labeling is essential for overcoming split incentives and asymmetric information barriers • Certification requires clear-cut inspection process to protect program credibility and brand equity
Technical Assistance	• Offer regular training opportunities • Encourage rates to offer technical assistance as part of inspections, i.e., emphasize role as builder's ally rather than rule enforcer • Engage raters in providing training courses for builders, contractors, architects
Bill Guarantee	• Utility's performance guarantee is effective at overcoming home buyer's uncertainty about expected performance • Bill guarantee provides builder with additional marketing tool, thus creating additional incentive to undergo inspections, document HVAC sizing calculations, and other program requirements • Properly structured bill guarantee creates minimal financial risk for utility

Exhibit R8-E4
Summary of Best Practices Rationales for Residential New Construction Programs

Best Practice	Rationale
Program Theory and Design	
Have a well-articulated theory or program logic	Helps identify any gaps in program focus or effort and assures that everyone involved understands program objectives.
Link program tactics to the stated theory	Assures that programs are fundable, feasible, and capable of being evaluated.
Plan thoroughly	A detailed, well thought-out plan is easier to present and explain to potential critics.
Involve multiple stakeholders	Include potential program beneficiaries, trade allies, and regulators / policy makers to get their buy-in and support.
Build feedback loops into the program design	Assures that stakeholders continue to provide input throughout program implementation.
Maintain program design flexibility	Program must be able to respond to changing market conditions and address unforeseen challenges throughout program implementation.
Understand local market conditions	Important for recognizing which lessons from other areas transfer to the local market and which ones do not; objective baseline market research bolsters design credibility.
Use targeted incentives	Help establish the program's credibility in the minds of private-sector market actors who may be reluctant to be the first to try something new.
Focus first on developing supply-side capacity	Program credibility will be undermined if program promises something to consumers it cannot deliver.
Do not over-promise results	Overly optimistic promises may attract more interest early on but they set the stage for disappointment later.

Best Practice	Rationale
Program Management: Project Management	
Include stakeholders in developing a program process or operational plan	Bolster the plan's credibility, produce a plan that reflects local market conditions, and address needs of stakeholders with divergent viewpoints.
Put the process plan in writing	A written plan is more likely to be a well thought-out plan and is easier to disseminate to the various affected stakeholders.
Keep management teams small	Small teams allow for maintaining close coordination, facilitating good communication, and increasing the likelihood of reaching consensus.
Maintain good staff morale	Ensure staffing stability and develop long-term institutional memory.
Make sure at least some of the institutional memory resides in-house, not with subcontractors	Avoid exclusive reliance on subcontractors for advice on key policy issues.
Avoid giving a single contractor exclusive responsibility for program implementation	Stimulate competition, provide a basis for accountability, and build in redundancy in the event any one contractor fails to perform.
Provide staff with good training that matches skill needs	Program services will only be as good as the people who deliver them. Human resources are as important to program success as financial resources.
Reward high performing staff and link performance evaluations to tangible measures which are known in advance and developed together jointly by the manager and employee	Staff will perform better when they clearly understand what is expected of them and they agree that the expectations are reasonable.
Match staff decision-making authority to responsibilities and delegate responsibility and authority to avoid institutionalized bottlenecks	Prerequisite for performance expectations that are perceived as reasonable.
Get upper management buy-in	Residential new construction programs require several years to generate tangible impacts. Upper management must embark on the process with patience, reasonable expectations, and a commitment to fund the entire start-up phase

Best Practice	Rationale
Program Management: Reporting and Tracking	
Define and identify the key information needed to track and report early in the program development process	Clearly articulated data requirements enhance the prospects that those requirements will be met.
Minimize duplicative data entry; link databases to exchange information dynamically	Minimize redundant data entry efforts, reduce inconsistencies.
Track market transformation program qualitative benefits and measures related to spillover effects, along with direct savings impacts	If program rationale is to generate market effects, those effects must be tracked to determine program success.
Develop accurate algorithms and assumptions on which to base estimates of savings	Help set reasonable expectations and avoid the temptation to oversell program benefits.
Design databases to be scalable to accommodate changes in program scope	Enhance the program's overall flexibility and ability to respond to unforeseen market conditions.
Use the Internet to facilitate data entry and reporting	Enhance the quality and cost-effectiveness of information management; help minimize duplicative data entry and storage and automate many routine quality-control steps.
Automate routine functions such as monthly reports	Build in quality control checks and free up staff time for more strategically important tasks.
Build in rigorous quality control screens for data entry	Minimize the extent of subsequent data cleaning and enhance the accuracy and credibility of reported results.
Document the tracking system carefully	Help mitigate problems stemming from staff turnover, especially when the system must serve a variety of users with varying computer skill levels.
Program Management: Quality Control and Verification	
Treat inspection visits as partnership-building and learning events rather than just regulatory enforcement activities	Rater should be builders' ally for quality control.

Best Practice	Rationale
Require builder or builder's representative to be on-site during inspection	Demonstrate the value of the inspection and reinforce the notion of the inspection as a training/education opportunity rather than program enforcement.
Plan to rely on third-party inspectors for quality control over the long-term	Builder self-certification provides too many opportunities for abuses that undermine brand equity and consumer confidence in program claims.
Encourage home inspectors to organize their own professional organization	Harness market forces to provide monitoring and quality control.
Conduct follow-up inspections of selected project	Provide quality control of rater's results and assess the program's influence on the project.
Provide timely feedback to builders, home inspectors, and other parties	Respect builder and contractor time constraints; capture one-time opportunities for positive program impacts.
Ensure that inspectors have plenty of hands-on construction experience	Essential if raters are to fill role of teachers and mentors
Establish a streamlined inspection scheduling process	Avoid imposing hidden costs on program participants in the form of project delays.
Recognize the different inspection needs of experienced builders and builders who are new to the program.	Newer builders need more attention to master the details of quality construction.
Host pre-construction meetings with the builder, key subcontractors, and suppliers to review project specifications and program requirements	Establish clear communication with the builder and demonstrate the importance of good planning.
Establish a robust program brand to differentiate energy-efficient homes from conventional homes.	Brands help capture the market value of energy efficiency and permit home buyers to identify more energy-efficient homes without mastering the technical details of home construction practices.
Offer assistance in preparing and submitting program applications	The level of documentation required to demonstrate whole-building performance can be significant. Minimize barriers to participation.
Minimize documentation requirements that would entail preparing new documents not already developed in the course of project permitting	Help minimize the administrative burden associated with program participation.

Best Practice	Rationale
Use targeted incentives	Help establish the program's credibility in the minds of private-sector market actors who may be reluctant to be the first to try something new.
Link incentives to building performance requirements	Performance-based incentives provide more project design flexibility than prescriptive incentives.
Establish minimum requirements for builders	Protect and enhance program's market reputation as a trustworthy arbiter of quality and energy efficiency.
Target measure incentives to home buyers to encourage them to ask for the higher efficiency equipment	Leverage existing market forces to enhance and extend program effectiveness.
Solicit home inspector input when developing ethics guideline and customer service standards	Particularly useful for technology choices that are frequently left to the buyer, such as light fixtures and appliances.
Encourage home inspectors to take over training functions	Produce guidelines that will be respected and followed rather than ignored.
Develop a technical and procedural manual for builders	Create opportunities for professional advancement as a rater, capitalize on raters' field experience.
Avoid vague or inconsistent technical standards that do not take into account broader building performance implications	Make participation straightforward, routine, and predictable; reduce the degree of "hand-holding" program staff must provide.
Avoid vague or inconsistent technical standards that do not take into account broader building performance implications.	Standards should include clearly defined metrics that are closely aligned with program goals.
Offer a bill guarantee	Could be a low-cost strategy for enhancing credibility of program benefit claims.
Extend program construction standards beyond energy features	Coupling energy efficiency with other desirable building attributes can enhance program appeal. Limit claims to those that can be supported by building science and cost-effective increases in consumer demand.

Best Practice	Rationale
Program Implementation Marketing & Outreach	
Market to multiple departments within volume builder organizations	Each department has an important role in the project. Lack of buy-in from any one department can undermine the effectiveness of other department efforts.
Take information to builders – use a "push" rather than "pull" marketing approach	Cannot wait for builders to come to you because they won't.
Know your target consumer demographic, tailor your message to the audience and develop effective cross-marketing strategies	Customer demographics vary widely by region and one-size does not fit all as a marketing strategy.
Combine point-of-sale marketing via builder sales agents with direct marketing to home buyers	Builders need to be convinced that improved energy efficiency can translate into added value at the point of sale.
Give builders an opportunity to participate in developing marketing messages	Take advantage of builders' accumulated marketing experience.
Program Evaluation	
Support program review and assessment at the most comprehensive level possible	Gain the most detailed understanding of program cause and effect that available resources and reporting requirements will support.
Ensure that evaluation metrics are in-line with program goals	The only way to assess program progress toward achieving predetermined goals is to establish metrics that measure that progress.
Clearly explain evaluation roles and responsibilities to participants in advance	Avoid later confusion from having multiple parties contacting the participant for similar information.
Select an evaluator who has a detailed understanding of the market context in which a program operates	Enhance the value of evaluation findings for improving program delivery.
Allow for plenty of interaction between evaluators and implementation staff	Direct interaction gives the evaluator a clear understanding of program dynamics. Clear communication channels are essential.

Best Practice	Rationale
Ensure the clarity of the evaluation document	Clearly describing program goals, strategies and lessons learned ensures that program staff, stakeholders and other interested parties may gain a good understanding of the program.
Periodically review and update market-level information about construction practices and energy efficiency measure adoption	Program design must reflect current market conditions. Program resources should not be expended to promote technologies and practices that are already widely adopted or standard industry practices.
Periodically review and update algorithms for calculating project savings	Savings algorithms should be reasonably calibrated with real-world building performance, which changes over time as construction practices and available technologies change.

1. OVERVIEW OF REVIEWED PROGRAMS

Although based in areas across the United States, all the R8 Programs focused on increasing the energy efficiency of residential new construction projects and were consistent in their emphasis on whole-house building science and quality construction. Several programs also included technology-specific requirements or incentives. All R8 Programs also relied on one or more site inspections during the construction process to verify building construction quality and provide feedback to the builder on opportunities for improvement. Five of the seven R8 Programs incorporated the EPA's ENERGY STAR® brand into their marketing and outreach strategy and a sixth program incorporated ENERGY STAR standards into its performance criteria.

ENERGY STAR-qualified homes are third-party verified to be at least 30 percent more energy efficient than homes built to the 1993 national Model Energy Code or 15 percent more efficient than state energy code, whichever is more rigorous. Builders who participate in the ENERGY STAR programs must also sign a partnership agreement with the EPA. As part of that agreement, builders commit to qualifying at least one ENERGY STAR-labeled home within any on-going 12-month period. Builders must also label all homes that are independently verified to meet the ENERGY STAR performance guidelines. Participating programs and builders are authorized to use the ENERGY STAR logo in the marketing and outreach campaigns, subject to the EPA's logo use guidelines.

The EPA requires a third-party verification process to prevent abuse of the ENERGY STAR label (i.e., the labeling of homes that do not meet the performance standard). The EPA has also established a minimum requirement sampling protocol that allows third-party verifiers to randomly test and inspect a minimum of 15 percent of a group of participating homes located within the same climate region (typically the same subdivision). Several R8 Programs implemented more stringent sampling policies.

Brief overviews of the R8 Programs follow.

The 2001-2002 Austin Green Building Program implemented by Austin Energy (Austin Green Building), the local municipal utility, was *not* structured around ENERGY STAR. Rather, it employed a membership structure requiring participating builders and architects to make a commitment to build "green" in order to join. The program also provided associate memberships for manufacturers, suppliers, and real estate agents who were associated with green building techniques and materials. Austin Green Building rated members built and designed new homes and remodels in the Austin Energy service area using "green" guidelines on a scale of one to five stars: the more stars the more green features in the home. Homes were rated in five areas: energy efficiency, water efficiency, materials efficiency, health and safety, and community.

In addition to new home ratings, member services included consultation services, marketing support, listing in the directory of Green Building professionals, and monthly training seminars. The program also co-sponsored the annual Cool House Tour with the Texas Solar Energy Society and made presentations to interested community groups. Austin Green Building also offered a variety of information resources to members and the general public including the

Sustainable Building Sourcebook, Green Building Newsletter, Green Home Buyers Checklist, and BEST Case Studies. In 2001–2002, the program rated almost 400 homes (21 percent market share) and provided code enforcement for 1,849 single family and 3,863 multi-family units.

The 2002 California ENERGY STAR New Homes Program (CA ENERGY STAR New Homes) was implemented by the four largest investor-owned utilities (IOUs) in California: Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas Company (SCG), and San Diego Gas & Electric Company (SDG&E). This ENERGY STAR-affiliated program was designed to encourage single-family and multi-family builders to construct homes that exceeded California's energy standards by at least 15 percent through a combination of financial incentives, design assistance, and education. Program requirements addressed overall building energy performance, AC efficiency, furnace efficiency, AC sizing, window performance, and duct design. The program design emphasized consistency across utility service territories by using identical program applications, incentive amounts and eligibility requirements. In 2002, the California utilities certified 20,515 new homes as ENERGY STAR Homes, which represented a 12.8 percent market share.

The 2002 New Jersey ENERGY STAR Homes Program (NJ ENERGY STAR Homes) implemented by the New Jersey Clean Energy Program was also affiliated with the ENERGY STAR program. To receive certification as a New Jersey ENERGY STAR Home, a home had to score 86 out of a possible 100 points on the Home Energy Rating System (HERS), equivalent to 30 percent better building performance than the Model Energy Code. In addition to the basic ENERGY STAR requirements, there were specific program requirements for central air conditioners and/or heat pumps (when installed), ducts (when installed) and house air sealing.

In order to ensure a home met program requirements, a utility representative worked with the builder to select the appropriate mix of energy-efficiency upgrades and to ensure proper building practices were followed. In addition, the utility provided technical advice during construction visits and performed a final rating after the home was completed to check all systems and certify the home as an ENERGY STAR Home. In 2002, 1,828 homes were certified through the program, with an average estimated impact of 1,784 kWh and 1.87 kW per home. The 1,828 homes certified in 2002 represented a market share of approximately 6 percent. In addition, 10,633 new homes were committed for future certification.

The 2002 Texas ENERGY STAR Homes Program (TX ENERGY STAR Homes) implemented by Oncor was also affiliated with the EPA initiative to encourage builders to produce ENERGY STAR-rated single-family homes. The program budget included incentives to builders, marketing, advertising, training and support for HERS raters, and measurement and verification. No direct incentives were provided to end-users (i.e., home owners). In 2002, 6,500 homes were built through the program, with an average impact of 3,800 kWh and 1.14 kW per home. The 6,500 homes built in 2002 represented a market share of approximately 17 percent.

The 2002 Tucson Guarantee Home Program (Tucson Home Guarantee) implemented by Tucson Electric Power (TEP) was a residential new construction program that guaranteed heating and cooling costs and comfort for five years. Program policy stipulated that if the annual cost exceeds the specified cost, the homeowner receives a refund for 100 percent of the exceeded costs. Homeowners also received a guarantee that the utility would install an alternate heating source if the customer was not satisfied with the electric heat pump. Each Guarantee Home customer received a reduced electric rate that ranged from 12 to 22 percent lower than the standard residential electric rate. Guarantee Homes exceeded ENERGY STAR requirements and received ENERGY STAR certification from EPA. TEP also offered builders on-site training and technical assistance from design to completion. Participation rates for Tucson Guarantee Home and its predecessor programs have increased significantly each year since 1977. There were 5590 participating homes through December 2002. During 2002, 2047 new homes were added representing 32 percent of all new homes permitted in the area. The average demand impact was 2.6 KW reduction per home and the average energy impact was 1,477 kWh reduction per home during the cooling months.

The 2001 Vermont ENERGY STAR Homes Program (VT ENERGY STAR Homes) implemented by Efficiency Vermont was also affiliated with EPA's nationwide initiative. As in New Jersey, participating home builders agreed to build to program energy efficiency standards and have their homes inspected by a HERS rater. The home had to score 86+ on the HERS inspection and include four energy-efficient light fixtures, power-vented or sealed combustion equipment, and an efficient mechanical ventilation system with automatic controls. In 2001, 85 builders participated in the program (15 percent of the estimated total). The program certified 196 homes, representing a 7.5 percent market share.

The 2001-2002 Wisconsin ENERGY STAR Program (WI ENERGY STAR) implemented by Wisconsin Energy Conservation Corporation was a voluntary participation program affiliated with ENERGY STAR. The program helped home builders construct healthy, safe and more durable energy-efficient homes through a process of education, training, technical assistance, and performance testing. In order to convince builders to build tighter homes, the program addressed builder concerns about potential indoor air quality (IAQ) and mold issues associated with tight homes with poor ventilation.

In addition to meeting the national ENERGY STAR Homes program requirements, the Wisconsin program had additional certification requirements that included air tightness, combustion safety, and mechanical ventilation standards. Energy consultants associated with the program conducted three site visits to each house at various stages of construction to verify that the homes met program standards. The consultants also conducted the home energy rating that qualified the home for the national program (rating score of 86 or higher). In 2001–2002, the program certified 612 ENERGY STAR Homes, for a 3.4 percent market share. The program goal was to certify 10 percent of all new homes within five years.

R8 Program summary characteristics are provided in Exhibit R8-1. Additional data and program characteristics are summarized in the remainder of this chapter. Detailed interviews, requesting the same data elements, were conducted with program managers representing each of the R8 Programs. However, not all of the requested data were available or received by the time of this writing. The R8 Study aimed to obtain data for a consistent target program year, selected in consultation with each program manager as the most recent year for which the most complete and representative data were available. While *ex-post* data on actual program expenditures and accomplishments were sought, in some cases only budgeted and planned accomplishments were available at the time of this writing. As a result of the above-listed limitations, not all data fields in Exhibit R8-1 are complete. Issues, limitations, and recommendations associated with data availability and inconsistencies are discussed in detail in other volumes of the Best Practices Study.

Exhibit R8-1
Summary of R8 Program Characteristics

Item	Austin Green Building	CA ENERGY STAR New Homes	NJ ENERGY STAR Homes	TX ENERGY STAR Homes	Tucson Guarantee Home	VT ENERGY STAR Homes	WI ENERGY STAR
Period Reviewed	FY 2000-2001	2002	2002	2002	2002	2001	2002-2003
Context	10+ years of program operation	Statewide ENERGY STAR program since 2002; builds on 12+ years of utility programs	2^{nd} year of program operation	Part of program portfolio mandated by SB 7 (1999)	Mature program; mostly funded by shareholders since 2000	Full-scale implementation since 2000; builds on prior program by Vermontwise Energy Services	In 4^{th} year of 5-year market transformation strategy
Program Budget ($000)	$605	$15,248	$10,945	$5,150	$3,010	$920	$2,870
Total Incentives Paid ($000)	$0	$10,089	$4,430	$4,000	$1,399	$321	$781
Eligible Participants	5,712 Homes	159,573 Units[1]	30,000 Homes	38,000 Homes	6,324 Homes	560 Builders; 1,711 Projects	Unknown
Gross MWh achieved	7,666[2]	10,655	3,262	24,700	3,023	841	1,049
Gross KW achieved	3,630	22,262	3,415	7,410	4,094	278	247
Unique Participants	5,712[3]	18,003 Units	1,828[4]	6,500	2,047	85 Builders, 622 Projects	883[5]

1 Statewide new home starts

2 92 percent of savings are derived from code enforcement activities

3 Code enforcement for 1,849 single-family units and 3,863 multi-family units. Also includes Green Building ratings for 396 units.

4 Reflects only certified homes. New commitments total 10,633.

5 Does not include over 575 participants at Smarter Buildings Smarter Business conference

2. CONTEXT

2.1 POLICY ENVIRONMENT

The R8 Programs incorporated a mixture of resource acquisition (achieving a certain level of kWh savings) and market transformation (marketing and other activities designed to permanently change the market for energy-efficient new homes) approaches. These programs were an outgrowth of new construction initiatives that extend back nearly 20 years.

In many locations, energy efficiency programs emerged largely in response to the energy price spikes of the late 1980s and pressure on utilities from consumer groups and regulators to acquire low cost resources through conservation. These early utility-sponsored programs focused almost exclusively on resource acquisition – using conservation activities to reduce the total load on utility resources and lower future costs.

By the mid-1990s residential new construction programs began focusing on market dynamics in an effort to achieve "market transformation" – using supply and demand to encourage permanent changes in the marketplace for energy efficient products. Program designers increasingly focused on two key components: inspections and related technical support to maximize construction quality; and labeling or branding, along with aggressive consumer education to help home buyers identify the energy efficiency attributes of program homes. This effort coincided with EPA efforts to expand the ENERGY STAR brand to residential new construction.

Austin Green Building was considered to be mature, having evolved through more than ten years of predecessor programs. Funding and staffing have doubled in the last five-six years and the market now shows clear evidence of transformation. Local building policies have generally changed in step with market changes. The City of Austin has incorporated additional policies related to land use and urban run-off and some green elements have become basic requirements. Green building is now a basic requirement for affordable housing projects to earn financial incentives from the City. In Austin, the comprehensive focus on green building rather than just energy efficiency is facilitated by the fact that the municipal utility answers to the City Council, which has responsibility for water and waste water service, solid waste, and land use planning functions as well as electric power delivery. Water conservation and open space preservation have been central political issues for several decades and green building gives policy makers the ability to respond to those concerns without taking a dogmatically no-growth stance.

A downturn in the Austin real estate market in 2000 and 2001 created new program challenges. High-end homes stopped selling, making homes under $250,000 a more important part of the overall market. Builders targeting the lower price ranges were less familiar with the local market, green building technologies and techniques, and with the Austin Green Building program.

CA ENERGY STAR New Homes was an outgrowth of utility residential new construction programs that extend back a number of years. California's efforts to influence building energy efficiency during new construction extend back at least to the mid-1970s with the establishment of building energy efficiency standards, commonly referred to as Title 24. Utility programs started in the early 1990s. PG&E launched a new construction incentive program in 1990, initially targeted at promoting higher Seasonal Energy Efficiency Ratio (SEER) air conditioners. The 1993 PG&E program added prescriptive incentives for additional measures and encouraged downsizing air conditioners. The utility's 1995-1999 program placed increasing emphasis on home buyer education. Market transformation emphasis in 1996 ushered in an increased focus on market barriers, especially split incentives, first costs, and home buyers' inability to identify energy-efficient homes. In 2000, the program was further redesigned to address AB 970 and Title 24 changes, which were enacted in response to the energy crisis of that year. The revised program encouraged the use of tight ducts, higher EER AC, condensing furnaces (>90 AFUE), high performance windows, Air Conditioning Contractors of America (ACCA) duct design, thermostatic expansion valves, and radiant barrier roof sheathing. In 2001, California's official demand side management (DSM) policy reverted back to resource acquisition. In 2002, the programs of PG&E, SCE and SDG&E merged into a single statewide program under a CPUC mandate. At that point, the program took on the ENERGY STAR brand. California's energy efficiency standards were made stricter in 2001 and will become even stricter in 2005.

Policy changes in New Jersey have tended to follow those in California. On March 1, 2001, New Jersey's State Board of Public Utilities (BPU) approved a plan to establish consistent, statewide energy efficiency programs. Programs are currently implemented jointly by the investor-owned utilities but long-term program administration structure is being shifted to the BPU, with the utilities having no role. In anticipation of the changeover, the BPU limited all program promotion, marketing, and evaluation. One significant change occurred in 2003: Only units to be constructed in designated "smart-growth" areas will be eligible for program benefits.

Program parameters (e.g., requirements, incentives) have not changed significantly since program inception. Some minor changes were adopted for 2004: requirements for mechanical ventilation and a minimum number of ENERGY STAR lighting fixtures. Promotion and marketing affected the program's outcome. By enlisting the state's number one volume builder with a 100 percent commitment of new projects, the program gained new legitimacy and credibility that drew in other major builders and set an example for builders of all sizes. Also, targeting the affordable housing market effectively established program participation as a standard in that market and became a model for the DOE/HUD partnership established in 2004.

TX ENERGY STAR Homes was part of a portfolio of programs implemented to meet energy efficiency goals mandated in 1999 by SB 7, the act that enabled retail electric competition in Texas. SB 7 called for a reduction in statewide energy consumption by at least ten percent of Oncor's annual growth in demand by 2004. The goal was to be achieved through market-based standard offer programs and limited market transformation programs. Energy efficiency in Texas got a further boost in 2001 from SB 5, which mandated energy efficiency to reduce air pollution in areas the EPA has designated as "non-attainment" for air quality. The success of TX ENERGY STAR Homes has been attributed, in part, to the stock market fall and to lower interest rates, which spurred new home construction and contributed to higher participation levels.

Tucson Guarantee Home and its predecessor programs were affected by a number of changes in policy, funding, and marketing. In 2000, the Arizona Corporation Commission instituted Renewable Portfolio Standards for Arizona. Most DSM dollars were transferred to this initiative, leaving very little available DSM funding for programs like the predecessors of Tucson Guarantee Home. TEP made the decision to continue the program, using primarily shareholder funds. As a consequence, shareholder rate of return was an important criterion for continued program funding.

Program design was also influenced by continuing competition with the gas utility, both in the marketplace and in the regulatory arena. Arizona's utility deregulation bill required builders to pay to install gas lines in all homes regardless of whether they chose to use gas services. TEP established a special three-tier electric rate for customers participating in Tucson Home Guarantee and required installation of electric water heaters and electric heat pumps to qualify for it. Because of the popularity of the rate election in TEP Guarantee homes, the local gas company decided in 2003 to refuse installation of gas service in any subdivision that participated in the program.

In Vermont, efficiency programs are implemented by an "efficiency utility" run by the nonprofit Vermont Energy Investment Corporation (VEIC), which is regulated by the Vermont Public Service Board. VT ENERGY STAR Homes was in the early stages of full-scale implementation, with its immediate predecessor having begun operation in March, 2000. Another residential new construction program operated for about two years prior and was implemented by the contractor Vermontwise Energy Services of Rochester, Vermont. In January, 2002, VT ENERGY STAR Homes was merged with Vermont Gas Systems' HomeBase program, with a six-month transition period. At the same time, the program's incentive structure was reduced from two-tier to single-tier.

Vermont differs from some jurisdictions in that most municipalities do not conduct health and safety inspections of new homes, nor do they issue occupancy permits. Vermont's energy standards do not include an inspection/enforcement component. Rather, builders self-certify compliance. An important program objective, then, was to get builders to meet and exceed energy standards.

Wisconsin's statewide energy efficiency program, Focus on Energy, contracted with Wisconsin Energy Conservation Corporation (WECC) to run the Wisconsin ENERGY STAR residential new construction program. The program was envisioned as a five-year market transformation process encouraging builders to supply and consumers to demand energy-efficient homes without subsidies. After three years, the program has been able to reduce incentives for site visits twice and has made significant inroads with state Home Builders Association. (The R8 Study examines the 2001-2002 period, herein referred to as WI ENERGY STAR.)

The program budget was reduced in July 2003 due to State budget shortfalls. At the same time, it was expected that the program would double the number of certified homes and added measure-specific incentives to increase the program's electric load impacts. Cost-cutting measures such as a "performance builder" element to reduce inspection requirements for consistently good builders are currently being examined for the program. Electrotechnology incentives offered through the program may also now need to be pared down. These incentives were introduced in response to increasing pressure to show tangible reductions in electricity consumption. The program has done a good job reducing gas usage. Opportunities for increased electric savings are being investigated.

Residential new construction program policy regarding building energy efficiency standards has far-reaching implications for program design, performance measurement and cost effectiveness. In most cases, energy efficiency programs can only claim energy impacts that are incremental to base levels as defined by state energy standards or the Model Energy Code.[6] Changing standards represent a challenge to program managers because as standards go up, the range of cost-effective strategies for capturing additional savings becomes narrower, incremental savings per project are reduced, and program cost-effectiveness goes down. Ironically, effective program design and implementation is often the very engine driving the increase in standards. By promoting new technologies and practices, programs accelerate their adoption in the construction industry and make it feasible to establish higher building standards with minimal disruption. In this sense, higher standards are a consolidation of industry advances attributable to the programs, which force market laggards to adopt technologies and practices that have already become *de facto* industry standards. Higher standards are the surest sign of market transformation and overall program success.

2.2 PROGRAM STRATEGY AND GOALS

Program managers articulated the following goals and objectives for R8 Programs:

The goal of **Austin Green Building** was to help build better, environmentally-sound homes via transformation of the residential new construction market.

CA ENERGY STAR New Homes was designed to increase energy efficiency levels of residential new construction, both single and multi-family to at least 15 percent over state energy efficiency standards. The program was performance-based, allowing the architect, energy analyst and builder to select measures appropriate to the area of construction.

NJ ENERGY STAR Homes was designed to increase the energy efficiency level of residential new construction in New Jersey to that of the national ENERGY STAR Homes Program. The program recognized and rewarded builders of premium, energy-efficient homes by helping them increase their profits and customer satisfaction while contributing to a cleaner environment.

The goal of **TX ENERGY STAR Homes** was to support Oncor's overall efforts to meet the energy efficiency goal mandated by SB 7. Program objectives, defined by the Public Utility Commission of Texas (PUCT), were to achieve peak demand reductions and/or energy savings through increased sales of ENERGY STAR homes; condition the market so that consumers are aware of, and demand ENERGY STAR homes; and help ensure that builders have the technical capacity to meet this demand. The ENERGY STAR New Home Program is one of several program "templates" that were pre-approved by the PUCT. Oncor selected this program for implementation because of the high level of residential construction activity in the service territory, the significant opportunities for increased efficiency levels in residential new

---

6 In contrast, code compliance is a key component of the Vermont and Austin programs. As previously noted, Vermont has no building inspection and enforcement process other than program participation.

construction, prior experience in implementing new construction programs, and the marketing potential of ENERGY STAR.

Tucson Guarantee Home focused on market transformation and education, with the goal of promoting homes that are healthy, safe, comfortable, affordable, and energy-efficient. The program aimed to reduce system peak demand, increase off-peak demand, and increase energy use during non-peak months. The program goal was to gain a 50 percent market share of new homes permitted each year by 2008.

VT ENERGY STAR Homes aimed for both resource acquisition and market transformation. Specific objectives were to decrease electrical energy consumption in the State, increase market recognition of superior construction; increase compliance with Vermont Residential Building Energy Standards (RBES); increase penetration of cost-effective energy efficiency measures; improve occupant comfort, health, and safety (including improved indoor air quality); and institutionalize HERS.

WI ENERGY STAR focused on market transformation, with a legislative mandate to achieve electric savings. The program goal was to certify 10 percent of all new homes as ENERGY STAR Homes within 5 years. In order to convince builders to build tighter homes, the program had to address builder concerns about poor indoor air quality (IAQ) and mold associated with tight homes with reduced natural ventilation.

Barriers and related activities associated with several of these programs are shown in Exhibit R8-2.

Exhibit R8-2
Residential New Construction Barriers and Related Activities

Identified Barrier	Activity
Information and Search Costs	Using an ENERGY STAR platform helps reduce the overall costs to home buyers of identifying energy efficient homes. On the supply side, programs typically offer technical training to help builders and contractors expand their knowledge and expertise relating to quality construction techniques and energy-efficient products.
Split Incentives	Builders perceive their customers to be unwilling to pay extra for energy efficiency. Since builders will not pay utility bills, provide maintenance and up-keep or live in the home, they are concerned about long-term financial and health consequences of their construction practices only if they impact home sales value and the builder's overall profitability. Programs typically addressed this barrier by promoting the ENERGY STAR brand and targeting education efforts to home buyers to enhance the market value of energy efficiency.
Asymmetric Information	For many features, the costs and benefits cannot be evaluated independently and the home buyer must rely on information from the builder's sales agent, which may not be a credible source. Programs offered a credible, objective source of information. Third-party inspections provide solid and credible information about a home's performance and construction quality.
First Costs	Builders are frequently reluctant to pay extra for inspections because they believe their contractors already do good work. Programs offered free or subsidized third-party inspections to verify construction quality.
Product and Service Unavailability	Programs provided training and technical assistance to builders and subcontractors to develop the technical skills needed to construct energy-efficient homes. Some energy-efficient technologies remain generally unavailable or harder to find than conventional alternatives, e.g., high-quality hard-wired fluorescent fixtures in an array of attractive styles. Programs expanded the demand for these products.
Inseparability of Product Features	Home buyers must weigh the value of energy efficiency against a list of competing criteria (e.g., square footage, location, school district, lot size, number of bedrooms and bathrooms, and style). Several programs attempted to make energy efficiency more influential by stressing the relationships between energy efficiency, health, comfort and maintenance considerations.
Organizational Practices and Customs	Programs typically required Manual J calculations for HVAC sizing and encouraged builders to adopt integrated design with their projects. Integrated design mitigates the problem of accumulating design errors associated with conventional practices.

3. COMPARISON OF PROGRAM COMPONENTS

This section compares the R8 Programs across the four major program components used to organize data collection and analysis. These program components are Program Design (including program theory), Program Management (including project management, reporting and tracking, and quality control and verification), Program Implementation (including participation process and marketing and outreach) and Program Evaluation.

3.1 PROGRAM THEORY AND DESIGN

Of the R8 Programs only NJ ENERGY STAR Homes and TX ENERGY STAR Homes had written program theory documents, both in the form of strategic planning documents either filed with or issued by the authorizing regulatory agency. The more important element across all R8 Programs was a thorough planning process that involved multiple stakeholders and leveraged past experience. Most program managers described an iterative process of program design. R8 Program designs built heavily on predecessor program design iterations, updated to reflect empirical conclusions as well as changes in the regulatory and economic context. For example, the PUCT-approved template for residential new construction programs in Texas builds on prior program experience, including Oncor’s (then TXU) Energy Checked Homes program and CenterPoint’s (then Houston Lighting and Power) Good Cents program, which ran for over ten years prior to SB 7.

Program designers also turned to outside sources of information and ideas for promising intervention strategies, including paid consultants with prior program design experience and focus groups. One program manager reported deriving the inspiration for the program design from a day-long workshop on integrated building science. The workshop inspired her to invite a building science expert to help her revamp the utility program.

A common theme that emerged from discussions of program design was the importance of tailoring the program to local economic and climate conditions. For example, the California construction market is dominated by large-scale builders who build whole subdivisions. In this context, a consistent statewide program helped establish the clout to influence these builders. In contrast, Vermont’s construction market is largely made up of small-scale builders who build a handful of homes per year. These builders have different information needs than a large production builder, which they meet through different channels. The exception is the northwestern region of the state, which includes Burlington, the state’s largest city. In this region, production builders building 50 to 150 homes per year participate in the program, largely influenced by the combined service partnership with Vermont Gas Systems.

Wisconsin’s climate makes shell improvements a higher priority issue than in milder parts of the country. The drive toward tighter shells raises the importance of good ventilation practices to avoid moisture build-up, carbon monoxide build-up, back-drafting, and other indoor air quality problems. Wisconsin also has an active manufactured homes market, which requires a unique outreach strategy.

Despite the variety of climates, regulatory systems, and market structures, a few common themes in program design emerged as noteworthy.

All R8 Programs emphasized whole building performance, as opposed to a narrower measure or end-use focus.

All programs emphasized quality control through on-site inspections and verifications to ensure that homes were built well. There seems to be a consensus that all aspects of the home must be well constructed for the occupant to enjoy the maximum advantages offered by energy-efficient technologies.

R8 Programs emphasized a collaborative partnership approach to builder relationships. In particular, on-site inspections were used as an opportunity to assist the builder with quality control and develop the skills of the builder and his contractors, rather than to engage in heavy-handed program policing.

All programs emphasized branding and labeling as a means of differentiating energy-efficient homes from conventional homes, thus capturing the latent market value of energy efficiency. Many R8 Programs leveraged the ENERGY STAR brand for this purpose. In the absence of branding, home buyers were unable to distinguish well-built homes from poorly built, inefficient homes.

Program designs were largely empirical. Designers drew heavily from previous experience (both their own and others') and used an iterative approach to determine intervention strategies that would be most effective in their market.

Most programs used incentives, at least initially, to overcome builder hesitation about program participation in general and inspections in particular. Over time, as builders have learned to appreciate the benefits of program participation and inspections, programs have been able to reduce or eliminate subsidies.

All programs recognized the importance of both the supply side and the demand side in the market place. Even those programs that primarily or exclusively targeted supply-side market actors helped prepare those actors to market their products and services to home buyers.

Program Theory and Design
• Have a well-articulated theory or program logic. • Link program tactics to the stated theory. • Plan thoroughly. • Involve multiple stakeholders. • Build feedback loops into the program design. • Maintain program design flexibility. • Understand local market conditions. • Use targeted incentives. • Focus first on developing supply-side capacity. • Do not over-promise results.

- **Have a well-articulated theory or program logic.** Even a relatively simple statement of program logic can reveal gaps in program focus or effort and assure that everyone involved knows what the program seeks to accomplish and why.
- **Link program tactics to the stated theory.** Articulating a program theory and structuring program tactics that are in line with it assures that programs are fundable, feasible, and capable of being evaluated.
- **Plan thoroughly.** Leverage prior experience, both locally and around the country. A detailed, well thought-out plan is easier to present and explain to potential critics.
- **Involve multiple stakeholders,** including stakeholders who should theoretically benefit from the program, trade allies whose cooperation will drive program success, and regulators / policy makers who must understand and approve the program design. Get buy-in from planners and implementers through communication and collaboration.
- **Build feedback loops into the program design** to assure that stakeholders continue to provide input throughout program implementation.
- **Maintain program design flexibility** to respond to changing market conditions and address unforeseen challenges throughout program implementation.
- **Understand local market conditions.** A solid understanding of local conditions is vital for recognizing which lessons from other areas transfer to the local market and which ones do not. As much as possible, justify program design with objective baseline market research to bolster design credibility with diverse stakeholders.
- **Use targeted incentives**, at least in the early stages of program roll-out, to reward program participation. Beyond buying down the cost of energy efficiency, incentives help establish the program's credibility in the minds of private-sector market actors who may be reluctant to be the first to try something new. Carefully link incentives to program objectives and overall marketing and outreach strategy.

- **<u>Focus first on developing supply-side capacity</u>** before selling program benefits to demand-side market actors. Make sure builders are able to offer energy-efficient homes before marketing them to home buyers. Make sure raters are fully trained to provide inspection services before requiring builders to use them.
- **<u>Do not over-promise results</u>**. Overly optimistic promises may attract more interest early on but they set the stage for disappointment later. Be prepared to justify all claimed program benefits with objective building science.

3.2 PROGRAM MANAGEMENT: PROJECT MANAGEMENT

The R8 Programs reflected considerable variation in their organizational structures. For example, Efficiency Vermont is, in effect, a regulated utility in Vermont, but rather than being investor-owned, it is administered by Vermont Efficiency Investment Corporation (VEIC) through a contractual relationship with the Department of Public Service. Austin Energy is a municipal utility with an oversight board appointed by the Austin City Council. WI ENRGY STAR was implemented by a nonprofit organization, WECC, under contract to Focus on Energy, the public-private partnership for energy efficiency created in 1998 with the cooperation of the Public Service Commission of Wisconsin (PSC) and the Wisconsin Public Service Corporation (WPS). The most traditional implementation structures are those of the California, New Jersey, Texas, and Tucson utilities, all regulated investor-owned utilities with in-house administration and subcontracted services for their energy efficiency programs.

Despite the observed variation in organizational structure, the R8 Programs exhibited remarkable consistency in their implementing structures and program management arrangements, at least at a high level. Most programs relied heavily on in-house management and administration with varying degrees of reliance on subcontractors to provide inspection and quality control services, marketing and outreach, and training and education. Only one program outsourced implementation to a turn-key contractor.

Exhibit R8-3 shows the different approaches for combined program management and implementation components for the R8 Programs.

The structure of program management appears less important than how well the program activities were aligned with program objectives and market characteristics. Program staff almost universally noted that relationship building, understanding the market and adapting to market shifts was critical to program success. Regardless of the overall project management structure (whether a turnkey contractor, in-house, or with significant subcontracting), program staff repeatedly mentioned the importance of knowing the market within which the program works, respecting the fact that the program is intervening in a market, and investing in the communication required to build relationships with a variety of market actors.

Exhibit R8-3
R8 Program Management/Implementation Approaches

Program	Program Management/Implementation Approach
Austin Green Building	Primarily in-house
CA ENERGY STAR New Homes	Primarily in-house; field inspections outsourced to independent HERS Raters
NJ ENERGY STAR Homes	In-house, with significant private-sector subcontractors
TX ENERGY STAR Homes	In-house, with significant private-sector subcontractors
Tucson Guarantee Home	Primarily in-house
VT ENERGY STAR Homes	In-house, with significant private-sector subcontractors
WI ENERGY STAR	Primarily in-house

Another recurring theme in program staff responses was the importance of clear lines of communication and decision-making to the success of project management. This issue was particularly noteworthy in California and New Jersey, where the programs were jointly implemented by multiple utilities, under a mandate to offer a single, consistent program design statewide. In those states, program management teams with representation from all participating utilities met regularly to address issues and make decisions, usually by consensus. The teams were kept as small as practicable, communication channels were well-defined, and a shared understanding of program goals and objectives facilitated decision-making on operational matters. Utility representatives to the management teams were fully empowered by their organizations to make and implement program decisions.

The importance of sound planning of the program operational plan also emerged as a theme for successful project management. Respondents repeatedly stressed the importance of tailoring the program process to local market conditions and actively engaging stakeholders in its review and testing. Once developed, the operational plan should be pilot tested to identify and resolve any remaining operational issues. Even after taking these precautions, program managers should maintain a degree of flexibility to respond to changing market conditions and unforeseen circumstances.

A final theme was the importance of finding well-qualified staff and contractors and then providing them the training they need to do their jobs. Since interactions with construction industry professionals was such an important part of all program designs, several respondents stressed the need to hire program staff and contractors with actual construction and design experience. One program reported success recruiting raters from the ranks of professionals who perform point-of-sale inspections. They were able to speak with authority about the long-term consequences of particular construction practices because they had seen those consequences first-hand. They also had a better understanding of occupant concerns.

Regardless of a new hire's previous skills and experience, a certain amount of training was required for the job. One respondent stressed the importance of matching the training to the specific skill sets needed to succeed. The same respondent also highlighted the value of staff performance awards which were linked to performance evaluations with tangible measures that were known in advance and developed jointly by the manager and employee.

Best Practices

Program Management: Project Management
• Include stakeholders in developing a program process or operational plan. • Put the process plan in writing. • Keep management teams small. • Maintain good staff morale. • Make sure at least some of the institutional memory resides in-house, not with subcontractors. • Avoid giving a single contractor exclusive responsibility for program implementation. • Provide staff with good training that matches skill needs. • Reward high performing staff and link performance evaluations to tangible measures which are known in advance and developed together jointly by the manager and employee. • Match staff decision-making authority to responsibilities and delegate responsibility and authority to avoid institutionalized bottlenecks. • Get upper management buy-in.

- **Include stakeholders in developing a program process or operational plan**. Doing so will bolster the plan's credibility and produce a plan that reflects local market conditions and works from the perspective of a range of sometimes divergent viewpoints. A well thought-out plan will contribute to smooth program implementation.
- **Put the process plan in writing** and document all important decisions that inform plan elements. A written plan is more likely to be well thought-out and is easier to disseminate to the various affected stakeholders.
- **Keep management teams small.** Small teams are necessary to maintain close coordination, facilitate good communication, and increase the likelihood of reaching consensus (when multiple entities are involved in decision making).
- **Maintain good staff morale** to ensure staffing stability and develop long-term institutional memory.
- **Make sure at least some of the institutional memory resides in-house, not with subcontractors**. This ensures program stability and increases ability to improve program design over time.

- **Maintain flexibility to respond to changing market conditions and unforeseen eventualities**. Clear-cut accountability and good communication with regulators and stakeholders may mitigate tendencies to impose regulatory requirements that limit flexibility.
- **Avoid giving a single contractor exclusive responsibility for program implementation**. If the program relies heavily on contractors as a strategy to develop private-sector service capacity, it is important to stimulate competition among multiple contractors to promote accountability, provide incentives for cost and quality control, and build in redundancy in the event any one contractor fails to perform. This is particularly important when the contractors delivering program-related services contract directly with other private market actors rather than with the program (e.g., inspectors and raters who contract directly with builders).
- **Provide staff with good training that matches skill needs**. Program services will only be as good as the people who deliver them. Human resources are as important to program success as financial resources.
- **Reward high performing staff and link performance evaluations to tangible measures which are known in advance and developed together jointly by the manager and employee**. Staff will perform better when they clearly understand what is expected of them and they agree that the expectations are reasonable.
- **Match staff decision-making authority to responsibilities and delegate responsibility and authority to avoid institutionalized bottlenecks**. A good balance between authority and responsibilities is a prerequisite for performance expectations that are perceived as reasonable. Delegate responsibility and authority to avoid institutionalized bottlenecks.
- **Get upper management buy-in.** Residential new construction programs require several years to generate tangible impacts. Upper management must embark on the process with patience, reasonable expectations, and a commitment to fund the entire start-up phase.

3.3 PROGRAM MANAGEMENT: REPORTING AND TRACKING

Despite variations in the degree of emphasis on resource acquisition versus market transformation, all R8 Programs had some system for quantifying program performance in terms of energy impacts. For new construction programs, this requires fairly thorough documentation of the project baseline as well as actual building performance. Most programs had a system in place for developing reasonable "deemed savings" values that approximate the actual savings achieved via program participation.

Programs with a more explicit market transformation focus tended to track a wider variety of performance indicators. For example, WI ENERGY STAR tracked builder performance trends (by builder), customer satisfaction, installed technologies, training events for builders, contractors and consultants, and cooperative marketing expenditures. The program also tracks builder "maturity" in three stages based on the following logic model: (1) builder starts by working closely with rater; (2) builder sends subcontractors to trainings; and (3) builder starts marketing program participation as part of the business model.

The array of information recorded supported a number of applications. In addition to the standard functions of regulatory reporting, internal performance monitoring, quality control, and project status tracking, the Wisconsin tracking system supplied concrete information about builder construction quality trends. Consultants used this information for program analysis, and builders were able to use it for their own marketing efforts. WI ENERGY STAR used participation data to determine eligibility to use the program name and brand. Third-party inspectors used tracking system results to help win bids from builders. Several other R8 Programs used tracking systems to initiate communications with participants and trade allies at key junctures and/or set program priorities, goals, and budgets. Austin Energy used its system to evaluate staff performance as well.

The application of computer technology for reporting and tracking was valuable to all R8 Programs, and was used to automate tasks, reduce the tedium of data management, impose quality controls on data entry and processing, and streamline overall program administration. Respondents described early versions of tracking systems that used multiple databases that did not communicate with each other, duplicative data entry protocols that led to inconsistencies, and other data management challenges. The earlier databases have generally been replaced with better designed and better integrated tracking systems.

TX ENERGY STAR Homes had the most thoroughly automated tracking system. Oncor and other Texas utilities have jointly sponsored the development of a Web-based interactive system for use by program administrators, builders, and raters. With this system each party was able to input data and track the progress of a home from the beginning of construction to final ENERGY STAR certification. The database made program participation virtually paperless for the builder. It also eliminated the use of program resources to manually enter program application data, since participants entered it themselves online. The database featured fairly rigorous quality control screens for data entry. Routine functions such as monthly reports and invoice tracking and payment were automated.

Exhibit R8-4 shows the different reporting and tracking methods used by each program. Exhibit R8-5 summarizes the different functions the tracked information served.

Exhibit R8-4
R8 Program Reporting and Tracking Tools

Program	Method
Austin Green Building	The program tracking system met minimum needs (e.g. reporting) but did not support activities such as marketing.
CA ENERGY STAR New Homes	Individual utility tracking systems designed to meet uniform reporting specifications. Systems generally linked to accounting systems. CHEERS tracked information required to coordinate builder/rater interactions.
NJ ENERGY STAR Homes	A combination of utility and contractor databases tracked all program participants, inspection results, incentive qualifications, and installed equipment efficiencies. Contractors had separate tracking systems but both contractors used the same standardized reporting template to maintain consistency.
TX ENERGY STAR Homes	A Web-based interactive database was developed for use by program administrators, builders, and raters. Each party was able to input data and track the progress of a home from the beginning of construction to final ENERGY STAR certification. Oncor and two other utilities also jointly sponsored the development of a software tool to evaluate the kW and kWh savings for ENERGY STAR homes. The HERS software tool allowed a more accurate estimate of energy and demand savings
Tucson Guarantee Home	In addition to the standard tracking and reporting functions, the TEP program database also played a key role in implementing the program guarantee. The database was linked to the customer billing system. At the customer's one-year anniversary, actual bills were compared to the guarantee amount to determine whether the customer qualifies for a billing credit.
VT ENERGY STAR Homes	The program has worked to consolidate and streamline tracking systems. Initially, the program used one database to track leads and projects and another database to track measures. The two databases did not link. More recently, the two have been merged.
WI ENERGY STAR	Program tracked an array of market transformation indicators as well as inputs required to estimate program impacts.

Exhibit R8-5
Reporting and Tracking Functions

Function	Austin Green Building	CA ENERGY STAR New Homes[7]	NJ ENERGY STAR Homes	TX ENERGY STAR Homes	Tucson Guarantee Home	VT ENERGY STAR Homes	WI ENERGY STAR
Reporting to Upper Management / Regulators	✓	✓	✓	✓	✓	✓	✓
Program Impact Calculations	✓	✓	✓	✓	✓	✓	✓
Internal Performance Monitoring / Quality Control / Project Status Tracking	✓	✓	✓	✓	✓	✓	✓
EM&V	✓	✓		✓		✓	✓
Financial Accounting		✓	✓	✓	✓		
Communications with Participants and Trade Allies		✓		✓	✓		✓
Set Program Priorities, Goals, Budget	✓	✓			✓		
Load Research and Forecasting	✓				✓		
Program Marketing Activities		✓			✓		✓
Market Trends		✓	✓				✓
Customer Satisfaction					✓		✓
Staff Performance Evaluations	✓						

7 PG&E and SCE only

Program Management: Reporting and Tracking
• Define and identify the key information needed to track and report early in the program development process. • Minimize duplicative data entry; link databases to exchange information dynamically. • Track market transformation program qualitative benefits and measures related to spillover effects, along with direct savings impacts. • Develop accurate algorithms and assumptions on which to base estimates of savings. • Design databases to be scalable to accommodate changes in program scope. • Use the Internet to facilitate data entry and reporting. • Automate routine functions such as monthly reports. • Build in rigorous quality control screens for data entry. • Document the tracking system carefully.

- **Define and identify the key information needed to track and report early in the program development process.** Clearly articulating the data requirements needed to measure success in advance ensures the ability to cost-effectively evaluate the program. Early identification of all stakeholders and their information needs allows for effective design of reporting and tracking systems.
- **Minimize duplicative data entry; link databases to exchange information dynamically**. This is especially important if the program uses separate tracking systems for program participation, inspection scheduling and coordination, and customer billing.
- **Track market transformation program qualitative benefits and measures related to spillover effects, along with direct savings impacts**. Residential new construction programs are often more effective when energy savings benefits are linked in to non-energy benefits that are more important to the buyer. Tracking non-energy benefits is an important tool for establishing credible claims. In addition, market transformation strategies are often chosen over resource acquisition strategies for their potential to generate spillover to non-participating market actors and projects. Tracking these spillover effects will help bolster program credibility.
- **Develop accurate algorithms and assumptions on which to base estimates of savings.** Use tracking system results to periodically review deemed savings estimates and bring them in line with actual building performance. This exercise will help set reasonable expectations and avoid the temptation to oversell program benefits.
- **Design databases to be scalable to accommodate changes in program scope.** Doing so will enhance the program's overall flexibility and ability to respond to unforeseen market conditions.
- **Use the Internet to facilitate data entry and reporting.** Internet access is now widespread and electronic data transfer and sharing can greatly enhance the quality and cost-effectiveness of information management. Internet-based systems can help

minimize duplicative data entry and storage and automate many routine quality-control steps.

- **Automate routine functions such as monthly reports**. Doing so provides an opportunity to build in quality control checks and frees staff time for more strategically important tasks.
- **Build in rigorous quality control screens for data entry**. Program the tracking software to reject inconsistent, inaccurate, or incomplete data to minimize the extent of subsequent data cleaning and enhance the accuracy and credibility of reported results.
- **Carefully document the tracking system**, including database structure, data field definitions and screening criteria, and data entry and analysis procedures. Good documentation will help mitigate problems stemming from staff turn-over, especially when the system must serve a variety of users with varying computer skill levels.

3.4 PROGRAM MANAGEMENT: QUALITY CONTROL AND VERIFICATION

The core quality control and verification procedures for all R8 Programs were periodic on-site inspections as homes were being built. Program managers noted a number of benefits to this strategy:

- Protects program brand equity
- Complies with ENERGY STAR program requirements
- Verifies the proper installation of energy savings measures, which enables validation of energy savings claims
- Establishes relations with the builder and trades people
- Provides a quality control service to the builder
- Helps ensure compliance with local energy efficiency codes and standards
- Promotes the application of best practices in construction (e.g., air-tight construction, properly installed thermal insulation, controlled mechanical ventilation, and procedures to minimize the risk of moisture, back drafting of combustion appliances, mold, and durability problems)
- Limits builders' financial exposure to construction defect issues (by providing additional quality control and project documentation)

The inspection programs shared a number of features in common. Programs generally relied on third-party inspectors or raters. This strategy is consistent with the market transformation objective of developing a private-sector inspection infrastructure that can provide these quality control services with minimal public subsidies. In most cases, raters had to be accredited through a Residential Energy Services Network (RESNET) approved rater training program. In many cases, the programs trained or helped train the raters and helped develop the organizational infrastructure to connect raters and home builders. In several areas, raters have organized their own professional organizations to self-monitor, regulate and generally advance their profession. At the national level, RESNET provides this function to raters as well.

A key inspection component was building performance modeling. Builders had to submit model results from approved building simulation software, showing that the homes would perform to specified program standards. Raters then confirmed that key design assumptions were incorporated into construction and confirmed or revised model results for as-built conditions. In many cases, raters also provided visual confirmation of installation quality of key energy-related features.

A number of programs also employed a system of spot checks at construction sites to verify rater results. These spot checks provided an additional layer of quality control, assuring that raters were doing a good job. In many cases, spot checks were conducted by in-house program staff.

Homes were inspected at least two and sometimes three times. Every program required home inspections at mechanical rough-in (prior to drywall installation) and at project completion. Some programs also conducted a separate insulation inspection. Final inspection generally included a duct pressure test, blower-door test, verification of equipment requirements and operation, and HVAC equipment startup.

Most respondents emphasized that inspection visits were first and foremost partnership-building events, and not intended as "policing" activities. It was in the rater's best interest to be the builder's ally for quality control rather than the program enforcer. Of course, a certain degree of tension between a rater's partnering and regulatory role was inevitable. For example, one program noted a potential for conflict of interest when the same agency is the builder's agent for program participation requirements, and responsible for compliance documentation, and conducting inspections and the final plan check.

Builders have generally embraced the inspection process as it provides valuable quality control benefits. Raters often revealed construction or equipment deficiencies unknown to the builder (such as HVAC equipment, windows, and water heaters with energy ratings much lower than the products specified and paid for by the builder) thereby increasing the program's value to the builder.

Virtually every program had some process for differentiating the inspection needs of experienced and inexperienced builders. In some cases, the program began by inspecting a sample of homes and then ratcheting up the inspection requirements if significant failure rates were observed. In other cases, the program started by inspecting all homes and then relaxing the inspection requirements for experienced program builders with a demonstrated good track record.

At least two programs required pre-construction meetings with the builder, key subcontractors and suppliers at which project specifications and program requirements were reviewed. The meetings helped establish clear communication with the builder, considered essential for minimizing the incidence of project failures. The meetings also showed builders the importance of good planning, which contributed to fewer change orders, smoother construction process, and better overall projects.

One program experimented with conducting post-occupancy inspections. The process did not work well due to challenges in obtaining homeowner consent to inspect.

Program Management: Quality Control and Verification
• Treat inspection visits as partnership-building and learning events rather than just regulatory enforcement activities. • Require builder or builder's representative to be on-site during inspection. • Plan to rely on third-party inspectors for quality control over the long-term. • Encourage home inspectors to organize their own professional organization. • Provide timely feedback to builders, home inspectors, and other parties. • Ensure that inspectors have plenty of hands-on construction experience. • Establish a streamlined inspection scheduling process. • Recognize the different inspection needs of experienced builders and builders who are new to the program. • Host pre-construction meetings with the builder, key subcontractors, and suppliers to review project specifications and program requirements.

- **<u>Treat inspection visits as partnership-building events rather than regulatory enforcement activities</u>**. It is in the best interest of both the program and the rater to be the builders' ally for quality control. Use inspections as an opportunity to teach good construction practices and sound building science. Do not just check minimal compliance items off a list.
- **<u>Require builder or builder's representative to be on-site during inspection</u>**. By being present, they can see for themselves the value of the inspection. This requirement reinforces the notion of the inspection as a training/education opportunity rather than program enforcement.
- **<u>Plan to rely on third-party inspectors for quality control over the long-term</u>**. Follow-up inspections of selected projects provide quality control of rater's results and assess the program's influence on the project. The success of a residential new construction program hinges on establishing a trusted brand to identify energy efficient homes in the minds of home buyers. Program credibility and brand equity are valuable components and follow-up inspections help maintain both.
- **<u>Encourage raters to organize their own professional organization</u>** to self-monitor, regulate and generally advance their profession. A well-organized professional organization can provide many of the necessary quality control functions. A robust professional association is an important step toward full-scale market transformation.
- **<u>Provide quick and timely feedback to builders, home inspectors, and other parties.</u>** The construction industry is particularly time-sensitive due to the central role of borrowed capital in most projects. Short feedback loops are important for respecting builder and contractor time constraints and capturing one-time opportunities for positive program impacts.

- **Ensure that raters have plenty of hands-on construction experience**. Raters can offer a valuable service to construction professionals as teachers and mentors. To fill that role, they must understand in detail how buildings are built and the long-term consequences of various material choices and construction techniques. Raters should be able to explain good practices in language the builders and contractors can understand. Finally, explanations that draw on personal experience will be perceived as more legitimate and credible.
- **Establish a streamlined inspection scheduling process** that permits a builder to schedule and receive the required inspections with minimal project delays. Again, due to the high reliance on borrowed capital to finance construction projects, any delays can quickly translate into financial loses. New construction programs must avoid imposing these hidden costs on program participants.
- **Recognize the different inspection needs of experienced builders and builders who are new to the program**. Newer builders need more assistance to master the details of quality construction and understand what the rater will be looking for. Once builders have demonstrated their commitment to quality construction and their ability to apply previously learned lessons, the builder should be able to derive the same program benefits with a lower level of program intervention.
- **Host pre-construction meetings with the builder, key subcontractors, and suppliers** to review project specifications and program requirements. These meetings help establish clear communication with the builder and minimize the incidence of project failures. The meetings also show builders the importance of good planning, which contributes to fewer change orders, smoother construction process, and better overall projects.

3.5 PROGRAM IMPLEMENTATION: PARTICIPATION PROCESS

Because all the R8 Programs featured on-site inspections, coupled with program branding, the participation processes were substantially the same across the board. The general process for ENERGY STAR programs is illustrative:

1. Builder submits project documents;

2. Program staff review documents and calculate initial energy rating. Rating is sent to builder, along with upgrade recommendations to reach required program standards (HERS score of 86 for ENERGY STAR);

3. Builder signs program participation agreements and ENERGY STAR Partnership Agreement;

4. In some cases, program representative meets on-site with builder, site supervisor, HVAC contractor, and insulation contractor to discuss program requirements, recommendations, and inspections;

5. Rater conducts pre-drywall inspection. Builder resolves any compliance issues identified during inspection;

6. Rater conducts post-insulation inspection. Builder resolves any compliance issues identified during inspection;

7. Rater conducts final inspection and testing. Builder resolves any compliance issues identified during inspection;

8. Certification granted based on successful inspection results;

9. Program pays incentive check and builder has access to ancillary program services (e.g., training and cooperative advertising).

The general design theory driving this process is that home buyers are inherently unable to identify and evaluate energy efficiency features of new homes on their own. Those features are typically concealed in the finished home or their performance attributes are difficult to evaluate through casual inspection. Home buyers are understandably reluctant to pay extra for unsubstantiated claims of energy performance benefits. Using an easily recognized brand such as ENERGY STAR to certify high performance homes helps home buyers identify energy efficient homes and properly value the energy performance benefits.

Two of the R8 Programs embraced this general design theory without adopting the ENERGY STAR platform and then extended it in unique ways. Tucson Guarantee Home went beyond simply certifying that a home incorporated certain design features, technologies, and construction practices. The program also guaranteed the cooling and space heating energy performance and comfort of the home for up to five years. If cooling and space heating bills were higher than the guarantee amount, the customer automatically qualified for a bill credit. Furthermore, if the customer was, for any reason, dissatisfied with the performance of the home's heat pump, the utility would replace it with an alternative type of heating system free of charge.

The guarantee amount was derived from a home energy budget, developed via computer simulation at the design stage and verified through the inspection process. The guarantee provided at least two key program benefits: (1) assurances from the HVAC contractor to follow program guidelines for right-sizing the equipment; and (2) a tangible marketing tool to home builders. The builders thus became champions and advocates for the program.

Austin Green Building also embraced the notion of a branding strategy to overcome home buyer information barriers. But the program took an innovative approach in extending the program's building standards to encompass the full range of environmental and health impacts of construction, not just energy use. Specifically, these "green building" elements included program construction practices that improve energy efficiency, reduce natural resource consumption, reduce pollution, recycle construction and demolition waste, conserve water, improve storm water management, produce healthier indoor environments, reduce maintenance costs, and generally result in higher quality, more durable buildings.

The rationale behind this more comprehensive approach was that green building programs can deliver energy benefits comparable to or exceeding those of existing energy efficiency programs; and non-energy benefits of green building address customer needs more directly than energy-only benefits, making green building projects easier to market. While a detailed evaluation of these claims is beyond the scope of the R8 Study, they merit further attention and research.

In some cases, program managers have begun reducing financial incentives over time. The rationale is that as program brands become established, they should deliver increasing market value to participants, which will enable them to recover incremental costs through higher sales values, without public subsidies. In cases where incentives have been reduced, program participation appears not to have been negatively impacted.

The exception to the above rationale is the incremental cost of verification inspections. To date, no program has succeeded in establishing a third-party inspection system that delivers enough market value to permit inspectors to deliver services without subsidies. The one program that does not pay any financial incentives, Austin Energy, handles inspections in-house.

Exhibit R8-6 summarizes the participation tactics of the R8 programs. Exhibit R8-7 displays insights and lessons learned by program staff about the participation process.

Exhibit R8-6
R8 Program Participation Tactics

TACTIC	Austin Green Building	CA ENERGY STAR New Homes	NJ ENERGY STAR Homes	TX ENERGY STAR Homes	Tucson Guarantee Home	VT ENERGY STAR Homes	WI ENERGY STAR
Financial Incentives	None	Single-Family: $400--900/home, depending on performance relative to energy standards and climate zone Multi-Family: $150-$250/unit Incentives targeted 60% of incremental costs. 2003 included design incentive for Multi-Family	Financial incentives covered ~100% of incremental cost Supplemental incentives available for HVAC, lighting, appliances.	$250/home, based on per-home impacts and allowable avoided costs and customer-class incentive caps	Predecessor started in 1997 with $800 / home; reduced cost of electric service installation. Incentives decrease each year and currently TEP provides $500/home.	$100 / home; various incentives for energy-efficient lighting and appliances	Builder incentives for inspections $520 per home; home owner incentives for electro-technologies, based on portion of incremental cost
Program Membership	Builder, Architect, or Designer	Builder	Builder	Builder	Builder	Builder or homeowner	Builder, Rater (contractor "allies" get access to coop advertising funds)
Membership Requirements	Attend the Green Building Basics course, plus 2 technical seminars per year; agree to build to minimum green building standards, provide project ratings for every project in service area	Builder must sign ENERGY STAR Partnership Agreement	Builder must sign ENERGY STAR Partnership Agreement	Builder must sign ENERGY STAR Partnership Agreement	Builder must sign a letter agreement to meet construction standards, undergo inspections and test and repair any deficiency prior to occupancy.	Builder or homeowner must sign ENERGY STAR Partnership Agreement	Builder must sign participation agreement and agree to certify at least 3 homes per year

TACTIC	Austin Green Building	CA ENERGY STAR New Homes	NJ ENERGY STAR Homes	TX ENERGY STAR Homes	Tucson Guarantee Home	VT ENERGY STAR Homes	WI ENERGY STAR
Design Review	Staff reviewed and recommended design enhancements	Program offered design assistance to builders and related players; ran plan check on all projects to verify project viability and qualifications	Ran plan check, developed customized energy upgrade package	Participating HERS raters reviewed designs to determine HERS scores.	Ran plan check to determine compliance with program's thermal requirements, made any recommendations for compliance, calculated Guarantee cost	Ran plan check, developed customized energy upgrade package; included compliance certification for State energy efficiency standards	Ran plan check, developed customized energy upgrade package
On-site Inspections	Mechanical rough-in and final for sampled projects	Periodic inspections, including final inspection, for sampled projects (1/7)	Mechanical rough-in and final for 100% of projects	Periodic inspections, including final inspection, for sampled projects (1/7)	Mandatory on-site preconstruction meetings with new builders; 3visual inspections for 100% of projects; most projects were performance tested including duct test, pressure test and blower door test.	Final inspection required; mechanical rough-in inspection on request	3 inspections required; 100% of projects inspected
Cooperative Advertising	Program promoted builders by name	Program promoted builders by name; provided brochures, yard signs, welcome mats, ENERGY STAR certificates	No	Builders contributed to coop ad budgets, and provided input	Advertising incentives; Program promoted builders by name	Yard signs, welcome mats, ENERGY STAR plaques	Advertising incentives; Program promoted builders by name
Technical Assistance	Periodic training required	Project design assistance offered; periodic training workshops and seminars to builders energy analysts, architects, and mechanical contractors	Yes	Sponsored HERS training; supported local trade association for HERS raters.	Quarterly training programs for builders focus on integrated building science; training sessions for architects, code and fire officials, homeowners	On demand	Periodic trainings

TACTIC	Austin Green Building	CA ENERGY STAR New Homes	NJ ENERGY STAR Homes	TX ENERGY STAR Homes	Tucson Guarantee Home	VT ENERGY STAR Homes	WI ENERGY STAR
Certification Requirements	1-5 stars, based on degree to which project incorporates measures from Green Building checklist and rating system	Exceed Title 24 by 15%	HERS score greater than 86	HERS score greater than 86 and 15% better than local code (IECC).	HERS score greater than 86; meet program standards	HERS score greater than 86; meet program standards	HERS score greater than 86; meet program standards
Bill Guarantee	None	None	None	None	Homeowner guaranteed that home's annual heating & cooling bill will not exceed specified amount	None	None

Exhibit R8-7
Lessons Learned – Participation

Participation Tactic	Lessons Learned
Financial Incentives	• Useful for overcoming builder resistance but not absolutely required • Most useful for off-setting financial impacts of inspection requirements • Best tied to building performance to provide flexibility in meeting program goals. • More mature programs can reduce incentive levels, based on demonstrated market value of homes built and certified to program standards
Program Membership	• Builder participation is key • Participation from architects and contractors also useful
Membership Requirements	• Require builder to sign ENERGY STAR Partnership Agreement or other pledge to build to program standards • Ongoing training requirements for builders, architects, and contractors add value
Design Review	• Offer design assistance to help builders trouble-shoot problematic designs and improve overall home performance at a stage where changes are still cost-effective • Assist with building energy simulations, life cycle cost analysis, Manual J calculations
On-site Inspections	• Inspect mechanical rough-in and final for sampled projects • Design sampling protocol to ease inspection burden on experienced builders with demonstrated track record of performance • Include performance tests; i.e., duct test, pressure test, blower door test
Cooperative Advertising	• Promote program builders by name • Solicit builder input on marketing messages and strategy • Train builder's sales staff
Certification Requirements	• Home certification and labeling is essential for overcoming split incentives and asymmetric information barriers • Certification requires clear-cut inspection process to protect program credibility and brand equity
Technical Assistance	• Offer regular training opportunities • Encourage rates to offer technical assistance as part of inspections; i.e., emphasize role as builder's ally rather than rule enforcer • Engage raters in providing training courses for builders, contractors, architects
Bill Guarantee	• Utility's performance guarantee is effective at overcoming home buyer's uncertainty about expected performance • Bill guarantee provides builder with additional marketing tool, thus creating additional incentive to undergo inspections, document HVAC sizing calculations • Properly structured bill guarantee creates minimal financial risk for utility

Best Practices

Program Implementation: Participation Process
• Establish a robust program brand to differentiate energy-efficient homes from conventional homes. • Offer assistance in preparing and submitting program applications. • Minimize documentation requirements that would entail preparing new documents not already developed in the course of project permitting. • Use targeted incentives. • Link incentives to building performance requirements. • Establish minimum requirements for builders. • Build strategic alliances with equipment manufacturers and encourage them to add their own incentives. • Target measure incentives to home buyers to encourage them to ask for the higher efficiency equipment. • Solicit home inspector input when developing ethics guideline and customer service standards. • Encourage home inspectors to take over training functions. • Develop a technical and procedural manual for builders. • Avoid vague or inconsistent technical standards that do not take into account broader building performance implications. • Offer a bill guarantee. • Extend program construction standards beyond energy features.

- **<u>Establish a robust program brand to differentiate energy-efficient homes from conventional homes.</u>** Brands help capture the market value of energy efficiency and permit home buyers to identify more energy-efficient homes without mastering the technical details of home construction practices.
- **<u>Offer assistance in preparing and submitting program applications</u>**. The level of documentation required to demonstrate whole-building performance can be significant. Construction industry professionals often cite the hassle of program application paperwork as one of the primary barriers to participation.
- **<u>Minimize documentation requirements that would entail preparing new documents not already developed in the course of project permitting.</u>** To the extent that the program can rely on pre-existing documentation to demonstrate compliance with program requirements, it will help minimize the administrative burden associated with program participation.
- **<u>Use targeted incentives.</u>** At least initially, financial incentives may be needed to convince customers to add cost to construction and try techniques that are new to their industries. Construction industry professionals tend to be risk adverse and are reluctant

to be the first to try something new. Beyond buying down the cost of energy efficiency, incentives help establish program credibility and legitimacy.

- **Link incentives to building performance requirements.** Performance-based incentives provide more project design flexibility than prescriptive incentives.
- **Establish minimum requirements for builders.** Do not necessarily accept all builders as participants. The program's market reputation as a trustworthy arbiter of quality and energy efficiency is perhaps its most important asset. Programs can and should impose minimum performance requirements on builders as a way of protecting and enhancing that reputation.
- **Build strategic alliances with equipment manufacturers and encourage them to add their own incentives**. Doing so will leverage existing market forces to enhance and extend program effectiveness.
- **Target measure incentives to home buyers to encourage them to ask for the higher efficiency equipment.** This strategy is particularly useful for technology choices that are frequently left to the buyer, such as light fixtures and appliances.
- **Solicit home inspector input when developing ethics guideline and customer service standards**. Avoid developing detailed policy manuals for raters without their input. Consider adopting a voluntary ethics guideline and voluntary customer standards document. This strategy is particularly relevant if combined with an active, organized professional association of raters. This recommendation seeks to balance the need to protect the program's market reputation with the desire to harness market forces to transform the market.
- **Encourage raters to take over training functions.** Doing so creates additional opportunities for professional advancement as a rater and capitalizes on the field experience raters are already accruing. In this case, an active, organized professional association of raters is helpful but not a prerequisite.
- **Develop a technical and procedural manual for builders**, including step-by-step participation checklists and comprehensive inspection forms. The intent of these manuals and forms should be to make participation as straightforward, routine, and predictable as possible. It also reduces the degree of "hand-holding" program staff must provide to help the builders through the process.
- **Avoid vague or inconsistent technical standards that do not take into account broader building performance implications**. Standards should include clearly defined metrics that are closely aligned with program goals.
- **Offer a bill guarantee.** Experience indicates that a properly structured guarantee can be a low-cost strategy that greatly enhances the credibility of program benefit claims.
- **Extend program construction standards beyond energy features,** to the extent that benefits from the additional elements can be supported by building science and cost-effective increases in consumer demand. Home buyers are shopping for an array of building attributes. Coupling energy efficiency with other more desirable attributes can enhance program appeal.

3.6 PROGRAM IMPLEMENTATION: MARKETING AND OUTREACH

The R8 Programs all included significant marketing and outreach components to both supply-side market actors (especially builders and contractors) and demand-side market actors (primarily potential home buyers). Program goals generally consisted of increasing builder participation in the program, increasing awareness of program brand (e.g., ENERGY STAR) among potential home buyers, and stimulating both supply of and demand for energy-efficient homes. Marketing and outreach was particularly important for the Austin programs, since it relied exclusively on education and information to achieve program goals. The program offered no direct financial incentives.

Supply-Side Strategies

Direct contact with builders, contractors, and other supply-side market actors proved key to successful outreach efforts. Virtually all R8 Programs recruited builders through a combination of phone, mail, and e-mail contacts, in-person visits, and long-term relationship building. Successful outreach often involved identifying one or more champions within the builder organization to promote and sustain program participation from within. For larger volume builders, it was generally necessary to reach multiple departments within the builder's organization including marketing, finance, construction, and purchasing.

Proactively taking program information to the builder rather than waiting for the builder to seek it out was also an important guideline for successful marketing. Builders tended not to contact program staff of their own volition, creating the need for a "push" rather than or in addition to a "pull" marketing strategy. Programs used an array of strategies to create opportunities to interact with builders including attendance at Building Industry Association (BIA) meetings, sponsorship of golf tournaments and awards ceremonies, participation in trade shows, and home showcase and tour events like Parades of Homes. One program focused particular attention on partnering with the various Home Builders Association (HBA) chapters to bring added value to HBA events. Relations with HBAs were facilitated by the fact that participating builders sat on HBA boards and committees. Trainers at HBA events were program raters.

While not the primary recruiting tools, programs also made use of more generic outreach tools such as Web sites, point-of-sale displays, direct mail, and articles and advertisements in trade publications. Radio, TV, and newspaper ads appear to be of little value for promotion to supply-side market actors.

For the most part, developing leads appears to be a straightforward proposition. The one possible exception may be in markets with a highly fragmented building industry made up of many small builders rather than a few large volume builders. One program in such a market relied on utility service requests to identify leads.

Two programs reported continuing challenges reaching out to realtors. No one reported any particular success in cultivating program champions within this segment.

Demand-Side Strategies

Identifying potential homebuyers was a continuing challenge. Two approaches used by R8 Programs to reach this demand-side market were mass market communications and targeted point-of-sale promotion. A point-of-sale strategy requires a cooperative relationship with the builder's marketing and sales staff. While cultivating these relationships was more time-consuming and sometimes unsuccessful, the pay-off was the ability to communicate specific information about specific homes directly to serious home buyers at a key decision point. Demand-side mass communication strategies were limited to simpler, more generic messages and had to achieve wide distribution to reach the few people actively in the market for a new home.

The R8 Programs appeared to be split in their approach to this challenge. While no program focused exclusively on a single outreach approach, there was considerable difference in the relative emphasis placed on mass marketing versus point-of-sale outreach. Programs with a point-of-sale focus invested considerable effort on sales training for builder representatives and model homes. The builder then took primary responsibility for selling energy efficiency to the home buyer. In many cases, the program complemented builder efforts with cooperative advertising and on-site promotional materials such as signs, welcome mats, flags and brochures.

The programs that emphasized consumer marketing all stressed the importance of understanding the target demographic, tailoring program messages to the audience, and developing effective cross-marketing strategies. Identifying and promoting to pools of likely home buyers was the central theme of this approach and critical to its success. One program targeted its outreach to renters of high-end apartments and condominiums. Another targeted female homeowners age 25 to 54.

Different communication channels have different effectiveness in different markets. One respondent cautioned against newspaper advertisements, stating that they did not provide any additional leads. But another program relied heavily on newspaper ads, along with radio spots, to reach its target audience. Several program managers mentioned radio as a successful marketing channel but stressed the need to be selective in choosing stations that would reach the target audience. Other strategies included locator maps in Sunday newspaper Homes section, billboards and Web sites.

Developing Marketing Messages

Three sources of information drove the development of most marketing messages: prior experience; focus groups and surveys; and standing committees of industry professionals. One program set up a Marketing Advisory Group made up of builders and raters to serve as a sounding board and to help define and refine communication messages. Another program hosted an annual builder conference at which stakeholders could provide suggestions and input.

Regardless of the information source, respondents stressed the importance of understanding the target demographic. Different messages resonate with different audiences. Key messages used by R8 Programs focused on the various benefits of energy efficiency and included:

- Health and quality of life
- Higher quality, comfort, and cost savings
- Environment control, ventilation capacity

One respondent specifically cautioned against relying on a message of "comfortable, durable, combustion safety, energy efficiency" to sell energy-efficient homes. In his experience, homeowners already took those features for granted. At a minimum, there appears to be consensus that messages of energy efficiency and cost savings alone are not sufficiently compelling for most home buyers.

Best Practices

Program Implementation: Marketing and Outreach
• Market to multiple departments within volume builder organizations. • Take information to builders – use a "push" rather than "pull" marketing approach. • Know your target consumer demographic, tailor your message to the audience and develop effective cross-marketing strategies. • Combine point-of-sale marketing via builder sales agents with direct marketing to home buyers. • Give builders an opportunity to participate in developing marketing messages.

- **Market to multiple departments within volume builder organizations**. Marketing, finance, construction, and purchasing departments all have an important role in the planning, construction, marketing, and sales process. Lack of buy-in from any one department can undermine the effectiveness of other department efforts.
- **Take the information to builders – use a "push" rather than "pull" marketing approach.** Don't wait for the builder to come to you. Leverage relationships with professional and trade associations. Create opportunities to interact with your target audience. BIA or HBA meetings, on-site interactions, personal contact, and e-mail offer opportunities to deliver information to builders.
- **Know your target consumer demographic, tailor your message to the audience and develop effective cross-marketing strategies**. These are key elements to consumer marketing. Customer demographics vary widely by region and one-size does not fit all as a marketing strategy.
- **Combine point-of-sale marketing via builder sales agents with direct marketing to home buyers**. Even if the demand-side outreach strategy emphasizes point-of-sale marketing via builder sales agents, a certain amount of direct marketing may be necessary to get builder buy-in. Especially initially, builders need to be convinced that improved energy efficiency can translate into added value at the point of sale. A parallel program marketing effort can help stimulate market demand and demonstrate that added value.

- **<u>Give builders an opportunity to participate in developing marketing messages</u>.** Since the purpose of consumer marketing is to stimulate sales for participating builders, this practice is key to marketing success. Builders have accumulated considerable marketing experience and have a vested interest in messages that are effective and well targeted.

3.7 PROGRAM EVALUATION

The depth and scope of evaluation activities varied dramatically across the R8 Programs, largely in response to varying reporting requirements imposed by management or regulatory agencies. At one end of the spectrum, Austin Green Building and Tucson Guarantee Home had brief annual summaries of program activities and results compiled for implementing agency senior management. Results were drawn almost entirely from in-house tracking systems and were prepared by program staff. At the other end of the spectrum, third-party evaluators were hired to conduct extensive primary data collection and develop *ex-post* estimates of program impacts for CA ENERGY STAR New Homes and WI ENERGY STAR.

In-house staff evaluated tracking system data for **Austin Green Building**. Program staff produced monthly reports summarizing impacts. Every two years, deemed savings values are re-evaluated and updated. Program staff cited lack of resources as a key reason for conducting evaluations in-house, and would have preferred using a third-party evaluator to minimize competing demands on implementation staff time and increase the independence of results.

California's IOUs have sponsored several recent studies of the residential new construction market that have contributed to program design, implementation, and evaluation of **CA ENERGY STAR New Homes**. Studies include *Statewide Residential New Construction Utility Program Comparison Study* (Quantum Consulting, et al. 2000), *Residential New Construction Study* (Regional Economic Research 2001a), *Summary of Findings on New Construction Training Offerings* (Wirtshafter Associates, et al. 2001), *Residential New Construction Demand Impact* (Heschong Mahone Group 2001), *California Residential Efficiency Market Share Tracking* (Regional Economic Research 2001b), and *Evaluation, Measurement, and Verification of the 2002 California Statewide ENERGY STAR New Homes Program* (RLW 2004). These studies characterize the residential new construction market (both single-family and multi-family) in the state, estimate the technical and market potential for savings, and assess key program design components.

The Phase 1 EM&V impact evaluation of **CA ENERGY STAR New Homes** (RLW 2004) estimates *ex-post* energy savings from as-designed project data that has been reviewed and verified by plan check agency. Phase 2 will incorporate as-built information from CHEERS inspections and will add a billing analysis. Evaluation results address program coordination, participation, impacts, building practices, builder awareness, data management and tracking, and quality control. Since the evaluation of the Program Year (PY) 2002 program, there have been increased efforts from CHEERS to address many of the data issues. Also starting in January 2004, CALCerts is a recognized provider of inspection services. The inspection protocols for this program are consistent with protocols developed by the CEC, EPA and ENERGY STAR organizations.

Evaluation activities for **TX ENERGY STAR Homes** and its predecessor programs have included baseline studies, program energy savings, contractor performance, and marketing plan effectiveness. Outside contractors were primarily used to conduct these evaluations.

Evaluation results have led directly to changes in implementation strategy. For example, the marketing plan was modified extensively as a result of evaluation findings.

A baseline study of homes constructed to standard code requirements was first conducted for **Tucson Guarantee Home**. Program technicians installed load research meters in selected participant homes to measure peak demand, compare actual heating and cooling costs to guaranteed heating and cooling costs, and evaluated energy use relative to standard customers. TEP's pricing department conducted a financial evaluation (audit), which looked at internal rate of return, program net present value, and cash flow. The forecasting group analyzed program load impacts for forecasting purposes.

Evaluation results have been instrumental in determining whether the impacts justify continuing the program and whether the bill guarantee appropriately balances risk and reward. Because of on-going evaluation activities, the program became increasingly cost-effective and enhanced the utility's system load profile. Demand was reduced during peak and increased during non-peak hours. The energy use curve shows reduction during peak months and increase in energy use during non-peak months. Actual heating and cooling costs were lower than guaranteed heating and cooling costs in 93-95 percent of the cases. The program cost evaluation led to reduced advertising budget and reduced builder incentives. The evaluation also identified the multi-family sector as one to avoid, due to high rates of free ridership.

A third-party contractor conducted a process evaluation of **VT ENERGY STAR Homes**. DPS performs an annual savings verification and audit to assess VEIC's conformance to its contract with the State. Program impacts were calculated using savings calculations included in the State contract. However, the State's audit team has found that it disagrees with the contractually agreed-upon calculation formulas and has recommended changing the formulas after the fact. A process evaluation of the programs was also conducted which addressed builder awareness of the program, program marketing and outreach, procedural issues, and data management and tracking. In response to evaluation findings, the program started marketing to manufacturers in the housing industry and creating an integrated data system.

WECC conducts in-house impact evaluations of **WI ENERGY STAR**. A third-party evaluator was hired to perform a process evaluation. The process evaluation addressed program procedures, builders' construction practices, and progress toward overcoming market barriers. R&D studies and studies to evaluate technical performance (e.g., furnaces, tight building analysis) were also commissioned for the program. In response to evaluation findings, WECC implemented a high-performance builder mechanism that reduces inspection requirements for builders with proven track records. The program's cooperative advertising component was also expanded.

Best Practices

Program Evaluation
• Support program review and assessment at the most comprehensive level possible. • Ensure that evaluation metrics are in-line with program goals. • Clearly explain evaluation roles and responsibilities to participants in advance. • Select an evaluator who has a detailed understanding of the market context in which a program operates. • Allow for plenty of interaction between evaluators and implementation staff. • Ensure the clarity of the evaluation document. • Periodically review and update market-level information about construction practices and energy efficiency measure adoption. • Periodically review and update algorithms for calculating project savings.

- **Support program review and assessment at the most comprehensive level possible.** For some programs, this will mean a comprehensive market assessment and impact evaluation, for others it may mean a program review document created in-house.
- **Ensure that evaluation metrics are in-line with program goals**. One evaluation objective should be to assess program progress toward achieving pre-determined goals. The only way to accomplish this objective is to establish metrics that measure that progress.
- **Clearly explain evaluation roles and responsibilities to participants in advance**. For example, builders should be informed that an evaluation is expected to include site inspections to avoid any later confusion caused by multiple contractors inspecting the same project.
- **Select an evaluator who has a detailed understanding of the market context in which a program operates.** This will enhance the value of evaluation findings for improving program delivery.
- **Allow for plenty of interaction between evaluators and implementation staff**. This is critical to giving the evaluator a clear understanding of program dynamics. Clear communication channels are essential.
- **Ensure the clarity of the evaluation document.** Regardless of the evaluation scope, it is essential that it clearly describes program goals, strategies and lessons learned so that program staff, stakeholders and other interested parties may gain a good understanding of the program.
- **Periodically review and update market-level information about construction practices and energy efficiency measure adoption**. The degree of sophistication of these market baseline studies will vary, depending on program and market factors. For example, a program operating in a large, highly fragmented market may require a full-scale study to obtain an accurate picture of market conditions, whereas a program in a small or

highly concentrated market may be able to compile a reasonable picture of market conditions through its routine interactions with key market players.

- **<u>Periodically review and update algorithms for calculating project savings</u>**. The objective should be to maintain a set of savings algorithms that are reasonably calibrated with real-world building performance. Depending on the level of precision required and available resources, calibration can involve simply re-estimating key engineering parameters or conducting billing analyses of whole building energy bills.

4. COMPARISON OF OUTCOMES

Energy efficiency programs and portfolios are often designed with specific policy objectives in mind, and those objectives can often impact the outcome of a program. For example, programs that target hard-to-reach areas may not exhibit the same rates of participation as those that do not. Key factors that affect cost effectiveness and program outcomes include:

- **Energy efficiency policy objectives –** policies that emphasize different goals such as market transformation, resource acquisition, equity, etc. will drive different program designs and program objectives.

- **Market barriers addressed** – programs that seek to mitigate difficult barriers may have poorer performance-related metrics because they attack tough problems, in contrast to programs that may have excellent ostensible metrics because of cream skimming.

- **Measure mix** – the mix of measures installed in a program can significantly affect a program's cost-effectiveness.

- **Demand/energy** – the extent of peak demand versus energy focus of the program can, by definition, affect the cost-effectiveness of the indicator in question (e.g., a peak demand oriented program may score poorly on an $/kWh metric). This can be considered a part of the measure mix factor listed above.

- **Multi-year policy objectives** – if consistent, help programs to achieve goals that require medium to long-term market presence and extensive program infrastructure; if inconsistent, make achievement of such goals more difficult.

- **Multi-year funding levels** – if consistent, allow programs to set multi-year goals and maintain consistent presence and messages among end-users and supply-side market actors; if inconsistent, makes maintaining a stable market presence more difficult.

- **Program/Market Lifecycle** – where a program or key measure is in its product lifecycle will affect its cost-effectiveness. For example, a program seeking impacts from the last 50 percent of the market to adopt a product that has penetrated the first 50 percent of the market should be expected to be more costly than one attacking a market with a low or insignificant saturation level.[8]

- **Climate** – for example, HVAC measures are more cost-effective in severe climates than in mild climates because absolute savings are strongly a function of base usage levels.

---

[8] There are at least two reasons for this. First, in more highly saturated markets, it is more difficult to find the remaining measure opportunities and, second, the remaining market is typically characterized by late majority and laggard organizations that are more resistant to adopting new products and practices. In addition, a program in the first-year of a multi-year plan to impact a market may have poor first-year metrics because of the associated startup costs and time it takes to create awareness and other program effects.

- **Customer/target market actor mix** – the mix of customers and trade allies often plays a role in cost-effectiveness, for example, a program in a market with larger commercial customers will tend to be more cost effective than an identical program in a market of smaller commercial customers, all other things being equal; similarly, programs with customer segments with longer full-load equivalent hours will be more cost-effective than those with lower average full-load hours of operation (also related to climate).

- **Customer density** – delivering an energy efficiency program to a relatively dense population base will be less costly than delivering to a sparser population, all other things being equal.

- **Customer Energy Rates** – higher electricity rates should lead to higher levels of measure adoption, all else being equal.

- **Economic Conditions** – willingness to invest in new products and practices changes in response to short-term economic and market conditions, which may vary across regions.

- **Customer Values** – efficiency program effectiveness can vary as a function of differences in customer values, again, all else being equal.

Exhibit R8-8 displays cost-effectiveness data for the R8 Programs. Information is presented on the Total Resource Cost (TRC) test, the associated discount rate and the average measure life, where available. The total program cost shown per kWh saved is an indicator related to the utility cost test in that the numerator includes all program costs and excludes any customer contribution to measure costs. Also shown are non-incentive dollars spent per kW, which offers an indication of the cost to market and administer. Incentive dollars per kW shows the overall average incentive amount per unit of estimated first-year impact.

The TRC test is one of the most commonly used metrics to determine if a program is cost-effective. Essentially the TRC is calculated as the ratio of the lifecycle avoided cost benefit of all the energy and demand savings, divided by all of the associated program and measure costs (specifically, full measure costs, not just those covered by incentives). Unfortunately, however, TRC values are not directly comparable across jurisdictions because of the variations in avoided costs, measure cost estimates, measure life estimates, and discount rates mentioned above.

Program planning assumptions can create large variations in both total resource benefit-cost ratios and program costs per unit of impact. Cost-effectiveness is driven by a set of assumptions about measure cost, measure life, per unit savings, savings per application, net-to-gross and other factors. The benefit side of cost-effectiveness is based on avoided cost, which differs substantially across service territories, as noted above. Furthermore, another factor that affects cost-effectiveness is measure mix. The program $/kWh is related to a utility cost test metric.

A comparison of TRC values for **NJ ENERGY STAR Homes and CA ENERGY STAR New Homes** suggests there may be differences in the costs and benefits included in the calculation and the value of those benefits. **NJ ENERGY STAR Homes** shows a much higher TRC despite spending almost twice as much per kWh. The difference may also be attributable to differences in the level of gas savings achieved, which are not reflected in the data in Exhibit R8-8.

Exhibit R8-8
Program Effects[9]

Element	Austin Green Bldg[10, 11]	CA ENERGY STAR New Homes	NJ ENERGY STAR Homes	TX ENERGY STAR Homes	Tucson Guarantee Home	VT ENERGY STAR Homes	WI ENERGY STAR[12]
Period Reviewed	2000-2001	2002	2002	2002	2002	2001	2002-2003
Net to Gross Ratio	NA	0.8	1.0	NA	NA	1.16	1.0
Free Ridership Rate	NA	0.2	0%	NA	NA	NA	0.0
Total Resource Cost/Societal Test	NA	0.57 – 0.94	1.59	NA	NA	1.73	NA
Average Measure life (years)	NA	19	20	>10	20	18	NA
Net MWh (Annual)	NA	8,524	3,262	NA	NA	974	1,049
Gross MWh	7,666	10,655	3,262	24,700	3,023	841	1,049
Net kW (Annual)	NA	17,809	3,415	NA	NA	278	247
Gross kW (Annual)	3,630	22,262	3,415	7,410	4,094	240	247
Real Discount Rate	NA	8.15%	5.24%	NA	6.93%	6.80%	NA
Budget Per Impact							
Program Expenditures ($000)	$604.5	$15,248	$10,945	$5,150	$3,010	$920	$2,870
Incentive Expenditures	$0	$10,089	$4,430	$4,000	$1,399	$321	$781
Program $/first-year kWh saved[11]	$0.08	$1.43	$3.35	$0.21	$1.00	$1.09	$2.74
Incentive Dollars per kWh[11]	$0	$0.95	$1.36	$0.16	$0.46	$0.38	$0.74
Non-Incentive Dollars per kWh[11]	$0.08	$0.48	$1.99	$0.05	$0.53	$0.71	$2.00
Program $/first-year kW saved[11]	$166	$685	$3,205	$695	$735	$3,833	$11,619
Incentive Dollars per kW[11]	$0	$453	$1,297	$540	$342	$1,337	$3,162
Non-Incentive Dollars Spent per kW[11]	$166	$232	$1,908	$155	$393	$2,496	$8,457

9 Table includes only electric impacts. Several of these programs also claim gas savings, which in some cases may be more significant from a resource value perspective than the electric impacts. The TRC tests should reflect gas resource value, however, the program $/kWh saved figures do not.

10 Austin Energy only considers first year impacts in its determination of program effects.

11 Gross impacts only

12 Table excludes gas impacts, which were an important component of program impacts in 2002–2003.

TX ENERGY STAR Homes is noteworthy for its large savings (24,700 MWh) and its extremely low expenditure per kilowatt-hour saved ($0.21). These results are driven by high savings per home (3.8 annual MWh), which more than doubles the next best program result (NJ ENERGY STAR Homes, with 1.78 MWh per home). Climate may have some bearing on results. While Tucson Home Guarantee (1.48 MWh per home) also operated in a hot climate, the program focused primarily on system load shifting (reducing peaks and filling valleys) rather than energy savings. Austin Green Building (1.34 MWh per home) was an information-only program, which presumably limited its ability to capture energy savings that required significant incremental investment on the builder's part. These results reflect a combination of program baseline, savings estimation methodology, climate, and perhaps average home size. In 2002 Texas had no state energy standards. With the State's adoption of the 2003 International Energy Conservation Code, the modified program baseline produced average per-home savings of 1.7 MWh for the 2003 program year.

TX ENERGY STAR is also noteworthy for its low ratio of non-incentive to total expenditures (22 percent). This result may reflect some efficiencies gained through its Internet-based program administration process. It may also reflect a lower emphasis on in-depth education and training for building professionals and contractors.

CA ENERGY STAR New Homes reported the lowest gross annual savings per home, 0.56 MWh. The result probably reflects, at least in part, a high program baseline driven by state energy standards considered to be the most stringent in the nation. California also places significant emphasis on calibrating modeled energy savings to actual billing histories, which may translate into more conservative impact estimates.

Relatively low demand impacts in Vermont and Wisconsin may reflect lower relative cooling loads on those regions.

Austin Green Building results reflect the fact that 92 percent of claimed program impacts are attributable to code enforcement activities. The other R8 Programs generally use the prevailing building standards as the program baseline, thus excluding code compliance from program benefit calculations. If results for Austin Green Building were recalculated counting only impacts attributable to home ratings (558 MWh and 277 kW), they would show that the program spent approximately $1.08 per kWh saved and $2,181 per kW reduced. Demand reduction expenditures are higher than most other programs but the energy savings expenditures compare favorably to results from most other regions.

In addition to quantitative benefits, program managers reported a variety of qualitative evidence that their programs were achieving the desired market effects.

Austin builders reported that the home buying public is becoming more sophisticated and there is increasing demand for green-built homes. Consumers now ask about volatile organic compounds (VOCs), air conditioner sizing, and dehumidification. Green materials that would be special order elsewhere are standard in-stock items in Austin. More construction projects are rating higher on the subsequent **Austin Green Building** Green Scale, even though the scale itself is getting more stringent. Projects now average 2.3 out of 5 stars. Market actors are now specializing in green building, including an appraiser and a mortgage broker. The Austin program compares favorably to other programs, particularly on the market share metric. **Austin**

Green Building was able to achieve a 20 percent market share for green certified homes without paying direct financial incentives to either the builder or the home buyer.

CA ENERGY STAR New Homes impacts include: a major builder in California has adopted ENERGY STAR standards for all homes it builds; other builders increasingly make it standard practice to build to ENERGY STAR standards. The phase 1 evaluation (RLW 2004) reported high builder awareness of the program (94 percent for single-family builders and 40 percent for multi-family builders). Two-thirds of participating builders report that they now specify energy-efficient measures that they would not have specified prior to program participation.

NJ ENERGY STAR Homes impacts include: a 100 percent commitment from two major builders to build to ENERGY STAR standards. The State has also adopted the New Jersey ENERGY STAR Homes standard for affordable development funding (NJHMFA). Compared to other programs implemented in similar markets, this program has a high program commitment rate with little attrition.

The transformation of the market due to efforts by TEP, including its **Tucson Guarantee Home** and predecessor programs is demonstrated in a number of ways. Over the last seven years inspections have found better installed ducts, better installed insulation, and less over-sizing on HVAC systems. The number of homes that have been successfully certified without repeat inspections has risen over time. Builders now request help and sign contracts in order to take advantage of the quality control testing and inspections rather than choosing not to participate due to the requirements for quality control inspections. Competing utilities now require similar steps for performance and competing programs are now marketed to homebuilders.

A key element of **WI ENERGY STAR** program theory is that in order to convince builders to build tighter homes (a key concern in cold Wisconsin), the program must address builder concerns about poor IAQ and mold associated with tight homes. Prior to the program, builders were already building fairly tight homes but were not providing good enough ventilation. The program taught builders how to build a house as a system. There is a spillover of builders of homes outside the utility service territories who are now paying full price for consultant service inspections. This demonstrates the value of the inspection process and shows that the program addressed barriers and helped builders manage risk.

Wisconsin Home Builder Associations are now taking an increasingly active role in hosting and promoting training programs. The HBAs use program trainings as fundraisers. Training has been very critical to subsequent program success. WECC has also leveraged considerable co-op advertising through its relationships with builders. Over an 18-month period, WECC spent $250,000 on cooperative advertising, which builders matched. HBA is now a partner for the statewide conference. This year the conference drew 100 attendees.

5. SOURCES

Austin Energy. 2003. Green Building Program Web site. www.ci.austin.tx.us/greenbuilder/.

Austin Energy. 2002. *State of the Environment 2002*. Austin Energy. Austin, TX.

Austin Energy. 2001. *State of the Environment 2001*. Austin Energy. Austin, TX.

Barros, Cecelia, Michelle Thomas, David Blanke (Program Managers, Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric). 2004. Best Practices In-Depth Interview, California ENERGY STAR New Homes. January 7.

Clean Energy for New Jersey. 2003. New Jersey ENERGY STAR Homes Program Web site. www.njenergystarhomes.com.

Cummings, Martin. 2002. *Independent Audit of Vermont Energy Efficiency Utility Energy and Capacity Savings for 2000 and 2001*. Montpelier, Vt.: Vermont Department of Public Service.

Douglas, Linda (Program Manager, Tucson Electric Power). 2003. Best Practices In-Depth Interview, Tucson Guarantee Home Program. October 28.

______________. 2003. Personal communication. October 29.

______________. 2004. Personal communication. February 9, May 18.

Efficiency Vermont. 2003. Vermont ENERGY STAR Homes Program Web site. www.efficiencyvermont.com.

Ellison, Steve (Program Manager, Oncor Group). 2003. Best Practices In-Depth Interview, Texas ENERGY STAR Homes Program. September 16.

Energy Center of Wisconsin. 2002. *Energy Savings from the Wisconsin ENERGY STAR® Homes Program*. Madison, Wis.: State of Wisconsin Department of Administration Division of Energy.

Focus on Energy. 2003. Wisconsin Energy Star Program Website. www.focusonenergy.com.

Forbes, Ashley. 2003. *State Implementation Plans: Energy Efficiency Update*. Austin, Texas: Texas Commission on Environmental Quality.

Gobris, Mary Kay (Evaluation Manager, Pacific Gas and Electric Company). 2004. Personal communications. June 21, 23, July 12

Haller, Pat (Marketing Manager, Efficiency Vermont). 2003. Best Practices In-Depth Interview, Vermont Energy Star Homes. October 6, 8.

______________. 2004. Personal communications. August 18, 24.

Heschong Mahone Group. 2001. *Residential New Construction Demand Impact*. San Francisco, Ca.: Pacific Gas and Electric Company.

Morgan, Richard (Program Manager, Austin Energy). 2003. Best Practices In-Depth Interview, Austin Green Building Program. August 19.

Nahn, Greg (Program Manager, Wisconsin Energy Conservation Corporation). 2003. Best Practices In-Depth Interview, Wisconsin Energy Star Program. October 27, November 5.

______________. 2004. Personal communication. August 23, 31.

Oncor Group. 2003. Texas ENERGY STAR Homes Program Web site. www.oncorgroup.com/electricity/teem/starhomes/default.asp

PA Government Services, Inc. 2003. *Focus on Energy Statewide Evaluation: Wisconsin ENERGY STAR® Homes Program: Evaluation Findings*. Madison, Wis.: State of Wisconsin Department of Administration Division of Energy.

______________. 2001. *Focus on Energy II Pilot Study Wisconsin ENERGY STAR® Homes Program: Third Interim Evaluation Report*. Madison, Wis.: State of Wisconsin Department of Administration Division of Energy.

Pacific Gas and Electric Company. 2003a. California ENERGY STAR New Homes Program Web site. www.pge.com/res/energy_tools_resources/efficient_new_homes/.

______________. 2003b. *2003 Annual Earnings Assessment Proceeding, Volume III: Energy Efficiency Programs Annual Report for 2002 and Energy Efficiency Programs Annual Report for 2002 Technical Appendix.* San Francisco, Ca.: Pacific Gas and Electric Company.

Peters, Jane, Shel Feldman, Brian Hedman and Lynn Hoefgen. 2002. *Best Practices from Energy Efficiency Organizations and Programs*. Portland, Ore.: Energy Trust of Oregon.

Quantum Consulting, Inc., Shel Feldman Management Consulting, Megdal & Associates. 2000. *Statewide Residential New Construction Utility Program Comparison Study*. San Francisco, Ca.: Pacific Gas and Electric Company.

Regional Economic Research, Inc. 2001a. *Residential New Construction Study*. San Francisco, Ca.: Pacific Gas and Electric Company.

______________. 2001b. *California Residential Efficiency Market Share Tracking*. Rosemead, Ca.: Southern California Edison Company.

Residential Energy Service Network. 2004. RESNET Program Web site. www.natresnet.org.

Ringhof, Susan (Program Manager, New Jersey Clean Energy Program). 2003. Best Practices In-Depth Interview, New Jersey Energy Star Homes. December 16.

______________. 2004. Personal communications. January 13, February 12, 23, March 24, May 25.

RLW. 2004. *Evaluation, Measurement, and Verification of the 2002 California Statewide ENERGY STAR New Homes Program: Phase 1 Report*. San Francisco, Ca.: Pacific Gas and Electric Company.

San Diego Gas and Electric Company. 2003a. California ENERGY STAR New Homes Program Web site www.sdge.com/construction/newHomes.shtml.

______________. 2003b. *2003 Energy Efficiency Programs Annual Summary and Technical Appendix: 2002 Results.* San Diego, Ca.: San Diego Gas and Electric Company.

Southern California Edison Company. 2003a. California ENERGY STAR New Homes Program. www.sce.com/sc3/011_reb_off/011c_nc/011c1_res/011c1b_bld_dev/011c1b1_energystarhomes.htm.

______________. 2003b. *2003 Energy Efficiency Annual Report, Summary Report: 2002 Results – 2003 Plans and Technical Appendix: 2002 Results.* Rosemead, Ca.: Southern California Edison Company.

Southern California Gas Company. 2003a. California ENERGY STAR New Homes Program Web site www.socalgas.com/construction/energystar.shtml

______________. 2003b. *2003 Energy Efficiency Programs Annual Summary and Technical Appendix: 2002 Results.* Los Angeles, Ca.: Southern California Gas Company.

Stockard, Mike (Program Manager, Oncor Group). 2004. Personal communication. August 27.

Tucson Electric Power. 2003. Tucson Guarantee Home Program Web site. www.tucsonelectric.com/Residential/GuaranteeHome/GuaranteeHome.asp.

U. S. Environmental Protection Agency. 2003. ENERGY STAR Program Web site. www.energystar.gov.

Vermont Department of Public Service. 2003. *Report to the Public Service Board: Evaluation Activities Related to Statewide Energy Efficiency Utility Initial 3-year Contract Cycle (Years 2000 - 2002)*. Montpelier, Vt.: Vermont Department of Public Service.

______________. 2002a. *Report and Recommendations to the Vermont Public Service Board Relating to Vermont's Energy Efficiency Utility*. Montpelier, Vt.: Vermont Department of Public Service.

______________. 2002b. *Report to the Energy Efficiency Utility Contract Administrator: Verification for Efficiency Vermont Year 2001 Savings and Total Resource Benefit (TRB) Claim*. Montpelier, Vt.: Vermont Department of Public Service.

West Hill Energy & Computing, Inc. 2003. *Vermont Residential New Construction 2002: Baseline Construction Practices, Code Compliance, and Energy Efficiency*. Montpelier, Vt.: Vermont Department of Public Service.

Wirtshafter Associates, Inc., Energy Market Innovations, Inc., Kreitler Research and Consulting. 2001. *Summary of Findings on New Construction Training Offerings*. San Francisco, Ca.: Pacific Gas and Electric Company.

Wisconsin Energy Conservation Corporation. 2002a. *Wisconsin ENERGY STAR Homes Builder Participation Agreement*. Madison, Wis.: Wisconsin Energy Conservation Corporation.

______________. 2002b. *2002 Annual Report: Proving the Value of Energy Efficiency*. Madison, Wis.: Wisconsin Energy Conservation Corporation.

Xenergy, Inc. 2003. *Final Report: Phase 1 Evaluation of the Efficiency Vermont Residential New Construction Program*. Montpelier, Vt.: Vermont Department of Public Service.

York, Dan, and Martin Kushler. 2003. *America's Best: Profiles of America's Leading Energy Efficiency Programs*. Washington, D.C.: American Council for an Energy-Efficient Economy.

APPENDIX R8A – BRIEF INTRODUCTION TO THE NATIONAL ENERGY EFFICIENCY BEST PRACTICES STUDY

INTRODUCTION

This report presents results of a comparative analysis of residential new construction programs included in the National Energy Efficiency Best Practices Study ("Best Practices Study"). The overall Best Practices Study objectives, scope, and methodology are briefly outlined in this Appendix. More details on methods and cross-program findings are provided in separate report volumes.

OBJECTIVE AND SCOPE

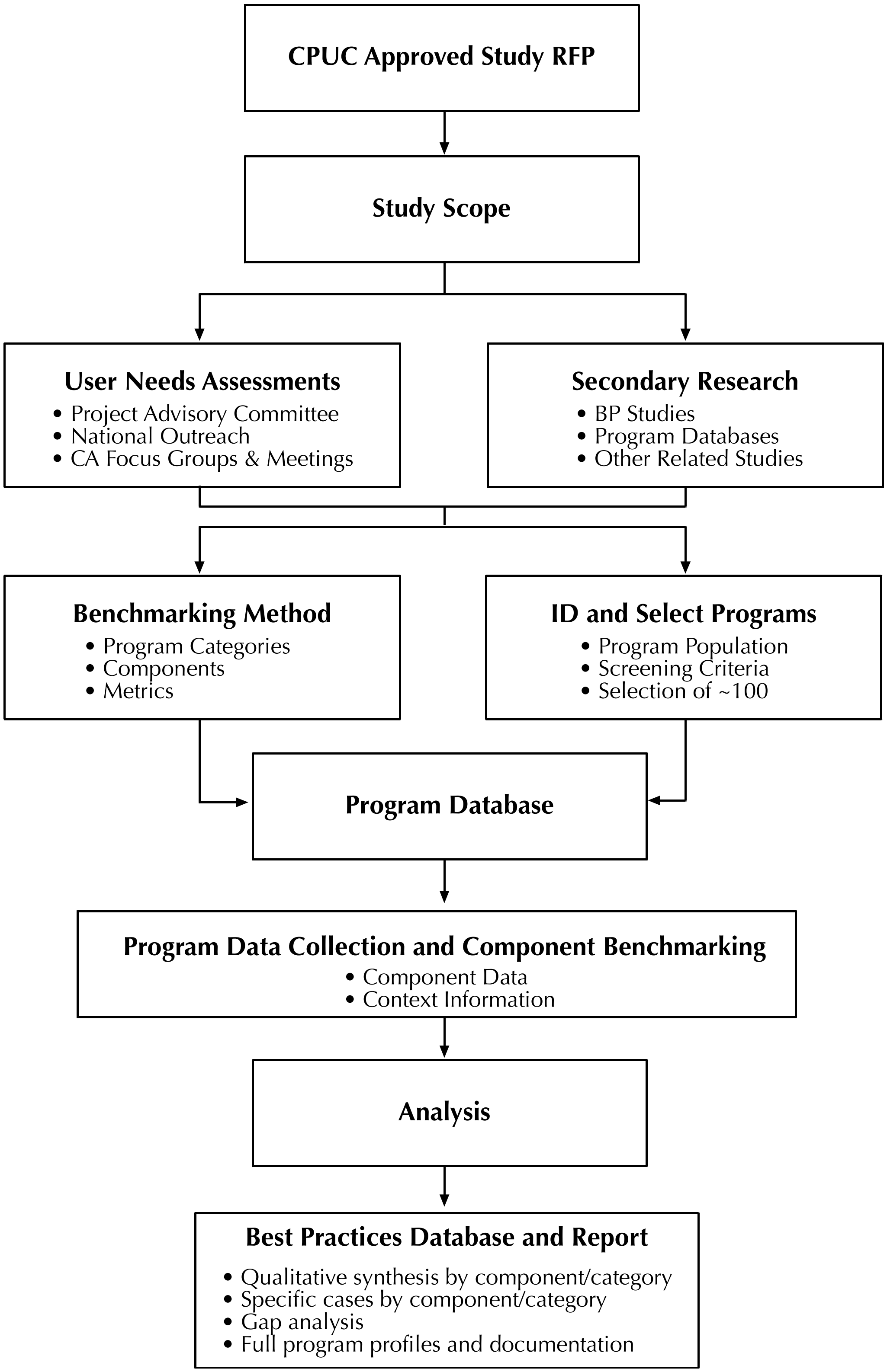
The overall goal of the Best Practices Study is to develop and implement a method to identify and communicate excellent energy efficiency program practices nationwide in order to enhance the design of such programs in California. In particular, program implementers supported through public goods funds are encouraged to use the Best Practices Study's products, along with other resources and their own knowledge and experience, to develop and refine energy efficiency programs.

The Best Practices Study is intended as a first-order effort to identify successful program approaches through systematic cross-program data collection and comparative analyses. It is not intended to produce a census of best practices across all types of programs. Such an approach would be neither practical nor useful given the number of programs that exist; the many differences in policies, goals, and market conditions around the country; the unique needs and market conditions in California; and the importance of encouraging innovation, which by its nature sometimes requires attempting approaches that are not yet proven. If the framework and results of the Best Practices Study prove useful, future phases of the work can expand the number and types of programs covered.

METHODOLOGY

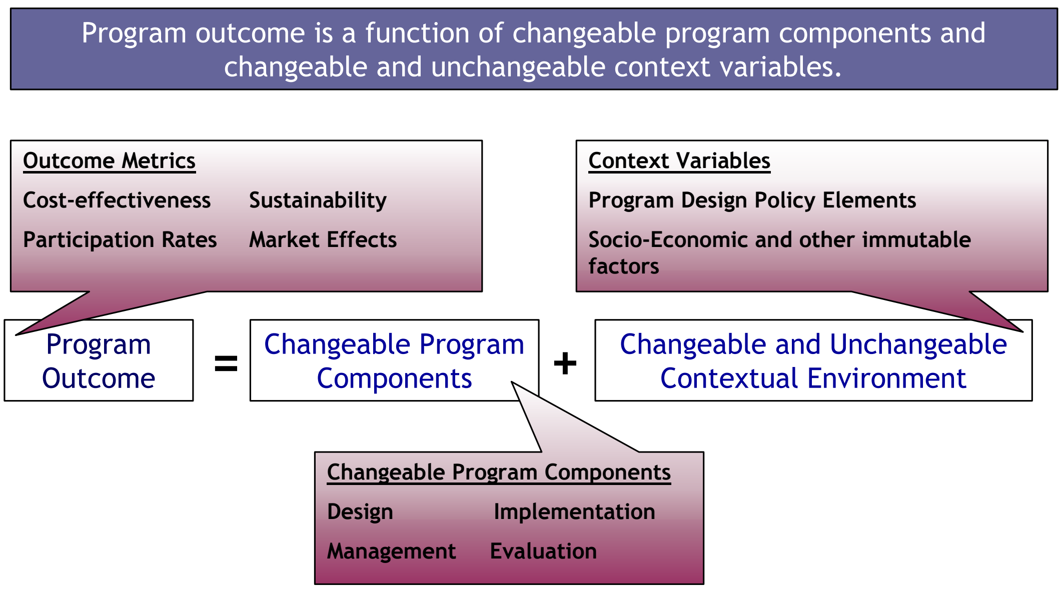
Key aspects of the Best Practices Study include a user needs assessment, secondary research, development of the benchmarking methods, identification and selection of programs to benchmark, development of the program database, data collection and program benchmarking, analysis, and preparation of the best practices report and final database. In addition, outcome metrics will be tracked. An overview of the Best Practices Study key activities is shown in Exhibit R8-9 below.

Exhibit R8-9
Overview of Energy Efficiency Best Practices Study



As shown below in Exhibit R8-10, the outcome of a program – as measured by $ per kWh saved, market penetration or sustainability – can be thought to be a function of changeable program elements, changeable portfolio-level design and programmatic policy decisions, and unchangeable social, economic, demographic, climate, and other factors. All of these factors can influence the ultimate success of an energy efficiency program. Some program elements (such as marketing, tracking or customer service) are directly controllable at the program level and can be modified to affect the success of the program. Other elements (such as the program policy objectives and whether the program has a single- or multi-year funding commitment) may not be changeable at the program level but may be changeable at a policy level. Other elements (such as the physical climate or density of the customer base) are not changeable and cannot be affected by program managers, implementers, or policy-makers.

Exhibit R8-10
Relationship Among Program Outcomes, Components, and Context



PROGRAM CATEGORIES

A program category is defined for the Best Practices Study as the basis for grouping "like" programs to compare across components and sub-components. Program categories may be defined in any number of ways, for example, as a function of target market (e.g., sector, vintage, segment, end use, value chain, urban/rural); approach (e.g., information-focused, incentive-focused [prescriptive; custom/performance based]); objective (e.g., resource acquisition, market transformation, equity), and geographic scope (e.g., local, utility service territory, state, region, nation); among other possible dimensions.

A number of criteria a good program categorization strategy should address were identified and include user accessibility, benchmarking compatibility, potential, compatibility with policy guidelines, and compatibility with scope directives**.** The number of program categories was limited to approximately 17 to conform to resource constraints. These are shown in Exhibit R8-11 below. The final scheme separates residential from non-residential programs, and distinguishes between incentive programs, information and training programs and new construction programs. Programs are also segregated based on targeted end-use and customer type. A Crosscutting section is included to address comprehensive programs that do not cleanly fall within the other 16 categories. Each program category has an associated code, which is used throughout the Best Practices Study for identification purposes (e.g., R8 Programs = Residential New Construction Programs reviewed for the Best Practices Study).

Exhibit R8-11
Program Categories & Related Codes

<table>
<tr><th colspan="3">Program Category</th><th>Code</th></tr>
<tr><td rowspan="8">Residential</td><td rowspan="5">Incentives</td><td>Lighting</td><td>R1</td></tr>
<tr><td>Air Conditioning</td><td>R2</td></tr>
<tr><td>Appliance and Plug Load</td><td>R3</td></tr>
<tr><td>Single-Family Comprehensive</td><td>R4</td></tr>
<tr><td>Multi-Family Comprehensive</td><td>R5</td></tr>
<tr><td rowspan="2">Information & Training</td><td>Whole House Audit with no/minimal incentive</td><td>R6</td></tr>
<tr><td>General & Other Comprehensive</td><td>R7</td></tr>
<tr><td colspan="2">New Construction Information & Incentives</td><td>R8</td></tr>
<tr><td rowspan="8">Non-Residential</td><td rowspan="5">Incentives</td><td>Lighting</td><td>NR1</td></tr>
<tr><td>HVAC</td><td>NR2</td></tr>
<tr><td>Refrigeration, Motors, Compressed Air, Process</td><td>NR3</td></tr>
<tr><td>Small Comprehensive</td><td>NR4</td></tr>
<tr><td>Large Comprehensive</td><td>NR5</td></tr>
<tr><td rowspan="2">Information & Training</td><td>End-Users</td><td>NR6</td></tr>
<tr><td>Trade Allies</td><td>NR7</td></tr>
<tr><td colspan="2">New Construction Information & Incentives</td><td>NR8</td></tr>
<tr><td>Other</td><td colspan="2">Cross Cutting</td><td>O1</td></tr>
</table>

PROGRAM SELECTION

Programs reviewed for each of the program categories in the Best Practices Study were selected through a three step process. First, programs were nominated using recent best practice studies, team member recommendations. Next programs were randomly selected from published data on energy programs to complete the roster. The third step involved conducting outreach interviews with the staff of nominated programs to determine if sufficient information was available to conduct the research. With the final set of programs determined, in-depth interviews were conducted.

PROGRAM COMPONENTS

The Best Practices Study approach focuses on analyzing programs primarily from the perspective of their changeable program characteristics. The Best Practices Team developed a method for breaking programs down into components and sub-components in order to systematically identify and compare specific program features of importance to overall program success. The four primary program components are program design, program management, program implementation, and program evaluation. These components and their associated sub-components are briefly summarized below.

- **Program Design** provides the initial foundation for a successful program. The program design category has two sub-components: **program theory** and **program structure** (which includes policies and procedures). Good program design begins with good program theory and a complete understanding of the marketplace. Good program structure, policies and procedures are necessary to translate program design theories and goals into practical and effective management and implementation actions.
- **Program Management** is the command and control center that drives the implementation process, and may be broken down into the sub-components of **project management**, **reporting and tracking**, and **quality control and verification**. Project management includes the structure and relationship among responsible parties. Reporting and tracking focuses on approaches to identifying and tracking useful and appropriate metrics that can be translated efficiently into reporting effective information. Quality control and verification includes accountability and improvement processes that are typically carried out through implementation and evaluation activities.
- **Program Implementation** is defined by the actual activities carried out in the marketplace to increase adoption of energy efficiency products and practices. Its sub-components include **outreach, marketing, and advertising**, the **participation process**, and **installation and incentive** mechanisms. Good outreach, marketing and advertising efforts should result in relatively high program awareness, knowledge of program specifics, and participation levels. The participation process is a critically important element of a program's ultimate success. Standard measures of market penetration and customer satisfaction provide one indication of a program's effectiveness at enrolling customers and processing their applications. Installation and incentives should demonstrate evidence of installation and delivery follow-through on marketing and outreach efforts.
- **Evaluation and Adaptability** of programs should also be analyzed. The Best Practices Study assesses the adequacy of evaluation efforts and how programs use evaluation results or other feedback mechanisms to improve over time.

DATA COLLECTION

Program information was gathered using primary and secondary sources. Primary data was collected largely through surveys of program managers and review of regulatory filings, annual reports, and program evaluations. The Best Practices Team conducted extensive interviews with program managers using a detailed survey instrument to guide the conversations. The survey instrument collected information on three main areas: policy context and environment, outcome metrics, and information about program components. The first set of questions elicited responses on how the program might have been affected by the broader context in which it operates. Next, respondents provided information on outcome metrics, such as program impacts and costs. The remainder of the instrument was devoted to collecting detailed program information for each program component. For each component, respondents were asked to provide factual information on how the program addressed each issue and qualitative judgments about what practices they felt contributed to the success of this program and what practices should have been avoided or could be improved.

STRUCTURE OF REPORTING

Complete project results are provided in project reports and a Web site that allows users to access information at varying levels of depth, including top-line summaries by program type or component, stand-alone chapters on best practices by program area, documentation of project methods, and individual program profiles.

DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix E:
Quantum Report: Home Retrofits

NATIONAL ENERGY EFFICIENCY BEST PRACTICES STUDY

VOLUME R4 – RESIDENTIAL SINGLE-FAMILY COMPREHENSIVE WEATHERIZATION BEST PRACTICES REPORT

Submitted to

California Best Practices Project Advisory Committee
Kenneth James
Contract Manager
Pacific Gas and Electric Company
P.O. Box 770000, N6G
San Francisco, CA 94177

Submitted by

PRIME CONTRACTOR
QUANTUM CONSULTING INC.
2001 Addison St, Suite 300
Berkeley, CA 94704

Volume R4 Report Contractor – Research Into Action

December 2004

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The Best Practices Study team would like to gratefully acknowledge the participation of the following individuals and their organizations in this report:

- Laura McNaughton and Kimberly Ihrig, National Grid
- David Galbraith and Rick Kallett, Sacramento Municipal Utility District
- Steve Shallenberger, American Synergy Corporation
- Sue Fisher, Pacific Gas & Electric
- Dana Teauge and Richard Moran, NSTAR Electric

These individuals participated in lengthy interviews in which they generously shared their expertise and lessons learned in program design, management, implementation, and evaluation. Without their participation and the support of their organizations this report would not have been possible.

In addition, we thank the many individuals that participated in the user needs focus groups conducted at the outset of the project.

We also thank the members of the Best Practices Study's Project Advisory Committee for their inspiration, insights, tireless review and thoughtful direction throughout the project:

- Kenneth James – Pacific Gas & Electric Company
- Pierre Landry – Southern California Edison Company
- Rob Rubin – Sempra Utilities
- Jay Luboff – California Public Utilities Commission, Energy Division
- Eli Kollman – California Public Utilities Commission, Energy Division
- Sylvia Bender – California Energy Commission

Finally, these reports benefited greatly from the diligent technical editing of Betsy Wilkins and the tireless production efforts of Alex Kang.

CONTACT INFORMATION

Kenneth James
Best Practices Study Contract Manager
Pacific Gas & Electric Company
P.O. Box 770000,N6G
San Francisco, CA 94177
415-973-0246
klj1@pge.com

Michael W. Rufo
Best Practices Study Prime Contractor Lead
Quantum Consulting Inc.
2001 Addison Street, Suite 300
Berkeley, California 94704
510-540-7200, ext. 2037
mrufo@qcworld.com

Jane S. Peters, Ph. D. and Dulane Moran
R4 Residential Comprehensive Single-Family Chapter Leads
Research Into Action Inc.
P.O. Box 12312
Portland, OR 97212
503-287-9136
janep@researchintoaction.com

ES. EXECUTIVE SUMMARY RESIDENTIAL SINGLE-FAMILY COMPREHENSIVE WEATHERIZATION PROGRAM AREA (R4)

ES.1 INTRODUCTION

This volume presents results of a comparative analysis of residential single-family comprehensive weatherization programs included in the National Energy Efficiency Best Practices Study ("Best Practices Study"). The overall Best Practices Study objectives, scope, and methodology are briefly outlined in Appendix R4A of this report. More details on methods and cross-program findings are provided in separate report volumes.

The Best Practices Study team ("Best Practices Team") reviewed six residential single-family comprehensive weatherization programs for this program area study ("R4 Programs" and "R4 Study," respectively), each of which has the goal of improving the overall efficiency of single-family homes. These programs focus primarily on resource acquisition – achieving cost effective kWh savings through installation of specific measures. Typically, the cost effectiveness of individual measures is determined measure by measure, with the most cost-effective measures being eligible for rebates, incentives, or loans through the weatherization program. The R4 Programs are listed in Exhibit R4-E1 below and presented in the body of this report. A discussion of the program selection process is provided in Appendix R4A.

ES.2 KEY CATEGORY THEMES

Six key crosscutting issues that affect multiple program components were identified.

Contractors were commonly used by R4 programs. Installation contractors played a major role in the delivery of services for many of these weatherization programs. While the actual role of contractors varied, in every R4 program they provided the primary link between customers and energy savings. Supporting the business development efforts of these market actors proved key to ensuring program success. Certification, training, and general business support were used to assure these partners marketed the program to all potential customers. Strong relationships with weatherization contractors who are capable of marketing the program to customers in their homes are an important component of successful residential weatherization and retrofit programs.

Issues of diminishing returns changed the way these programs were implemented. For the most part, the R4 Programs were off-shoots of residential weatherization programs offered consistently for 10 to 20 years. Initial programs focused on low-cost, high-leverage activities that in some cases dramatically reduced the overall energy use of the home. As increasing percentages of homes are touched by program efforts, the obvious, low-cost measures become rarer. The remaining efficiency resources are likely to continue to be harder to implement and less cost-effective, thus less expensive implementation approaches must be found to ensure continued program success.

It is important to leverage a variety of funding choices. The R4 Programs used a variety of tools for funding efficiency upgrades in single-family homes including rebates, loans, contractor payments, and low or no co-payment for selected groups or measures. The specific mix varied by community need and organizational structure.

A long term commitment to the sector is beneficial. These programs generally demonstrate that a long-term commitment to the residential sector and a relatively stable program is important to program success. Trade allies and customers are most responsive to programs that have been in operation for many years with consistent approaches. Annual program changes confuse market actors and lead to a reduced willingness by trade allies to support the program and a reduced ability of customers to know how to participate.

Monitoring and controlling the impact of free-ridership can help contain program costs. Free-riders are those customers who receive incentive dollars for measures they would have purchased anyway. The R4 Programs demonstrate that periodic evaluations allow program managers to modify program design or measure mix to assure the program is not paying for "standard practice" measures.

Several R4 programs included ENERGY STAR® rebates and market transformation efforts to support the business development of weatherization contractors. Market transformation activities are not traditionally associated with single-family weatherization programs, but there are signs that this may be changing. For example, some of the likely strategies for transforming the overall market for single-family weatherization include focusing on the desire of homeowners to improve the value and comfort of their homes (Thorne 2003).

While residential weatherization programs will likely continue to be focused on resource acquisition, the influence of market transformation thinking and program activities is likely to have continuing impact on program design. The increasing awareness of ENERGY STAR brand appliances and homes and the availability of high-efficiency room air conditioners and HVAC systems will likely mean their inclusion as the components of comprehensive residential programs. These programs offer marketing leverage and can potentially raise general awareness of the importance of choosing high efficiency equipment whenever possible.

ES.3 BEST PRACTICES SUMMARY

Best practices are identified in the R4 Study for each of the four major program components used to organize data collection and analysis. These program components are Program Design (including program theory), Program Management (including project management, reporting and tracking, and quality control and verification), Program Implementation (including participation process and marketing and outreach) and Program Evaluation. Best practices were developed by analyzing information across programs developed from detailed interviews of program managers and thorough review of all relevant secondary sources such as program filings and evaluations. Exhibit R4-E2 presents the list of best practices developed from the analysis of R4 programs. Exhibit R4-E3 provides the rationales associated with each best practice. The remainder of this report provides detailed analysis and discussion of program features and best practice rationales.

The scope of this study also includes a California gap analysis. A comparison of the best practices presented in this report with the practices employed in California's Statewide Single-Family Rebate Program is in progress and will be published when complete in a separate document.

Exhibit R4-E1
R4 Programs: Residential Single-Family Comprehensive Weatherization Programs Reviewed For R4 Study

Program Name	Implementer/s	Abbreviation for R4 Report
2001-2002 Central Valley Hard-to-Reach Mobile Home Energy Savings Program	American Synergy Corporation	ASC HTR Mobile Home
2002 California Statewide Single-Family Energy Efficiency Rebate Program	Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric Company (SDG&E)	CA SW Single-Family
1999-2000 Residential High-Use Program	NSTAR	NSTAR Res High-Use
2001 EnergyWise Program	National Grid USA	NG EnergyWise
2002 Efficiency Equipment Loan Program	Sacramento Municipal Utility District (SMUD)	SMUD Equipment Loan
2002 Residential Weatherization Program	Tacoma Power	Tacoma Res Weatherization

Exhibit R4-E2
Summary List of Best Practices for Residential Single-Family Comprehensive Weatherization Programs

Program Theory and Design
• Know the market within which the program works • Offer a stable and consistent program available to single-family residential customers • Have a sound program plan and clearly articulated program theory which describe the program niche, its resources and ultimate goal • Define and locate hard-to-reach customers and target programs accordingly, as appropriate
Program Management: Project Management
• Maintain in-house oversight of program • Set clear expectations and provide adequate support for all contractors
Program Management: Reporting and Tracking
• Build and maintain a database capable of tracking key program progress indicators • Obtain specialized software for loan tracking • Track project cycle time, customer complaints and other indicators of contractor and program performance • Use comprehensive, logical and easy to use tracking systems
Program Management: Quality Control and Verification
• Use a verification method capable of confirming measure and installation quality • Select an appropriate percentage of properties for inspection and verification • Write clear specifications for measure installation using "contractor-friendly" language and train contractors on what is expected • Pre-screen installers who have been trained for and are committed to high-quality installation • Create processes for tracking complaints and failure by measure and by contractor • Require that installers honor the warranties that come from product manufacturers
Program Implementation: Participation Process
• Develop a network of local installers who are committed to high-quality standards • Balance simplicity and risk management through offering "one-stop-shopping" for customers • Establish systems that fund loans and issue rebates in shortest possible time • Control for free-ridership through periodic market studies, consumer surveys and by tying popular measures to those more cost-effective measures that are less likely to be installed • Offer a mix of services and measures attractive to homeowners • Provide low-interest loans or financing as an additional, high leverage tool
Program Implementation: Marketing and Outreach
• Develop marketing tactics that reflect program strategies • Promote messages that equate efficiency improvement with home improvement • Leverage efforts of other programs that seek to increase overall awareness of the benefits of efficient choices, including ENERGY STAR appliances and homes • Offer industry education when necessary to help bridge the gap between standard practice and efficiency improvements
Program Evaluation
• Connect the implementation team with the evaluation effort • Conduct periodic *ex-post* impact evaluations • Leverage limited evaluation dollars by jointly funding expensive engineering reviews with other programs or other utilities • Conduct process evaluations early in a program's life or after major programmatic changes

Exhibit R4-E3
Summary of Best Practices Rationale and CA Gap Summaries for Residential Single-Family Comprehensive Weatherization Programs

Best Practice	Rationale
Program Theory and Design	
Know the market within which the program works	Much of a comprehensive weatherization program's success depends on understanding the market within which the program works. This permits the program to have effective relationships with market actors involved in home improvement and weatherization.
Have a stable and consistent program available to single-family residential customers	Many of the opportunities to cost effectively improve the efficiency of single-family homes occur periodically and randomly as equipment fails or remodeling is scheduled. A stable and consistent program offering will impress upon homeowners and contractors over time that they should always check for options in efficiency upgrades.
Have a sound program plan and clearly articulated program theory which describe the program niche, its resources and ultimate goal	These programs demonstrate that program theory and program planning can achieve similar ends. Program planning, when well done, includes a clear articulation of the programs target market, its resources and its goal.
Define and locate hard-to-reach customers and target programs accordingly, as appropriate	For single family programs, hard-to-reach populations might include those outside of urban/suburban areas, those whose primary language is something other than English, and those with moderate incomes. Where appropriate given the policy environment, efforts to include these groups assure that energy efficiency funds are spent in an equitable manner.
Program Management: Project Management	
Maintain in-house oversight of program	Adequate oversight and successful relationships with program contractors assures that program actors are clear about their responsibilities in program implementation. In cases where problems may exist, oversight assures that they are discovered and corrected quickly.
Set clear expectations and provide adequate support for all contractors	Successful relationships with turnkey implementation or with local contractors are vital to assuring that the program is marketed at appropriate customers and to eligible household systems.

Best Practice	Rationale
Maximize incentive budgets without undermining the efforts of weatherization contractors and others to continue to offer the services valued by the program	Not all measures are conducive to a customer rebate. Programs must choose measures that offer the most energy savings per incentive dollar, and that are unlikely to be chosen without incentives. At the same time, caution should be taken when reducing ancillary program components like field support and contractor training – these may tie less directly to immediate energy savings, but over time they can improve the overall capacity of the market to consistently supply high-quality installation of energy-efficient equipment.
Program Management: Reporting and Tracking	
Build and maintain a database capable of tracking key program progress indicators	Indicators that should be tracked include assumptions of energy savings, participant data and any program-specific data. This information should be entered as close to real time as possible, to allow for active, adaptive, program management. Systems that are able to track participation and energy savings by measure are not only typically required by regulators, but also provide for effective program management.
Obtain specialized software for loan tracking	Loan programs have their own standard practices that typically are not compatible with utility program management databases. Specialized loan software facilitates quick loan processing, and allows for accurate tracking of the financial components related to loan servicing.
Track project cycle time, customer complaints and other indicators of contractor and program performance	Having information on cycle time and contractor complaints can help program mangers identify problem areas or anomalous events and pursue corrective actions.
Use comprehensive, logical and easy to use tracking systems	If data tracking systems are too complex or unwieldy, staff may keep duplicate records in spreadsheets or other documents, taking time away from other program tasks.
Program Management: Quality Control and Verification	
Use a verification method capable of confirming measure and installation quality	Achieving energy savings is the goal of most residential weatherization programs, something that requires periodic, random inspection and verification of installations.
Select an appropriate percentage of properties for inspection and verification	Begin by inspecting all of the first installation jobs by a contractor, as quality becomes consistent the percentage of inspected jobs can be reduced.
Write clear specifications for measure installation using “contractor-friendly” language and train contractors on what is expected	Significant assurances may be available through up-front training of contractors and through establishing clear expectations with contractors; however this will not replace the overall need for at least periodic measurement and verification efforts.

Best Practice	Rationale
Pre-screen installers who have been trained for and are committed to high-quality installation	When local weatherization contractors are used in a program, training and pre-screening can meet contractor concerns about openness and provide assurance to customers and to the utility that quality installations will be obtained.
Create processes for tracking complaints and failure by measure and by contractor	Tracking enables the responsible agency to monitor contractor field success and to provide contractors with feedback to help them improve delivery.
Require that installers honor the warranties that come from product manufacturers	For products that fail prematurely or never work properly, this requirement will mean that installers be available to solve the performance problem and handle any interaction with the manufacturer.
Program Implementation: Participation Process	
Develop a network of local installers who are committed to high-quality standards	This offers support for the weatherization industry and allows these contractors to benefit from the trust customers have in their utility while building the capacity of the weatherization services market.
Balance simplicity and risk management through developing "one-stop-shopping" for customers.	It can be difficult to implement levels of control appropriate for protecting the program administrator while allowing for simple, streamlined participation. It is important to keep both goals prominent in program planning and management. Whenever possible, simplify agreements, language and processes for consumer and contractor participants and avoid letting risk management supersede the need for simplicity.
Establish systems that fund loans and issue rebates in shortest possible time	SMUD's ability to fund loans and make disbursements to contractors in five business days demonstrates a clear best practice to the more typical four - six weeks it takes most utilities to issue rebate checks.
Control for free-ridership through periodic market studies, consumer surveys and by tying popular measures to those more cost-effective measures that are less likely to be installed	Scheduling periodic assessments of free-ridership rates for the most popular measures will assure that the program is actually having an impact and not paying for something unnecessarily.
Offer a mix of services and measures attractive to homeowners	The program offering should be capable of spurring homeowners into action and increasing their awareness of the value of investments in residential energy efficiency.
Provide low-interest loans or financing as an additional, high leverage tool	For customers who would like to install high-cost HVAC or window replacement, financial tools can make efficiency upgrades accessible and affordable. This reduces lost opportunities. For programs using contractors, loans provide a high value tool for the contractors to use in getting customers to choose efficient solutions.

Best Practice	Rationale
Program Implementation: Marketing and Outreach	
Develop marketing tactics that reflect program strategies	Customer-driven programs need tactics that drive customers to seek out program information and follow through on installation. Contractor-driven programs will need tactics to maintain strong relationships with contractors and assure that they continue to promote the benefits of program participation to their customers.
Promote messages that equate efficiency improvement with home improvement	Messages that appeal to homeowner desire to improve property value and home comfort are appealing.
Leverage efforts of other programs that seek to increase overall awareness of the benefits of efficient choices, including ENERGY STAR appliances and homes	Retail outreach and support can play an important role for measures that are typically installed by customers including insulation, programmable thermostats, and appliances. The national ENERGY STAR efforts provide a common brand for both customers and trade allies to associate with high-value energy savings.
Offer industry education when necessary to help bridge the gap between standard practice and efficiency improvements	Demonstration efforts like California's pool pump trailer give market actors a chance to "kick the tires" and ask questions. Similar efforts in HVAC and windows in the past have provided a way to open dialogue with market actors about product improvements with the potential to save energy.
Program Evaluation	
Connect the implementation team with the evaluation effort	Creating a climate within which evaluation findings are used to improve program delivery and provide important information to staff maximizes the value of the evaluation investment.
Conduct periodic *ex-post* impact evaluations	Impact evaluations may not need to be annual. However, scheduling them at least every two to three years will ensure that changes in program savings are sufficiently tracked to identify changes in program success.
Leverage limited evaluation dollars by jointly funding expensive engineering reviews with other programs or other utilities	Partnering with other utilities, targeting measures of concern and/or simply using data from other utilities are all ways of stretching the funds available for these studies. Programs with similar target markets and measure mixes can leverage evaluation dollars by co-funding impact evaluations.
Conduct process evaluations early in a program's life or after major programmatic changes	Process evaluations help identify barriers to participation and other issues with the potential to impact program effectiveness that may not show up in measurement and verification efforts. These evaluations can provide critical information that may increase participation, ultimately saving more energy.

1. OVERVIEW OF REVIEWED PROGRAMS

The R4 Programs shared a common goal of improving the overall efficiency of single-family dwellings including, in one case, mobile homes. The programs offered a variety of incentives, rebates and low cost financing designed to reduce the incremental cost associated with high-efficiency measures. The following briefly introduces each program.

The **2001-2002 Central Valley Hard-to-Reach Mobile Home Energy Savings Program (ASC HTR Mobile Home**) was **implemented by American Synergy Corporation (ASC)**, a private for-profit contractor, through California's third party local program offering. The program targeted hard-to-reach (HTR) mobile home customers in California's Central Valley, installing measures at little to no cost to residents. Weatherization crews completed the work as scheduled by ASC. The program offered shell and infiltration measures as well as lighting, water heating, programmable thermostats, and efficiency education activities to mobile home residents. The program's two-year goal was to provide energy savings measures to 6,000 mobile home customers. Halfway through the implementation period ASC was on target, having served over 2,900 customers.

The **2002 California Statewide Single-Family Energy Efficiency Rebate Program (CA SW Single-Family**) was **implemented statewide by California's four largest investor-owned utilities** (IOUs): Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas Company (SCG), and San Diego Gas & Electric Company (SDG&E). The program used public goods funds to offer prescriptive rebates for energy-efficient products in four distinct markets: HVAC, home improvement, appliances, and pool pumps. The program sought energy savings and demand reduction, and was open to all single-family residential customers in the service territories of PG&E, SCE, SCG and SDG&E. The program garnered 35,488,363 kWh savings, or 75 percent of its goal. This was a mass market program that also had a formal regulatory mandate for HTR customer participation.

The **2001 EnergyWise Program (NG EnergyWise**) was **implemented by National Grid USA**, an investor-owned utility serving territories in the Northeastern United States, through turnkey contractors. Services of the single-family component of NG EnergyWise included site visits to customer homes with measures recommended and installed on a case-by-case basis. Electrically heated residences were eligible to receive insulation, thermostats and air sealing. All residences, regardless of heating type were eligible for installation of baseload measures such as lighting. The program offered residential customers an incentive that covered up to 50 percent of the cost of all allowable measures, up to a maximum of $1,000. Rebates of $300 were also available to replace inefficient refrigerators. Multi-family customers were served through a separate component of the NG EnergyWise program. In 2001, the program served 5,012 single-family participants.

The 1999-2000 Residential High-Use Program (NSTAR Res High-Use) was **implemented by NSTAR**, Massachusetts' largest investor-owned utility, through turnkey contractors. The program targeted "high-use" residential customers, defined as using more than 8,000 kWh annually. NSTAR Res High-Use services included energy audit and education activities, coupled with incentives for and installation of specific measures. Measures included lighting, refrigeration, water heating, space conditioning and infiltration, and waterbeds. NSTAR Res High-Use served 3,827 participating customers.

The **2002 Efficiency Equipment Loan Program (SMUD Equipment Loan)** was **implemented in-house by the Sacramento Municipal Utility District (SMUD or the District)**, a customer-owned utility serving the Sacramento, California area**.** SMUD Equipment Loan supported the efforts of other SMUD efficiency programs by offering its home-owner customers streamlined, point-of-sale financing of energy-efficiency equipment. Participants were required to use SMUD-approved contractors, who helped prepare the loan application and other documents for the customer. Financing was offered at interest rates close to market rates. Eligible equipment included central air conditioning systems, windows, attic and wall insulation, heat pumps, solar water heating and insulated siding. Since 1996, an annual average of 5,000 SMUD customers have applied for loans through SMUD Equipment Loan and its predecessor programs. In 2002 the program had 3,360 participants.

The **2002 Residential Weatherization Program implemented by Tacoma Power (Tacoma Res Weatherization)**, a municipal utility in Washington State, served residential customers who use electric heat as their primary heat source. Program services included Home Energy Check, a free evaluation of home energy efficiency, and incentives for recommended measures. Measures included insulation, infiltration and windows. Zero interest loans were available to qualified customers. 930 audits were performed through the program, resulting in 630 weatherization jobs.

Specific program characteristics are noted in Exhibit R4-1.

Exhibit R4-1
Summary of R4 Program Characteristics

	ASC HTR Mobile Home	2002 CA SW Single-Family	NG EnergyWise	NSTAR Res High-Use	SMUD Equipment Loan	Tacoma Res Weatherization
Period Reviewed	Oct 2002 - Oct 2003	Jan – Dec 2002	Jan – Dec 2001	Aug 1999 – Aug 2000	Jan – Dec 2002	Jan – Dec 2002
Average Retail Price /kWh	$.135	$.135	$.11	$.11	$.09	$.06
Program Expenditures	$1,421,312[1]	$25,921,725	$1,165,000[7]	$3,464,000[10]	$2,361,418	$938,000
Total Incentives Paid	NA	$16,874,639	Unknown[8]	$497,000	NA	$229,000
Eligible Households	45,000	9.1 million[4]	NA	~76,945[3]	370,000	145,000
Net MWh goal	3,565[2]	47,303	3,591[6]	NA	NA[5]	NA
Net kW goal	1,757[2]	35,356	953[6]	NA	NA[5]	NA
MWh achieved	3,447[2]	36,028	3,461[6]	3,179	1,254	2,031
kW achieved	1,329[2]	31,869	743[6]	Winter: 1164 Summer 831	700	NA
Unique Participants	2,957[1]	177,123[9]	5,012	3,827 (2000)	3,360	930 audits 630 jobs

1. Budget and goals were set for a two year program cycle (2002-2003) as proposed to the CPUC. Total projected budget for the program is $2,277,632. Target number of participants for the two year program is 6,000.
2. 2002-2003 CPUC Energy Efficiency Programs Quarterly Report 3rd Quarter 2003
3. NSTAR's database keeps a 15 month record of residential customers whose total kWh usage makes them eligible for the program; currently those who use 8,000 kWh or more annually.
4. Approximate. 2001 residential accounts of PG&E, SCE and SDG&E. California Energy Commission Web site: http://www.energy.ca.gov/electricity/utility_sales.html
5. Program goals are expressed in loans granted, both number and value and in the percentage of District peak load reduction and energy savings goals for all residential programs made possible through loan financing.
6. Massachusetts Electric and Nantucket Electric territories, 2001 single-family component as reported by evaluation staff via email communication.
7. Actual expenditures for single-family program in Massachusetts, as reported by program staff via email communication.
8. National Grid does not provide rebates, instead paying vendors for installation. Customers pay a co-pay.
9. This number (177,123 measures) represents the number of measures (generally appliances) rebated. It excludes 5,767,224 square feet of attic insulation, 3,814,949 square feet of high performance dual pane windows, and 2,056,196 square feet of wall insulation. Multiple measures installed in the same home make the total number of participants lower than this.
10. In-house costs are tracked separately from external costs. Implementation is contracted out at a cost of $2,752,000. Includes $497,000 in incentive costs.

2. CONTEXT

2.1 POLICY ENVIRONMENT

The residential sector represents a large portion of electricity use in America, being responsible for 42 percent of electricity sales nationwide (EIA 2003). However, unlike the large customers of the commercial or industrial sectors, each individual housing unit represents only a small fraction of the total load for a given utility. Recent energy efficiency studies estimate that potential savings across households range from 20-40 percent, although only half that amount is likely to be cost-effective and achievable through efficiency programs (Nadel 2004). Since average residential consumption ranges from roughly 5,000 to 15,000 kWh per year (depending largely on weather and the presence or absence of electric heating), these savings can be relatively small on a per unit basis and scattered over what are often large geographic areas – and, therefore, not cost-effective to obtain through efficiency programs.

Regardless of the small per unit savings, residential ratepayers contribute to program funding and should, therefore, receive program-related benefits. This sector also represents a large aggregate consumer of energy, making it an important sector for efficiency programs. As a result, hundreds of programs for energy efficiency in the residential sector have been offered to ratepayers nationwide over the past 25 years. These programs have provided customers with various combinations of rebates, information, audits, and direct installation of measures—all designed to save energy or reduce demand (DeCicco 1996).

Historically, residential weatherization programs have relied upon a resource acquisition approach, being designed primarily to help utilities avoid the cost of acquiring new generation resources. The consideration of energy efficiency as resource acquisition emerged after Congress enacted a federal statute in 1980 that defined conservation of electricity as a resource that could substitute for new electrical generation (16 USC Chapter 12H. S. 885). Initial program efforts included expansive demonstrations of maximum potential savings through blanket installations of all technically feasible measures.[1]

Later in the 1980s and through the first half of the 1990s, utilities began accounting for potential conservation resources in their integrated resource planning efforts, including more typical residential program offerings. Typical program types included rebate programs that relied on the utility or a turnkey contractor to serve as the key contact for participants, and direct installation programs that use a contractor as the key contact providing program-related services. An increasingly common approach is contractor-driven programs, for which the

[1] One of the first efforts to demonstrate maximum technical potential was the Hood River Conservation Project (HRCP) HRCP was a demonstration project implemented in Hood River, Oregon in the early 1980's (between fall 1983 and the end of 1985). Participating homeowners signed an authorization for the work to be done by the Project. However, they did not choose, supervise, or pay contractors; Project staff performed these functions. HRCP assumed much of the authority and responsibility normally held by homeowners. The project's extensive research and data collection activities helped define the appropriate role for Northwest utilities in securing "conservation resources" in the residential sector (Hirst 1987).

contractor seeks customers and qualifies them for installation. The choice of program approach is driven by a combination of needs including maximizing kWh, minimizing program administrative costs and maintaining program cost-effectiveness within a declining range of cost-effective opportunities.

More recently, some comprehensive residential weatherization programs were affected by a shift in orientation in some jurisdictions toward market transformation strategies. As the name implies, market transformation efforts employ a variety of tactics aimed at permanently altering the choices and decisions made by consumers, distributors, and manufacturers in a given product market. For residential weatherization programs, a market transformation strategy could mean providing business training and product support to installation contractors, branding and marketing of energy-efficient home improvement products (for example, Energy Star windows), or establishing incremental code improvements for residential dwellings. While market transformation programs gained favor and increased dramatically in the 1990s, the effect on comprehensive residential weatherization programs has generally been less significant on these programs than on other types of programs.

Over the 25-year history of residential efficiency programs, program managers, evaluators, and regulators have learned a great deal about energy usage in the residential sector. These lessons continue to inform the design of residential weatherization programs and the policy driving it, and fall into two main categories: non-behavioral and behavioral.

Non-behavioral factors tend to drive much of the energy consumption of residential buildings. The key non-behavioral factors are:

- Weather (the single best predictor of energy use)
- Variability in housing stock: configurations, square footage, age
- Cost of electricity and the cost of substitute fuels
- Impact of regional and national economic issues (recession or growth)

Behavior affects both overall energy consumption and what can be saved by program participants. Energy-affecting behavior varies widely across many factors, and can appear random when observing usage at an individual household level (Hwang 1989). In short, it is not the building consuming energy, but human activities and decisions that drive that energy use. Changes in these behavioral factors can make it difficult to measure and otherwise observe the effects of energy efficiency or conservation actions on overall energy use. Examples of factors potentially affecting behavior include changes to:

- Household demographics including income, age and number of residents in a house
- Increases in energy use due to new equipment loads
- Variations in perceptions of comfort
- Attitudes toward energy consumption and related environmental concerns

Improving the understanding of the links between behavioral and non-behavioral drivers of residential energy consumption has been an important part of the history of residential weatherization programs. A large body of research based on the results of process and impact evaluations has shown that some measures have much more significant impacts than others on household energy use. This research, along with knowledge developed from program managers' personal experience and supply-side market research, also demonstrates the importance of many other factors that can affect program savings—factors such as maintaining quality control in measure installations, changes in the types and availability of efficiency measures, and the influences on adoption levels through different programmatic and incentive strategies.

2.2 PROGRAM STRATEGY AND GOALS

Steady improvement in the efficiency of household appliances and systems creates gaps over time between technology in existing homes and the improved efficiency available in new equipment. R4 Programs' goals often included taking advantage of natural replacement of home heating or air conditioning equipment, renovation activities, and upgrades. When a homeowner replaces a major system or energy-using component of a home, there is an opportunity to influence decisions so that significant efficiency improvements can be captured. If the opportunity is missed, and the homeowner replaces a system with a less efficient option, the opportunity to improve the system is thought to be lost for the life of the measure–often 15-20 years. Capturing these lost opportunities is a major objective of most of these comprehensive residential weatherization programs.

In an effort to capture these lost opportunities, R4 Programs generally offered incentives that covered all or a portion of the incremental cost difference between standard equipment and high-efficiency equipment. Some programs also added turnkey services to market and deliver measures by contractors or program implementation specialists.

All of the R4 Programs were focused on resource acquisition, although a few programs also had secondary market transformation objectives (for example, promoting the ENERGY STAR brand) and objectives related to equity (for example, offering services in the HTR mobile home market). The cost-effectiveness tests applied to individual measures prior to their inclusion in a program generally reflect the avoided costs to the utility in energy or demand savings that are achieved by equipment upgrades or shell improvements. While these savings make residential retrofit programs generally cost-effective, the large variation across households makes such investments economically risky for the *individual* homeowner. (Hirst et al. 1986) Many of the strategies of current programs are focused on reducing the perception of risk.

Program design has historically reflected efforts to overcome long-standing barriers to homeowner investments in energy efficiency upgrades: uncertainty about what measures to take, uncertainty about the effectiveness of a given measure, and uncertainty in selecting a contractor (Hirst et al 1986). Uncertainty about which measures to take can be addressed through a variety of activities, including public information campaigns, Web-based information, lists of qualified prescriptive measures, coordination with national certification efforts like ENERGY STAR® , and point of purchase (POP) information at retail outlets. Uncertainty about the effectiveness of a given measure can be addressed through cost-effectiveness analyses, measurement and verification efforts, engineering estimates and experience. Programs may also try to reduce the uncertainty in selecting a contractor by pre-screening contractors and/or requiring contractors to have certain training prior to approval.

While experience has improved the understanding of the market and program delivery in residential weatherization, significant barriers remain in both the supply and demand for energy efficiency services in the residential retrofit market. Demand-side barriers include: the impact of higher incremental cost for energy-efficient upgrades; a limited understanding of the benefits of energy efficiency; a lack of clear, reliable information on the best measures and contractors; and the ability of programs to reach potential participants at key points (such as remodeling or at the point of equipment failure) (Thorne 2003). Supply-side barriers center around the limitations of the skills, knowledge and abilities of contractors in the retrofit market - including contractors who perceive a lack of consumer demand, lack the skills to market new services, cannot absorb the risk of investing in new skills or equipment, and those who resist recommending measures outside their expertise or core business (Thorne 2003).

3. COMPARISON OF PROGRAM COMPONENTS

This section compares the R4 Programs across the four major program components used to organize data collection and analysis. These program components are Program Design (including program theory), Program Management (including project management, reporting and tracking, and quality control and verification), Program Implementation (including participation process and marketing and outreach) and Program Evaluation.

3.1 PROGRAM THEORY AND DESIGN

None of the R4 Programs had formal program theory documents available. However, many represent the present day evolution of predecessor programs, in some cases more than 15 years of program implementation. Given the long history of residential weatherization programs, the theory on which these types of programs rest is thought by program staff interviewed to be well established. Relying on simple, familiar resource acquisition strategies may mean less overall attention to program theory than might be the case in more experimental programs or in market transformation efforts. In residential resource acquisition programs, the major challenges driving program design remain establishing a list of qualifying cost-effective measures, identifying and locating eligible customers, and convincing them to act.

Qualifying measures can be identified using national data estimating kWh usage of various equipment and the bounds of achievable savings. Identifying and locating eligible customers can be less straightforward. Indeed, the R4 Programs present a range of customer types (Exhibit R4-2). The choice of target customers is driven by a combination of regulatory requirements, estimated savings potential, and equity considerations. Equity concerns can emerge in program planning discussions and relate to who benefits from program offerings. For a variety of reasons the typical participant in energy efficiency programs tends to have more education and a higher income than a non-participant, raising issues of potential inequity. Simply pursuing the greatest amount of cost-effective resource savings, regardless of customer type, may appear rational from an economic perspective, but can create concerns about the distribution of public benefits funds if segments that contribute funds do not participate at proportionate levels. If weatherization measures result in improved property values for program participants by helping pay for high-efficiency equipment and home improvement measures, it is important that these benefits be realized by all types of consumers.

Equity concerns have affected California particularly, where the California Public Utilities Commission (CPUC) has set aggressive targets to assure HTR customers are targeted in all program offerings. HTR customers are defined by the CPUC as "those who do not have easy access to program information or generally do not participate in energy efficiency programs due to language, income, housing type, geographic, or home ownership (split incentives) barriers." CA SW Single-Family made concerted efforts to get participation in each of the HTR market sectors, mainly identified through zip code analysis. Similarly, ASC HTR Mobile Home, a local California program, targeted a specific HTR segment (mobile homes) and NSTAR Res High-Use targeted high-use customers in response to regulatory concerns about the needs of owners of electrically heated homes.

Exhibit R4-2
Customer Targeting

Program	Eligible Customers*
ASC HTR Mobile Home	Mobile home owners
2002 CA SW Single-Family	All residential customers, excluding multi-family
NG EnergyWise	All residential homeowners
NSTAR Res High-Use	Homeowners using more than 8,000kWh per year
SMUD Equipment Loan	All residential homeowners, properties do not need to be owner-occupied
Tacoma Res Weatherization	Residential customers with electric heat

Three of the R4 Programs were implemented by IOUs. Staff from NSTAR, the California statewide effort and National Grid USA all described developing program planning and documentation through regulatory processes that required varying levels of detail. While the programs may have emerged in a regulatory process and were described to varying extent in filing documents, this effort does not necessarily indicate that the program is based on a formal program theory. For these programs, the documents developed are better characterized as traditional program plans.

The regulated utility programs included in the R4 Study illustrate the variety of ways that the regulatory environment affects program selection and planning. Staff at National Grid USA reported documenting their program plan as part of a five-year plan filing. NSTAR staff reported defining measures and the eligible customer base by working with Vermont Energy Investment Corporation (VEIC) and others in a collaborative process.

In 2002, the CPUC directed the California IOUs to offer a customer-driven rebate program, meaning that customers apply by contacting their utility by phone or via the utility Web site. CA SW Single-Family represents a shift from a previous strategy associated briefly with the predecessor Residential Contractor Program (RCP), which was implemented between 1999 and 2001. The RCP used a market transformation strategy and enlisted local contractors to promote program products. The program had been found to be costly and the CPUC suggested that offering a straightforward rebate program would provide more money for incentives by reducing the overall field training and contractor support that had been part of the RCP. CA SW Single-Family is a descendent and has features of both the RCP and the Appliance and Lighting Initiative, a program that targeted and promoted ENERGY STAR appliances and lighting. However, in 2002, residential ENERGY STAR lighting was addressed directly by a separate statewide program. Equity concerns in public benefits expenditures drove the CPUC to set specific, aggressive targets for HTR customers for all utility programs, including the single-family effort.

ASC is a private program implementation and energy services firm. It implemented ASC HTR Mobile Home through the CPUC third-party program funding. In order to assure proposal acceptance, they submitted descriptions of specific program rationale and activities to the CPUC, including details of implementation and market size and characteristics. Staff secured buy-in from planners, implementers and other key players in this process. ASC program staff reported relying on market research and estimates of deemed savings in developing their program theory and plan.

SMUD staff reported no documentation of the original program theory for SMUD Equipment Loan. It is now considered a legacy program of its predecessor which began in 1981 as Watt Wise financing. However, SMUD occasionally reviews the program's purpose and approach, including a report commissioned in 2003 reviewing program strategy and theory. This recent review of program operations was informed by actual market conditions and specific information relevant to the loan program. The program review used language related to market transformation, noting that the program is designed to overcome the barrier related to access to financing and basing the program opportunity on a market assessment and characterization. This document also reviewed ways the program could continue to offer loans that were attractive to consumers, while addressing the barriers to increased installation of high efficiency equipment and technologies in ratepayer homes. While not an official program theory document, the review contained many of the critical components of a program theory.

At Tacoma Power, staff reported that Tacoma Res Weatherization program efforts were based on the program designs that emerged through the residential programs implemented by the Bonneville Power Administration in the early 1980s. Tacoma was one of a handful of public utilities in the Northwest that participated in Bonneville's Long-Term Residential Weatherization Pilot Program, beginning in 1983. Tacoma Power's involvement with Bonneville programs and general adoption of conservation codes developed regionally through the Northwest Power Planning Council have provided the utility with a solid foundation on which to base their residential programs. The utility has offered a residential weatherization program similar to Tacoma Res Weatherization for 20 years.

Best Practices

Program Theory and Design
• Know the needs of the market within which the program works. • Offer a stable and consistent program available to single-family residential customers. • Have a sound program plan and clearly articulated program theory, which describe the program niche, its resources and ultimate goal. • Define and locate hard-to-reach customers and target programs accordingly, as appropriate.

- **<u>Know the needs of the market within which the program works.</u>** Much of a comprehensive weatherization program's success depends on understanding the market within which the program works, and aligning the goals of the program with the desires of market participants. The program will need effective relationships with the variety of market actors involved in home improvement and weatherization. Contractors, retailers, and Web sites are all sources of information and referral for home improvement and all play roles in how customers choose equipment, how they finance it and the level of installation quality. Programs that leverage existing relationships in the market are most effective.

- **Offer a stable and consistent program to single-family residential customers.** While the components of programs and delivery strategies may change over time, there is great value in maintaining a standard residential program with a high degree of stability. Many of the opportunities to cost effectively improve the efficiency of single-family homes occur periodically and randomly as equipment fails or remodeling is scheduled. Stable program funding and a standard program also assure contractors who commit to meeting weatherization program requirements will continue to see benefits from their association with the program and encourage homeowners to check for program opportunities before replacing any energy-using product or system.

- **Have a sound program plan and clearly articulate a program theory describing the program's niche, its resources and ultimate goal**. R4 Programs demonstrate that program theory and program planning can achieve similar ends. Program planning, when done well, includes a clear articulation of the programs target market, its resources and its goal. Program theory goes a step further, articulating the underlying assumptions about how a program is expected to work and how the program causes the intended or observed outcomes (Jordan 2003). When the underlying assumptions are stated clearly in a program theory document or program planning documents, those involved in program implementation and delivery are more likely to have a clear understanding of why certain measures and program tactics are advocated or included. These documents also provide a sound basis for judging program accomplishments.

- **Define and locate hard-to-reach customers and target programs accordingly, as appropriate.** For single family programs, hard-to-reach populations might include those outside of urban/suburban areas, those whose primary language is something other than English, and those with moderate incomes. Efforts to include these groups assure that energy efficiency funds are spent in an equitable manner. (The ability of a program to target and reach hard-to-reach segments will depend upon regulatory support and a willingness to invest in needs assessment work that can help the programs locate and understand the needs of these groups.)

3.2 PROGRAM MANAGEMENT: PROJECT MANAGEMENT

The R4 Programs assigned responsibility for the program management activities to both contractors and in-house staff. Exhibit R4-3 summarizes this program management structure. The R4 Programs also offered a variety of implementing structures, but all retained some in-house oversight, generally through inspections. All of the utility programs rely on contractors (either local or turnkey) to actually install the weatherization measures, with varying levels of in-house staff. The different implementation approaches are shown in Exhibit R4-4.

Exhibit R4-3
Program Management Responsibilities

Program	Administration And Reporting	Energy Audit / Home Review	Inspection
ASC HTR Mobile Home	In-house	In-house	In-house
2002 CA SW Single-Family	In-house	No Formal Requirement	In-house
NG EnergyWise	Implementation Contractor	Implementation Contractor	Implementation Contractor
NSTAR Res High-Use	Implementation Contractor	Implementation Contractors	Third-party Contractor
SMUD Equipment Loan	In-house	By participating contractors during bid process. No formal requirement	In-house, as needed
Tacoma Res Weatherization	In-house	In-house	In-house

Exhibit R4-4
Program Implementation Responsibilities

Program	Marketing And Outreach	Installation
ASC HTR Mobile Home	In-house	In-house
2002 CA SW Single-Family	Through Flex Your Power subcontractor and trade allies with some in-house marketing	Contractor chosen by customer
NG EnergyWise	Implementation Contractor	Implementation Contractor or Subcontractor
NSTAR Res High-Use	Implementation Contractor	Implementation Contractor
SMUD Equipment Loan	In-house through other efficiency programs, Web site information and via participating contractors	Independent Contractor
Tacoma Res Weatherization	In-house	Qualified Contractor

While the R4 Programs varied in how program management responsibilities were assigned, for all programs effective project management was critical to success. A strong understanding by all parties of expectations is a key factor and is facilitated by a clear initial articulation and review of roles, responsibilities and deliverables. All the R4 Programs maintained in-house oversight and inspection ability, allowing for on-going management of contractor work and a continued connection with customers. Maintaining strong, flexible relationships with contractors also proved important for those programs relying on outsourced services.

ASC conducted a program planning and implementation retreat in which all key parties participated and reviewed program roles. Additionally, an outside contractor was hired to conduct a project management workshop and ASC staff reported holding quarterly retreats in addition to weekly trainings, tailgate meetings, and regular reporting.

CA SW Single-Family was implemented in-house by participating utilities with limited project management and administration. The California utilities relied less upon the implementation contractors that had performed field support functions in previous program years. This trend towards in-house utility program operations reflects a decrease in the intensity of field support provided and utility desire to reduce implementation costs and maximize incentive budgets (Quantum 2003).

National Grid USA had less than two full-time utility staff members for NG EnergyWise. Two turnkey implementation contractors had responsibility for project management and monitoring. National Grid USA has learned that successful project management of NG EnergyWise requires a hands-on utility program manager, as many projects are large and have long timelines. The availability of high quality subcontractors has been an issue.

NSTAR Res High-Use was implemented at three affiliate utilities in Massachusetts, through two turnkey contractors. Vendors were responsible for all audit activities. The NSTAR program manager tracked the program overall, reviewing documents and surveys and making adjustments. Project management and oversight was tied to monthly data tracking and reporting through monthly management meetings between NSTAR management and program vendors.

SMUD relied on independent contractors extensively, empowering them to offer point-of-sale utility financing to customers for qualified measures as part of the bidding process. While the delivery and installation of measures is managed by qualified contractors, the utility kept all of the other program components in house, including administration, reporting and inspection activities.

Tacoma Res Weatherization was delivered via in-house staff (5 full-time employees) and nine independent, "qualified" weatherization contractors. Tacoma Power staff provided oversight of project completions, reporting of jobs over 90 days old and corrections over 14 days old. According to staff at Tacoma Power, successful project management depended upon avoiding inflexible relationships with contractors.

The R4 Programs had various methods for managing issues related to installation and delivery (which typically centered on contractor scheduling of the installation of complex systems in single-family homes). Approaches included having more than one vendor, holding vendors to participant and measure goals, using a qualifying-product database to assist contractors, and conducting contractor training to assure that the measures are installed correctly the first time.

Best Practices

Program Management: Project Management
• Maintain in-house oversight of program. • Set clear expectations and provide adequate support for all contractors. • Maximize incentive budgets without undermining the efforts of weatherization contractors and others to continue to offer the services valued by the program.

- **Maintain in-house oversight of program.** Regardless of the implementing structure, all of the R4 Programs maintained in-house oversight and inspection ability for residential weatherization efforts. Adequate oversight and successful relationships with program contractors assures that program actors are clear about their responsibilities in program implementation. In cases where problems may exist, oversight assures that they are discovered and corrected quickly. At a minimum maintaining a role in the program ensures that there is a connection to the customers.

- **Set clear expectations and provide adequate support for all contractors.** Whether using a turnkey contractor or local contractors, it is important to set clear expectations for their responsibilities for marketing, installation quality, and equipment selection, and the level of support the program administrator will provide. A clear understanding of roles and responsibilities is critical to the successful relationships with installation contractors vital to assuring that the program is marketed to appropriate customers and includes all eligible household systems.

- **Maximize incentive budgets without undermining the efforts of weatherization contractors and others to continue to offer the services valued by the program.** Not all measures are conducive to a customer rebate. Programs must choose measures that offer the most energy savings per incentive dollar, and that are unlikely to be chosen without incentives. At the same time, caution should be taken when reducing ancillary program components like field support and contractor training – these may tie less directly to immediate energy savings, but over time they can improve the overall capacity of the market to consistently supply high-quality installation of energy-efficient equipment.

3.3 PROGRAM MANAGEMENT: REPORTING AND TRACKING

All of the R4 Programs had electronic database systems capable of tracking program activity, applications for loans and rebates, measures installed through the program, and associated kWh savings. These systems are important for assessing progress and accomplishments, and for meeting the oversight needs and requirements of regulators. The components of program tracking systems for these programs were often dictated by regulatory requirements.

Virtually all program managers interviewed for the R4 Study cited timely access to accurate and relevant information as the most critical component of program tracking. All relied on savings assumptions based on algorithms that include factors that account for variability related to weather, patterns of usage, snapback, and other variables. Programs also tracked indicators related to resource acquisition goal achievement, including the details of models installed, models replaced, participating houses and installing contractors.

For ASC HTR Mobile Home, ASC staff counted the number of informational meetings held, flyers distributed and participants. They maintained a database for the CPUC that tracked the number of specific measures and estimates of savings per measure. Program managers at ASC valued having a simple, nimble system that could quickly create daily reports that tracked overall program progress and provided a systematic approach to quality assurance follow-up.

CA SW Single-Family application data were entered within 5 days of receipt and used to generate weekly reports. Application data included measures of commitment, payments, energy savings, as well as applications processed, pending, rejected and approved. Program staff also tracked "leading" indicators (applications in the mail, online application downloads, number of application requests, and Web site hits) to identify program trends. This information was used to make projections to effectively manage program resources.

National Grid USA tracked participants by segment (single- or multi-family), service territory, specific measures installed, estimated kWh savings, billing data and approximate project completion date. Program staff used the system to track NG EnergyWise vendor progress in selling work to customers and to facilitate program evaluation. Billing analysis was used to estimate savings *ex-post* with deemed savings used as *ex-ante*. At the time of the R4 Study, National Grid USA was replacing its tracking system with one better able to integrate information from program contractors using a streamlined, Web-based process.

NSTAR's system tracked measures installed and assumptions related to kWh savings for NSTAR Res High-Use. The system tracked the number of participants and measures installed, the kWh savings and persistence associated with installed measures, and bill tracking and review (to identify "high use" customers). Following a Program Year (PY) 2000 process evaluation, NSTAR refined and tested the program tracking system assumptions. The process evaluation noted that the system is "very flexible and can be expected to provide management with information that will help make timely program decisions… and was clearly able to provide critical information with respect to program activity and progress toward program goals." (RLW Analytics 2000)

SMUD maintained a loan management system that allowed staff to track the entire SMUD Equipment Loan portfolio (including the number of loans, loan value and loss rate). Loan programs have their own standard practices requiring a different system than those typically used for utility program management. SMUD staff noted that having a real loan management system was important, and resulted in a valuable database for tracking measures as they were funded. SMUD maintained a system capable of providing loan funding back to implementing contractors in five business days.

Tacoma Power tracked all Tacoma Res Weatherization projects from the time of first inquiry through project completion. Data tracked included building characteristics, occupant statistics, audit/inspection dates and history, weatherization measures, cost of measures, as well as Tacoma Power funding and payment information (dates and amounts). The utility relied on measure savings assumptions created regionally through the Northwest Power Planning

Council's Regional Technical Forum. Data are gathered from routine and ad hoc reports on an as-needed basis.

Best Practices

Program Management: Reporting and Tracking
• Build and maintain a database capable of tracking key program progress indicators. • Obtain specialized software for loan tracking. • Track project cycle time, customer complaints and other indicators of contractor and program performance. • Use comprehensive, logical, and easy to use tracking systems.

- **Build and maintain a database capable of tracking key program progress indicators.** Indicators that should be tracked include assumptions of energy savings, participant data and any program-specific data. This information should be entered as close to real time as possible, to allow for active, adaptive, program management. Systems that are able to track participation and energy savings by measure are not only typically required by regulators, but also provide for effective program management.

- **Obtain specialized software for loan tracking.** Loan programs have their own standard practices that typically are not compatible with utility program management databases. Specialized loan software facilitates quick loan processing, and allows for accurate tracking of the financial components related to loan servicing.

- **Track project cycle time, customer complaints, and other indicators of contractor and program performance.** Simply tracking kWh savings and measures installed will not provide information about how the program is functioning from a process standpoint. Having information on cycle time (the time between initial contact and installation, or installation to rebate fulfillment) and complaints about specific contractors can help program mangers identify problem areas or anomalous events and pursue corrective actions.

- **Use comprehensive, logical, and easy to use tracking systems.** If data tracking systems are too complex or unwieldy, staff may keep duplicate records in spreadsheets or other documents, taking time away from other program tasks and reducing overall tracking and reporting effectiveness. Duplicate records may also create uncertainty in the accuracy of numbers if or when the two sets of records conflict. Web-based systems are emerging as a tool that works both for program implementation and for program oversight and management.

3.4 PROGRAM MANAGEMENT: QUALITY CONTROL AND VERIFICATION

Successful resource acquisition assures that energy savings are achieved both at the point of installation and through long-term measure persistence. This requires that measures are selected with quality in mind. High-quality measures are likely to both function for a longer time than those of lower quality and have higher customer satisfaction levels making them more likely to remain in place, thereby leading to persistent energy savings. For utilities that expect shareholder payments based on avoided cost over measure life, persistence rates determine not only how successful the program is, but also the long-term shareholder return value of those investments.

Residential weatherization programs have a long history of quality control and verification efforts. Often required by regulators to justify program spending and confirm savings estimates, verification may include detailed inspections of every measure or of a random sample of them. At its most basic level verification will be required to match lists of qualified rebated equipment with invoices.

Verification efforts for residential weatherization programs focus on three things: assuring that measures rebated are actually qualified and installed, that the best equipment is selected, and that the equipment is actually operating as expected. Often these efforts are made for regulatory reasons – especially for programs with shareholder payments at stake. For this reason evaluation, measurement and verification (EM&V) requirements are an important component of these programs, occasionally being the major evaluation activities.

Verification activities may change over time as program administrators gain experience with contractors and vendors. As inspections confirm and refine savings estimates, everyone involved gains confidence in the estimates of savings. Similarly, an extensive verification effort for one program can provide inexpensive, valuable information for the refinement and design of other programs.

The R4 Programs conducted a variety of verification activities, including:

- Inspection of randomly selected properties
- Inspection of every installed measure
- Visual inspection of measures that can be inspected visually
- Random inspection by third-party auditors
- Installation of data loggers to confirm savings assumptions and actual equipment performance

ASC reported an extensive effort in quality control and verification, including inspection of randomly selected properties. ASC staff reported that quality control processes tended to become more formulaic with experience. As ASC HTR Mobile Home was a new program, clear requirements for quality control and verification of savings were set by the regulating body (the CPUC) and known by ASC in advance of program implementation.

In addition to this required EM&V work, ASC HTR Mobile Home had internal quality control processes that included calling customers, visiting properties with a quality control team and tracking the pass/fail rates in a sample of homes. Staff reported that having independent oversight of work installed was a key practice. Quality control conducted by ASC was comprehensive and included measuring installation quality, failure rates, implementation quality and adherence to process.

For CA SW Single-Family, on-site inspection depended upon who installed the measure – customer or contractor. Insulation was the only measure that could be installed by either customer or contractor. 100 percent of customer-installed insulation was inspected, 5 percent of measures installed by contractors were selected for random inspection. These inspections verified customer and measure eligibility, and installation quality. Quality control was also addressed through the tracking system, with a random inspection of applications, match-up to tracking system entries, and verification that rebated measures were qualified. Evaluation efforts included 1,087 surveys and 127 on-site inspections to verify that rebated equipment was installed and qualified for the program.

National Grid USA relied on several strategies to assure the quality of the measures installed via NG EnergyWise. Efforts included some on-site measurement as well as inspections by the implementation contractor. While National Grid USA has used third-party vendors for inspection occasionally, this work was reportedly less satisfactory than that of their own program implementation contractors. Staff reported struggling to find inspectors as highly skilled as the contractors themselves, noting that finding quality inspectors is important to ensuring that inspector standards are not lower than those of the program administrator.

For this reason, routine inspections were done by the two NG EnergyWise implementation contractors. Over the course of the implementation contract the utility initially inspected the work and provided detailed feedback to the contractor. As the contractor gained experience with the utility's expectations, and the inspections showed work meeting these expectations, the number of properties inspected declined. Eventually the implementation contractor took over the inspection role.

For NSTAR Res High-Use a third-party auditor selected random properties and conducted on-site field audits of them to verify that the implementation contractor had actually completed work as reported. NSTAR staff stated that the verification methods were designed to assure customer satisfaction and that measures were installed correctly, and reported that the overall quality control process was included in the RFP for the implementation contractor. The program manager occasionally reviewed jobs and was responsible for initiating customer satisfaction surveys, the results of which were presented to the implementation contractor for follow-up.

SMUD no longer conducts inspections of installations on a regular basis, due to confidence in their participating contractors and measure selection. If a customer calls and requests it, or if there is a customer complaint about a job or contractor, SMUD staff will arrange an inspection of the installation. This strategy applies for installations completed through both SMUD's loan and rebate programs, including SMUD Equipment Loan. The District conducts measurement and verification (M&V) studies periodically, which may include energy-use monitoring, billing analysis, and customer surveys. M&V studies are typically done through the individual programs or even other utilities, if applicable.

Tacoma Power used trained in-house inspectors to visually inspect every measure installed via Tacoma Res Weatherization. Inspections were documented and the utility obtained an approval of completed work signed by the customer and the inspector. Staff reported that this level of verification was selected to protect utility liability and assure a high level of customer service.

In the mid 1990s, the Puget Sound utilities, including Tacoma Power, worked together to draft specifications for weatherization activities. The Bonneville Power Administration (BPA), which funds efficiency efforts at many publicly owned utilities in the Northwest, accepted the specifications. These specifications took the place of the more technically worded BPA specifications. The resulting document is described as a "big volume" containing "contractor-friendly terms" that has increased the clarity and coordination between utilities and regional weatherization contractors and established upfront quality control standards for regional weatherization efforts.

Best Practices

Program Management: Quality Control and Verification
• Use a verification method capable of confirming measure and installation quality. • Select an appropriate percentage of properties for inspection and verification. • Write clear specifications for measure installation using "contractor-friendly" language and train contractors on what is expected. • Pre-screen installers who have been trained for and are committed to high-quality installation. • Create processes for tracking complaints and failure by measure and by contractor. • Require that installers honor the warranties that come from product manufacturers.

- **Use a verification method capable of confirming measure and installation quality.** Achieving energy savings is the goal of most residential weatherization programs, and requires periodic, random inspection and verification of installations. Utilities can also leverage relatively expensive EM&V efforts across companies, creating economies of scale capable of reducing costs and increasing information sharing.

- **Select an appropriate percentage of properties for inspection and verification.** All projects do not need to be inspected at all times. Begin by inspecting all of the initial installation jobs by a contractor, as quality becomes consistent the percentage of inspected jobs can be reduced.

- **Write clear specifications for measure installation using "contractor-friendly" language and train contractors on what is expected.** Significant assurances may be available through training of contractors and through establishing clear expectations with them. However, this will not replace the overall need for at least periodic measurement and verification efforts.

- **Pre-screen installers who have been trained for and are committed to high-quality installation.** When local weatherization contractors are used in a program, training and pre-screening can meet contractor concerns about openness and provide assurance to customers and the utility that installations will be of high quality.

- **Create processes for tracking complaints and failure by measure and by contractor.** This type of tracking enables the utility to monitor contractor field success and to provide contractors with feedback to help them improve delivery. It also helps identify poor quality products that fail prematurely or create customer dissatisfaction.

- **Require that installers honor the warranties that come from product manufacturers.** For products that fail prematurely or never work properly, this requirement will mean that installers be available to solve the performance problem and handle any interaction with the manufacturer.

3.5 PROGRAM IMPLEMENTATION: PARTICIPATION PROCESS

As summarized in Exhibit R4-5, participation in residential weatherization programs often begins with an energy audit or home review to identify potential energy savings measures. These audit or home review activities are conducted on-site in customer homes, by telephone or over the Internet by the customer. This screening or review process generally results in a list of potential energy saving measures, typically arranged so that the most cost-effective choices are clear. After the screening process, measure installation is arranged, either by locating a local contractor or retailer or, if the program is turn-key or contractor-driven, agreeing to the installation by the specified contractor.

Installation involves scheduling the work and arranging for program rebates or loans to help cover the first costs of the measures. How the rebates or financing is provided depends on program structure. Some programs discount the measure and its installation through the contractor, collecting a co-payment fee from the customer. Other programs offer point-of-sale or other financing or direct rebates. Rebate programs typically require consumers to pay the full cost of the measure and any installation before applying for rebate dollars. In this case, the customer assumes the risk that the rebate application will be denied and must absorb the initial "out-of-pocket" impact of high first costs.

Financing and loan distribution lessen some of this risk to the consumer, but also tend to be more complicated, requiring a determination of credit-worthiness and a contractual agreement to repay the loan. SMUD has developed systems that hold the utility's risk to acceptable levels while quickly funding loans.

As a last step in the participation process, and as discussed above, most programs call for some form of installation verification or inspection.

Exhibit R4-5
R4 Program Participation Tactics

TACTIC	ASC HTR Mobile Home	2002 CA SW Single-Family	NG EnergyWise	NSTAR Res High-Use	SMUD Equipment Loan	Tacoma Res Weatherization
Audit/Home Energy Review	✓	3	✓	✓	5	✓
Offer Loans				✓[4]	✓	✓
Prescriptive Rebates		✓	✓	✓	✓[1]	
Direct Install (No Co-pay)	✓					✓[2]
Point-of-Sale Financing					✓	

1. Rebates are available for certain measures through other programs. Rebated measures include ENERGY STAR fixtures and appliances, and duct improvement. The loan program focuses on larger investments in insulation, central air conditioning, heat pumps, solar water heating and windows – many of these measures also qualify for certain rebates.
2. Grants are available at 70 percent or 100 percent of the measure cost depending on income level
3. Home audits are provided through a separate audit program. Once a customer has an audit, he or she may be referred to the specific measures covered by CA SW Single-Family.
4. According to National Grid's 2004 Residential program pre-approval filing, low interest loans will be offered for customers who live in one to two unit facilities to install additional weatherization, including insulation and ENERGY STAR windows.
5. SMUD does not have any requirement or offer of a home energy review or audit linked to qualifying for financing or incentives. The District does offer a computer-based home energy review customers may perform themselves. The District documents what is being replaced when financing and rebates are offered. This information is captured by the contractors. Most energy audits are performed in association with high bill complaints.

ASC HTR Mobile Home is the only R4 Program that used its own staff to install measures directly. ASC has 26 in-house weatherization staff capable of installing all measures covered by the program. Program staff reported that installers were broadly trained and had multiple certifications. ASC did not process rebate applications and payments, as ASC HTR Mobile Home was a direct-installation program.

CA SW Single-Family was customer-driven, meaning that customers were responsible for their own participation from determining eligibility to filing the application for a rebate. The customer began participation by contacting her utility by phone or via the utility Web site. Customers purchasing appliances participated using rebate applications provided by appliance retailers. Customers were responsible for completing required documentation by submitting an application and a sales receipt for the eligible measure. The utility confirmed measure eligibility and issued a rebate check.

CA SW Single-Family rebates were processed internally by each utility using systems that have developed over the years to support a variety of different programs. SDG&E and SCE combined their rebate processing in the summer of 2002. PG&E used a contract rebate fulfillment and processing organization on-site at the utility. Rebate processing for each of the utilities generally took 6-8 weeks.

Shifting from the upstream Residential Contractor Program (implemented 1999-2001) to the downstream rebate program (CA SW Single-Family) created issues for customers applying for rebates. As mentioned, customers were responsible for applying for rebates, which was generally straightforward for qualifying dishwashers or light fixtures, but became complicated for HVAC systems such as central air and evaporative coolers. This complexity may have resulted in relatively high application rejection rates for HVAC measures.

Local contractors interviewed for the *2002 Statewide Residential Retrofit Single-family Home Energy Efficiency Rebate Program Evaluation* (Quantum Consulting 2003) stated that they preferred the downstream rebates because they did not have to deal with the rebate fulfillment process. However, the same evaluation notes that "most customers do not understand enough about air conditioner efficiency to identify a high efficiency unit, let alone fill out a complicated rebate application that calls for an EER rating or ARI data…. even HVAC professionals find the specification requirements daunting." CA SW Single-Family program staff subsequently created a qualifying-product database to assist contractors, provided education to contractors about the information needed to process applications, and arranged for the processing center to call contractors back directly when customer questions arose.

NSTAR relied on an implementation contractor and subcontractors to deliver NSTAR Res High-Use. After initial customer contact, an on-site home energy audit was scheduled. Auditors explained kWh usage by appliance and measure to help the customer understand household energy use, and discussed efficiency options with them. Auditors also explained which measures required a 25 percent customer co-pay. Program staff reported that the requirements for participation were designed to assure that there were, indeed, potential energy savings. Additionally, the audit served to educate customers about energy usage, efficiency options and program requirements, and then, hopefully, led to installation.

NG EnergyWise was divided into two tiers. Tier One provided low-cost educational assistance and access to technical information, self-audit tools and on-line resources during initial telephone contact. This first tier process helped to determine whether a customer needed an in-home energy survey or other services. Tier Two involved a Home Energy Assessment (HEA) focused on delivering on-site services and motivating the customer to implement recommended energy efficiency measures. During the HEA, the building's heating and domestic hot water systems, shell insulation, and appliances were examined.

NG EnergyWise was implemented by two turnkey implementation contractors who had responsibility for installation of measures, marketing, and education. Rather than offering rebates directly to consumers, National Grid USA paid the contractor to install cost-effective measures and required a co-pay from participants that varied depending on the measure. The availability of high quality subcontractors was an issue. Staff at National Grid noted varying levels of skill in the Energy Service Company (ESCO) community in selling energy efficiency work when a co-pay is required.

For R4 Programs that used local contractors, participation generally required agreeing to certain terms set by the program administrator. For example, SMUD Equipment Loan was delivered via 180 participating contractors who had signed an agreement with the District. Their licenses and insurance were reviewed and they agreed to follow SMUD program guidelines. SMUD conducted training sessions with contractors and required them to come to classes. SMUD staff noted that it is important to balance requirements and benefits – if the system is too onerous, it is difficult to get contractors on board, but a certain level of stringency is necessary to manage risk. Effective risk management as well as internal financing was important to SMUD's success in offering loans for efficiency upgrades

SMUD relied on contractors to complete loan paperwork, yet the actual processing and financing was done in-house. SMUD intentionally kept its loan servicing work in-house, reporting that District staff was able to provide a higher level of service at a lower cost than was possible if loans were processed by a third party. A District review of the program noted that outsourcing can lead to potentially higher interest rates charged to customers, poorer quality customer service, poorer relationships with contractors and decreased participation. SMUD did try outsourcing origination, servicing, and funding as a pilot project in 1996, but found that the commercial bank (1) was interested only in nonresidential projects as residential loans were too small, (2) charged higher rates to SMUD for financing, and (3) provided slow customer service (averaging 21 business days to make a credit decision, compared to one day for SMUD).

Maintaining good working relationships with the local contractors was also critical to SMUD's success. Contractors carried the financial risk of the transaction from inception to the time the loan funds are disbursed. In an effort to assure that these small businesses were not extending funds for long periods of time, the District reduced the time to reimburse contractors from 45 days in the early 1990s, to 15-20 days by 1995, and finally to the loan industry-standard five days by 2003. Reducing time to release funds to contractors was also important in light of evaluation findings that contractors were charging customers for "factoring their receivables" (selling accounts receivable at a discount for immediate cash), something that could potentially drive up costs.

Tacoma Power provided a Home Energy Check audit and weatherization services to customers with electrically heated homes built before 1988 as part of Tacoma Res Weatherization. The program was delivered via five in-house staff members and nine independent "qualified" weatherization contractors. A central scheduling coordinator scheduled Home Energy Check audits for participants. These were performed by in-house auditors and served to identify potential weatherization services based on a list of predetermined measures maintained by Tacoma Power. Customers had the option to choose from a list of qualified contractors to install identified measures or perform the work themselves. The utility reviewed bids, prepared agreements and arranged for measure installation. After installation, measures were inspected and payment was made upon completion.

Additionally, Tacoma Power customers could have qualified for no- or low-interest loans based on their payment history with the utility or Equifax credit rating. Like SMUD, Tacoma Power provided its own loan funding directly to its customers, securing the loans with property liens and a provision for disconnection of electric service if loans were not repaid as agreed. The loan default rate was less than 1 percent.

As noted previously, many of the measures targeted by residential weatherization programs ultimately improve the value and comfort of participants' homes. While this makes these programs very popular, it also increases the odds of free-ridership (whereby customers accept a rebate for a measure they would have installed without a rebate). For example, people install new windows for many reasons, only one of which is energy savings. Since free-ridership rates on windows can be very high, it is interesting to note that two of the R4 programs that included windows as a measure (SMUD and Tacoma Power) would only do so through loan financing.[2]

CA SW Single-Family was the only other program to include windows as an eligible measure, offering a rebate of $0.50/sq ft for dual-pane ENERGY STAR windows. Windows were a very popular measure; over 3.8 million square feet of windows were rebated through the program in 2002 alone. The *Program Evaluation* noted the need for a free-ridership analysis for high performance window rebates, citing the possibility that high efficiency and ENERGY STAR windows may already have significant market share. Comments from local contractors suggest that greater than 90 percent of customers would have installed the rebate-qualifying high performance windows in absence of the rebate (Quantum Consulting 2003).

As illustrated in Exhibit R4-6, a diverse mix of measures was eligible for rebates or loans across the R4 programs. The variety of measures reflects the different climates of the areas served by these programs. For example, only the programs in California targeted pool pumps and motors or solar hot water heating. At the same time, the *Program Evaluation* notes difficulties even in California with these climate issues across utilities, stating that "at times it proved difficult to establish consistent product eligibility standards and rebate levels that were appropriate across the state for weather-sensitive measures such as furnaces and windows" (Quantum Consulting 2003).

Many utilities had a separate ENERGY STAR appliance program in addition to a residential weatherization program, offering rebates for ENERGY STAR appliances only as appropriate to overall weatherization efforts. California was unique in combining weatherization measures with an overall ENERGY STAR appliance effort. It is not clear that the appliance rebates and contractor-driven HVAC rebates were similar enough to be handled by the same program processes. Appliance rebates tended to be relatively formulaic, often for measures purchased in a retail setting. Retailer training and rebate advertising goes hand-in-hand with efforts targeting lighting or other more general information about ENERGY STAR but did not have much similarity to other aspects of CA SW Single-Family.

[2] In 2003, National Grid changed the program design in several ways, including the addition of a loan and windows. However, they also required the windows be financed only through the loan.

Exhibit R4-6
Eligible Measures and Rebate Levels

Measures	2002 CA SW Single-Family	ASC HTR Mobile Home	NSTAR Res High-Use	NG EnergyWise	SMUD Equipment Loan[7]	Tacoma Res Weatherization[8]
Insulation (Wall, Ceiling or Floor)	$0.15/sq ft	No charge	25% co-pay	75% of measure cost	Loan financed	70% of measure cost
Ventilation	NA	NA	NA	NA	NA	70%
Pipe insulation	NA	No charge	25% co pay	NA	NA	70%
Duct sealing or insulation	NA	No charge	unclear	No co-pay	$300 rebate, loan funding available	70%
Windows	$0.50/ sq ft	NA	NA	Through loans contingent on other measures[6]	Loan financed	No rebate, covered only through loans, contingent on other measures[4]
Heat Pumps	$275-$500	NA	25% co-pay	$50 for tune-up	$275-$700 rebate - loan funding available	NA
Central Air Conditioning	$200-$425	No charge[1]	NA	NA	$200-$625 rebate - loan funding available	NA
Whole House Fan	$75	NA	NA	NA	NA	NA
Whole House Evaporative Cooler	$300	NA	NA	NA	NA	NA
ENERGY STAR Natural Gas Furnace	$200	NA	NA	NA	NA	NA
Insulated Siding	NA	NA	NA	NA	Loan financed	NA
Solar Water Heating Systems	NA	NA	NA	NA	$400 rebate loan funding available	NA
Efficient Lighting Fixtures	NA	No charge	unclear	$10 co-pay	$20[3]	NA
Programmable Thermostats	$20	NA	25% co-pay	No co-pay, first 5	NA	NA

Measures	2002 CA SW Single-Family	ASC HTR Mobile Home	NSTAR Res High-Use	NG EnergyWise	SMUD Equipment Loan[7]	Tacoma Res Weatherization[8]
Electric Water Saving Measures	NA	No charge	No charge	No co-pay	NA	NA
ENERGY STAR Refrigerators	NA	NA	Sliding scale[2]	\$200-\$400[5]	NA	NA
ENERGY STAR Dishwasher	\$50	NA	NA	NA	NA	NA
ENERGY STAR Clothes Washers	\$75	NA	NA	NA	NA	NA
Room Air Conditioners	\$50	NA	NA	NA	NA	NA
Pool Pump & Motor Replacement	\$100-\$250	NA	NA	NA	NA	NA

1. AC diagnostics and tune-up
2. Rebates depend upon the size and age of model being replaced.
3. Rebates were offered for ENERGY STAR ceiling fans with CFL lights, not eligible for financing
4. Windows are eligible only for loans, not grants
5. Refrigerators or freezers were available to qualifying participants only after a customer's existing refrigerators and freezers were monitored during an initial site visit. The appliance/s had to meet or exceed a threshold usage level. Rebates depend upon the size of model being replaced.
6. The program offered low interest loans to customers living in one or two unit facilities to install additional weatherization, including insulation, and ENERGY STAR windows.
7. SMUD offers rebates through a separate rebate program. Loans cover the difference after the rebate
8. Tacoma Power offered two levels. Level 1 covered 100 percent of measure costs, based on a means tested threshold. The percentages described here are Level 2.

Best Practices

Program Implementation: Participation Process
• Develop a network of local installers who are committed to high-quality standards. • Balance simplicity and risk management through developing "one-stop-shopping" for customers. • Establish systems that fund loans and issue rebates in shortest possible time. • Control for free-ridership through periodic market studies, consumer surveys and by tying popular measures to those more cost-effective measures that are less likely to be installed. • Offer a mix of services and measures attractive to homeowners. • Provide low-interest loans or financing as an additional, high leverage tool.

- **Develop a network of local installers who are committed to high-quality standards.** Establish a requirement for high standards that contractors agree to in order to participate in the program. This offers support for the weatherization industry and allows these contractors to benefit from the trust customers have in their utility while building the capacity of the weatherization services market.

- **Balance simplicity and risk management through developing "one-stop-shopping" for customers.** Ideally, this includes assessment, installation and even financing. While it can be difficult to implement levels of control appropriate for protecting the program administrator while allowing for simple, streamlined participation, it is important to keep both goals prominent in program planning and management. Program managers need to simplify agreements, language, and processes for consumer and contractor participants and avoid letting risk management concerns supersede the need for simplicity.

- **Establish systems that fund loans and issue rebates in shortest possible time.** Contractor-originated financing, available at the point a customer accepts a bid represents the fastest possible turn-around from the customer's perspective. SMUD's ability to fund loans and make disbursements to contractors in five business days demonstrates a clear best practice compared to the more typical four to six weeks it takes most utilities to issue rebate checks. This was achieved after a hard look at program processes revealed ways that rebate fulfillment and financing could be streamlined. Training for participating contractors and adequate documentation are tools to reduce rejection rates and speed payments.

- **Control for free-ridership through periodic market studies, consumer surveys and by tying popular measures to those more cost-effective measures that are less likely to be installed.** If the market has moved enough that the rebated measure is standard practice, reconsider the rebate. Free-ridership issues can sneak up on program managers as the overall efficiency of household systems and appliances continues to improve. Scheduling periodic assessments of free-ridership rates for the most popular measures will assure that the program is actually having an impact and not paying for something unnecessarily.

- **Offer a mix of services and measures attractive to homeowners.** The program offering should be capable of spurring home owners into action and increasing their awareness of the value of investments in residential energy efficiency. Weatherization measures can be expensive and somewhat inconvenient to install (behind walls, in attics and basements, or in complex machinery). Having a mix of measures that allows homeowners to end up with something they can see and enjoy can increase overall participation. Offering popular measures like windows only in tandem with other, less visible measures like insulation or duct sealing may simultaneously increase participation and reduce the impact of free-ridership on popular measures.

- **Provide low-interest loans or financing as an additional, high leverage tool.** For customers who would like to install high-cost HVAC or window replacement, financial tools can make efficiency upgrades accessible and affordable. In the case of popular measures like windows, most of the programs only rebated windows if other measures were also installed, while programs with loans provided no rebate funds for windows – instead only funding them through loans. This approach reduces free-ridership, while continuing to rely on popular measures to drive program participation. For programs using contractors, loans provide an additional high value tool for them to use in getting customers to choose efficient solutions in cases where rebates may not be enough.

3.6 PROGRAM IMPLEMENTATION: MARKETING & OUTREACH

Marketing and participation were closely tied in the R4 programs. The potential participant had to become aware of the program, make contact, and invite a representative into her home (for most measures) in order to participate. Therefore, marketing strategies tended to focus on ways to:

1. Establish a need (concern about high energy bills, uncomfortable living spaces, equipment replacement, home energy review or audits)
2. Establish contact (with toll-free "800" telephone numbers, Web sites, direct mail pieces, telephone appeals, information booths)
3. Urge specific solutions (high-efficiency equipment, insulation, improved functioning of household systems); and
4. Facilitate purchase and installation (certified contractors, loans and rebates, quality assurance).

ASC marketed its program to customers living in mobile homes in California's Central Valley area through direct mail and personal contact to mobile home park owners and managers. ASC HTR Mobile Home relied on the park owners and managers to get the word out about the program opportunity, using park-wide community meetings to identify interested customers. As customers responded to the information, installation work was scheduled and completed by weatherization crews.

Customer-oriented marketing efforts appeared to play an important role in the overall success of CA SW Single-Family, as the program was customer-driven. As a customer-driven program, customers had to become aware of and seek program incentives to participate. CA SW Single-Family used limited levels of marketing specifically for the weatherization measures. The program created consumer information and educational materials, directed customer support through toll-free telephone customer service centers and utility Web sites, coordinated marketing through outreach and field support, and leveraged other utility and non-utility programs. One such leveraged program was the Flex Your Power campaign, a separate marketing program authorized by the CPUC to educate California consumers about behavior changes that would lead to energy savings and to build awareness of the need to save energy. CA SW Single-Family coordinated with the Flex-Your-Power campaign while each utility conducted separate activities related to program-specific advertising.

One particularly successful marketing strategy targeted to California equipment vendors used a mobile training exhibit for the pool industry. This pool pump demonstration was taken on the road and used at monthly pool industry association meetings and in training classes. This hands-on approach helped convince some reticent pool pump vendors of the merits of two-speed pumps.

CA SW Single-Family relied on a contractor to provide support to retailers in the form of application forms, point-of-purchase (POP) displays, informational materials and retailer training. The implementing firm was the prime contractor for the California Appliance and Lighting Initiative (a predecessor of the Single-family Rebate Program), and targeted ENERGY STAR participating retailers. The retailer training focused on energy-efficient appliances and how to sell them.

The role of retailers was greater in the 2002 program than in the previous single-family comprehensive programs, which relied more on weatherization contractors to market the program directly. Retailers played a large role in distributing rebate applications for appliances. For example, in 2002 75 percent of appliance rebate applications were obtained by participants from a retailer. On the other hand, only 20 percent of rebate applications for home improvement or HVAC measures were obtained from a retailer. These participants most likely received an application from their utility (44 percent home improvement, 38 percent HVAC) or contractor (17 percent home improvement, 21 percent HVAC) (Quantum Consulting 2003).

Research has shown that there was a great variability in how and if installation contractors promoted CA SW Single-Family. One large firm "actively promoted the program through print advertising and other marketing efforts." Other contractors mentioned the program to customers while preparing estimates, provided the 800 number for information, or noted that a rebate may be available. A few contractors reported that they would not mention the rebate program unless the customer brought it up. Most of these contractors reported that they will not put anything about the program in writing on an estimate (Quantum Consulting 2003). Experience with predecessor programs may be creating some reluctance on the part of these contractors, particularly for those who participated in the program in previous years when funding ran out and the program ceased.

National Grid marketed NG EnergyWise to customers by mail, through annual bill inserts, and through occasional targeted marketing. After contacting the program, customers were given information and screened in an effort to determine whether or not a customer needed further services. A Home Energy Assessment (HEA) was offered to customers deemed in need of it. The HEA focused on delivering site services to the customer and motivating the customer to implement the recommended measures.

NSTAR Res High-Use was implemented by turnkey contractors provided with a database of all non-low income customers whose average energy use qualifies them as "high-use" customers (over 8,000 kWh) eligible for the program. Contractors developed and sent marketing material to eligible customers describing program benefits. Although contractors were responsible for marketing the program, NSTAR also marketed it through bill inserts, bill message centers and its customer call center.

SMUD Equipment Loan was managed entirely in-house but the marketing and sales agents were the participating contractors, authorized to prepare loan documents for the customer at the point of sale. Staff note that using contractors as the program's primary marketing channel or sales agent was very effective, providing a cost effective method of program delivery and meeting customers' needs. The program also benefited indirectly from other energy efficiency marketing done by the District through its other programs.

Tacoma Power marketed its program through direct mail and bill inserts as well as brochures made available at seminars, workshops, shows and exhibits. Tacoma Res Weatherization also targeted multi-family property owners and low-income customers (those qualified for Section 8 housing benefits). Low-income customers were eligible for grants, others could take advantage of zero interest loans.

All of the programs relied on Web sites to provide information about the variety of incentives and services available to their customers. As most utilities and other implementing organizations have Web sites for other purposes, adding detailed program information proved an inexpensive way of presenting the occasionally complex schedule of incentives. The effectiveness of providing energy-efficiency information via Web sites is not directly addressed by the R4 Study.

Best Practices

Program Implementation: Marketing and Outreach
• Develop marketing tactics that reflect program strategies. • Promote messages that equate efficiency improvement with home improvement. • Leverage efforts of other programs that seek to increase overall awareness of the benefits of efficient choices, including ENERGY STAR appliances and homes. • Offer industry education when necessary to help bridge the gap between standard practice and efficiency improvements.

- **Develop marketing tactics that reflect program strategies.** Customer-driven programs need tactics that drive customers to seek out program information and follow through on installation. Contractor-driven programs call for tactics to maintain strong relationships with contractors and assure that they continue to promote the benefits of program participation to their customers. Programs that rely on web sites or other electronic sources of information need to assure that the information is accurate and concise, and that measures and program processes are explained in clear, jargon-free language.

- **Promote messages that equate efficiency improvement with home improvement.** Messages that appeal to homeowner desires to improve property value and home comfort have great potential to capture lost opportunities during remodeling or system upgrades. Thorne notes that homeowner spending on home improvements reached $104 billion in 1999 and is expected to match or even surpass spending on new construction by 2010 (Thorne 2003). Program managers should make every effort to align the interests of energy efficiency with broader home improvement activities.

- **<u>Leverage the efforts of other programs that seek to increase overall awareness of the benefits of efficient choices, including ENERGY STAR® appliances and homes</u>**. Retail outreach and support can play an important role for measures that are typically purchased and installed by customers directly including insulation, programmable thermostats, and appliances. The national ENERGY STAR® efforts provide a common brand for both customers and trade allies to associate with high-value energy savings.

- **<u>Offer industry education when necessary to help bridge the gap between standard practice and efficiency improvements</u>**. Demonstration efforts like California's pool pump trailer give market actors a chance to "kick the tires" and ask questions. Similar efforts in HVAC and windows in the past have provided a way to open dialogue with market actors about product improvements with the potential to save energy.

3.7 PROGRAM EVALUATION

Lessons learned regarding evaluation have changed over time in response to program maturity and experience. The R4 Programs have predecessor programs that have existed for many years. Process evaluations, typically more valuable for new programs or programs in transition, were only being conducted for those programs that were new, had changed tactics, stopped and started, or changed management structures. Most of the evaluations for these programs focused on verifying assumptions in energy savings, relying on models and statistical tests to account for the impact of weather, human behavior and other external influences in measuring energy impacts.

Given the high number of variables at play in the residential sector, impact measurement has evolved over the years to control for factors such as weather, snapback, and the interplay of other household systems. Princeton University's PRISM (Princeton Scorekeeping Method) software estimates weather-adjusted energy consumption before and after weatherization for individual homes using billing data. Another common strategy for analyzing total savings achieved is regression analysis, a statistical technique that helps control for the variability in degree days or hours, billing periods, and the impact of behavior. Regression analysis can estimate average savings across a sample or population of homes. Data loggers are sometimes used to provide additional checks on assumed savings for specific measures such as lighting or water consumption.

ASC used data loggers to measure performance of equipment. They also estimated kWh savings and adjusted for the impacts of weather and home orientation. At the time of the R4 Study, ASC was halfway through its contract period with the CPUC and was relying on early EM&V reports almost exclusively to estimate program accomplishments to date. These reports focused on confirming estimated savings and involved determination of kWh realization rates. They also included some process questions related to customer satisfaction. ASC relied on an EM&V subcontractor to conduct the evaluation, reporting that the program improved its quality assurance processes and technician training in response to some evaluation findings. ASC staff noted that getting to the EM&V work as early as possible was very helpful, allowing for quick course correction and improved program delivery.

CA SW Single-Family was extensively evaluated by a verification study, a process evaluation, an impact evaluation for pool pumps and thermostats, and a market assessment. It was noted that 2002 was a transitional year for the program, marked by a shift from the upstream, contractor-driven approach of its predecessor program to a downstream, direct consumer rebate approach. This fact made the process evaluation more critical than it might have been for an unchanged program. Pool pumps, programmable thermostats and dual pane windows accounted for nearly 60 percent of the program's statewide kWh savings. Point-of-sale rebates were popular with retailers, who reported believing that they were very powerful sales tools. These rebates were also popular with those interested in reducing administrative costs associated with rebate processing. However, it was also noted that point-of-sale strategies can make it difficult to verify that rebated equipment was actually installed.

NSTAR conducted an evaluation of NSTAR Res High-Use that included impact and process elements. The impact segment focused on measurement issues related to tracking system assumptions and deemed savings. The process portion was also valuable to the relatively new program, assessing the program administration, the lines of communication and the extent of goal agreement. Program staff reported following recommendations from the evaluation that directed the utility to implement a centralized database.

National Grid USA conducted process evaluations early in the life of NG EnergyWise, but at the time of this review efforts were focused mainly on impact evaluations to determine the energy and demand savings realized by the program. Program staff reported that the evaluation findings helped refine the installation of specific measures. For example, through evaluation it was determined that bulb installation locations were not ideal and that the program was not realizing the savings expected from timers.

Tacoma Power conducts a billing analysis evaluation every two years in which consumption data from participants in its residential weatherization programs are analyzed to estimate the program impact on residential heating energy use. In 2000, billing data from single-family residents whose homes were weatherized in 1997, 1998 and 1999 were analyzed using PRISM. The result was a net savings of 2,899 kWh per participating home per year.

SMUD does not conduct traditional demand side management (DSM) evaluations of its loan programs, focusing instead on the financial impacts, portfolio characteristics and loss rates of the loan office. More traditional DSM evaluations are conducted for other rebate and efficiency programs that rely on the loan program for leveraged financing. In 2003, the District developed an in-house Program Review and Recommendations document that recommended continuing a loan program – noting that program benefits far outweigh any avoidance of risk by terminating the program. Staff reported that SMUD loan programs have adapted to evaluation findings and market changes, implementing a better system for credit review and approval in the late 1990's and expanding eligible measures in response to participant feedback. The District also reduced the time it took to release funds to contractors after an evaluation revealed that contractors were charging customers for "factoring their receivables" (selling accounts receivable at a discount for immediate cash), something that could potentially drive up costs. The longer disbursement period meant that contractors had to pay suppliers and/or subcontractors before the funds were received. Currently, average payment time is five days.

Best Practices

Program Evaluation
• Connect the implementation team with the evaluation effort. • Conduct periodic *ex-post* impact evaluations. • Leverage limited evaluation dollars by jointly funding expensive engineering reviews with other programs or other utilities. • Conduct process evaluations early in a program's life or after major programmatic changes.

- **Connect the implementation team with the evaluation effort.** Creating a climate within which evaluation findings are used to improve program delivery and provide important information to staff maximizes the value of the evaluation investment. This can be accomplished by including the experiences of the program staff in the evaluation, making sure the evaluations are conducted early and in real time, and providing the staff with early feedback on the results, so that there are no surprises.

- **Conduct periodic *ex-post* impact evaluations.** Impact evaluations may not need to be annual but conducting one at least every two to three years will ensure that changes in program savings are sufficiently closely tracked to identify changes in program success.

- **Leverage limited evaluation dollars by jointly funding expensive engineering reviews with other programs or other utilities.** Resource acquisition efforts like those represented by these programs require reliable estimates of savings, but these studies can be prohibitively expensive. Partnering with other utilities, targeting measures of concern and/or simply using data from other utilities are all ways of stretching the funds available for these studies. Programs with similar target markets and measure mixes can leverage evaluation dollars by co-funding impact evaluations. This is becoming increasingly common as utilities work together in regional organizations.

- **Conduct process evaluations early in a program's life or after programmatic changes.** Process evaluations help identify barriers to participation and other issues with the potential to impact program effectiveness that may not show up in measurement and verification efforts. These evaluations can provide critical information that may increase participation, ultimately saving more energy.

4. COMPARISON OF OUTCOMES

Energy efficiency programs and portfolios are often designed with specific policy objectives in mind, and those objectives can often impact the outcome of a program. For example, programs that target hard-to-reach areas may not exhibit the same rates of participation as those that do not. Key factors that affect cost effectiveness and program outcomes include:

- **Energy efficiency policy objectives –** policies that emphasize different goals such as market transformation, resource acquisition, equity, etc. will drive different program designs and program objectives.

- **Market barriers addressed** – programs that seek to mitigate difficult barriers may have poorer performance-related metrics because they attack tough problems, in contrast to programs that may have excellent ostensible metrics because of cream skimming.

- **Measure mix** – the mix of measures installed in a program can significantly affect a program's cost-effectiveness.

- **Demand/energy** – the extent of peak demand versus energy focus of the program can, by definition, affect the cost-effectiveness of the indicator in question (e.g., a peak demand oriented program may score poorly on an $/kWh metric). This can be considered a part of the measure mix factor listed above.

- **Multi-year policy objectives** – if consistent, help programs to achieve goals that require medium to long-term market presence and extensive program infrastructure; if inconsistent, make achievement of such goals more difficult.

- **Multi-year funding levels** – if consistent, allow programs to set multi-year goals and maintain consistent presence and messages among end-users and supply-side market actors; if inconsistent, makes maintaining a stable market presence more difficult.

- **Program/Market Lifecycle** – where a program or key measure is in its product lifecycle will affect its cost-effectiveness. For example, a program seeking impacts from the last 50 percent of the market to adopt a product that has penetrated the first 50 percent of the market should be expected to be more costly than one attacking a market with a low or insignificant saturation level.[3]

- **Climate** – for example, HVAC measures are more cost-effective in severe climates than in mild climates because absolute savings are strongly a function of base usage levels.

---

[3] There are at least two reasons for this. First, in more highly saturated markets, it is more difficult to find the remaining measure opportunities and, second, the remaining market is typically characterized by late majority and laggard organizations that are more resistant to adopting new products and practices. In addition, a program in the first-year of a multi-year plan to impact a market may have poor first-year metrics because of the associated startup costs and time it takes to create awareness and other program effects.

- **Customer/target market actor mix** – the mix of customers and trade allies often plays a role in cost-effectiveness, for example, a program in a market with larger commercial customers will tend to be more cost effective than an identical program in a market of smaller commercial customers, all other things being equal; similarly, programs with customer segments with longer full-load equivalent hours will be more cost-effective than those with lower average full-load hours of operation (also related to climate).

- **Customer density** – delivering an energy efficiency program to a relatively dense population base will be less costly than delivering to a sparser population, all other things being equal.

- **Customer Energy Rates** – higher electricity rates should lead to higher levels of measure adoption, all else being equal.

- **Economic Conditions** – willingness to invest in new products and practices changes in response to short-term economic and market conditions, which may vary across regions.

- **Customer Values** – efficiency program effectiveness can vary as a function of differences in customer values, again, all else being equal.

This section presents cost-effectiveness estimates obtained from R4 Programs. Information is presented on the Total Resource Cost (TRC) test, the associated discount rate and the average measure life, where available. A second cost-effectiveness metric, the Utility/Program Administrator Cost test, was not generally available. The total program cost shown per MWh saved is an indicator related to the Utility/Program Administrator Cost test in that the numerator includes all program costs and excludes any customer contribution to measure costs. Also shown are non-incentive dollars spent per kW, which offers an indication of the cost to market and administer. Incentive dollars per kW shows the overall average incentive amount per unit of estimated first-year impact.

Exhibit R4-7 displays cost-effectiveness data for the reviewed programs. The Exhibit illustrates some of the general components of cost effectiveness. The information in this Exhibit has not been normalized to control for the differences in equations and it does reflect the variety of assumptions used by program administration in efforts to determine actual energy savings resulting from program activities. For example, programs focused on different measures and had different mechanisms to support their installation, in hotter climates AC diagnostic tune-ups may have offered the most savings, in others it may have been lighting or heating measures. Whenever possible, these numbers reflect actual budget and savings numbers, rather than projected.

The wide range of measures covered by R4 Programs, differences in weather and associated consumption levels, and the range of incentive levels make direct comparison difficult. While the overall energy savings related to a given measure may be relatively straightforward, the actual cost effectiveness varies depending on the rebate or incentive level. Similarly, free-ridership rates and average measure life are often determined measure by measure – in residential weatherization a variety of disparate measures may be included with a resulting range of free-ridership and measure life values. Even the Net to Gross (NTG) ratio is calculated differently in each program. California's programs were directed by the CPUC to use an NTG value of .89 for all residential programs (based on the average value from studies conducted by the CA IOUs throughout the 1990s), while National Grid USA and NSTAR NTG values were calculated by the reviewers from their reported net and gross energy savings using equations listed in program evaluations and annual reports. The formula and assumptions for NTG were not provided by Tacoma Power staff. Variation in realized savings can result from a variety of influences including:

- Changes in occupant behavior after retrofit
- Measure lifetime assumptions
- Whether or not measures are installed by a contractor or by the home owner

Many of the standard cost-effectiveness tests do not apply to the loan program at SMUD, since the program costs are covered by interest payments. Instead, these tests are applied upfront to establish measure by measure cost effectiveness when rebates are offered for particular measures through other programs. The loan program is judged on its own as a service SMUD offers to its customers to facilitate other energy efficiency efforts.

Exhibit R4-7
Program Effects

	ASC HTR Mobile Home	**2002 CA SW Single Family**	**NG EnergyWise**	**NSTAR Res High-Use**	**SMUD Equipment Loan**	**Tacoma Res Weatherization**
Period Reviewed	Oct 2002-Oct 2003	Jan-Dec 2002	Jan-Dec 2001[1]	Mid 1999-Dec 2000	Jan 2002 – Dec 2002	Jan-Dec 2002[2]
Net to Gross Ratio	.89[10]	.89[10]	.97[6]	.93[7]	NA[8]	.94
Free-ridership Rate	NA	NA	3%	4.4%	NA	NA
Total Resource Cost/Societal Test	1.55	.55	.95	NA	NA	NA[9]
Average measure lifetime	12	Varies	11.4	Varies	Varies	20
Net MWh (Annual)	3,447[2]	36,028	3,461[6]	3,179	1,254	2,031
Net kW (Annual)	1,329[2]	31,869	743[6]	Winter: 1164 Summer 831	700	NA
Real Discount Rate	5%	5%	5%	NA	6%	7%

Exhibit R4-7
Program Effects (Continued)

	ASC HTR Mobile Home	2002 CA SW Single Family	NG EnergyWise	NSTAR Res High-Use	SMUD Equipment Loan	Tacoma Res Weatherization
Budget Per Impact						
Program $/first-year kWh saved	$.41	$.72	$.34	$1.08	$1.88	$.46
Incentive Dollars per kWh	NA	$.47	NA	$.15	NA	$.11
Non-Incentive Dollars per kWh	NA	$.25	NA	$.93	NA	$.34
Program $/first-year kW saved	$1,069	$813	$1,568	Winter: $2,975 Summer: $4,168	$3,373	NA
Incentive Dollars per kW	NA	$529	NA	Winter: $427 Summer: $598	NA	NA
Non-Incentive Dollars per kW	NA	$283	NA	Winter: $2,549 Summer: $3,570	NA	NA

1. The 2001 single-family component of EnergyWise was evaluated and is referred to here. The 2002 multi-family component was evaluated – multi-family numbers are noted when used.
2. The billing analysis data covers 1997, 1998, 1999.
3. ASC goals are for the two-year program horizon, dividing the two year goal by two results in goals of 2,259 MWh and 1,079 kW goals. However, simply dividing their stated two year goal does not reflect the reality of program ramp-up.
4. Actual accomplishments reported in 3rd Quarter 2003 Quarterly Report Narrative to the CPUC.
5. Massachusetts Electric and Nantucket Electric, 2001 planning targets as reported via evaluation staff in email communication.
6. Calculated from 2002 evaluation data. Net kWh reduction = Gross kWh*(1-free-ridership+spillover)*kW adjustment factor. Spillover is assumed=0. Free-ridership=3 percent
7. Free-ridership rates and NTG ratios are averaged across ComElectric and BECo territories (RLW 2000)
8. The NTG ratio, free-ridership rates and TRC values are determined in the efficient products program. The loan program does not directly address these issues, as funds are repaid by customers. Measures eligible for incentives through other programs would have values associated with them. A District program review notes that the loan program "is the single most cost-effective energy-efficiency program… the District's costs for operating the program are fully recovered."(Sacramento Municipal Utility District 2003)
9. Levelized Utility Resource Cost test value = 27.4. The calculation is based upon forecast for 2001 Integrated Resource Plan.
10. The NTG ratios for the California programs are set by the CPUC, not calculated by each implementer per program.

5. SOURCES

American Synergy Corporation. (2002) Hard-to-Reach Mobile Home Proposal. Prepared for the California Public Utilities Commission. January 15, 2002.

DeCicco, John, Rick Diamond, Sandra Nolden, Janice DeBarros, and Tom Wilson. (1996) *Improving Energy Efficiency in Apartment Buildings*. Washington, D.C.: American Council for an Energy-Efficient Economy.

Energy Information Administration. (2003) "Revenue from Retail Sales of Electricity to Ultimate Consumers: Total by Sector 1990 through September 2003." On *Energy Information Administration (EIA) Web site*. www.eia.doe.gov/cneaf/electricity/epm/table5_2.html

Galbraith, David. (2003) Sacramento Municipal Utility District. Personal communication via telephone and email. October 2003.

Hirst, Eric. (1987) *Cooperation and Community Conservation, Final Report, Hood River Conservation Project*. Washington, D.C.: U.S. Department of Energy.

Hwang, Ho-Ling. (1989) *Assessment of Princeton Scorekeeping Method Space-Heating Estimates Using End-Use Data from the Hood River Conservation Project*. Oak Ridge, Tenn.: Oak Ridge National Laboratory.

Ihrig, Kimberly. (2003) National Grid USA. Personal communication via telephone and email, October 2003-May 2004.

Jordan, Gretchen. (2003) "Developing Logic Models and Using Them to Define a Balanced Set of Metrics." In *Workshop Materials of the International Energy Program Evaluation Conference*. Seattle, Wash.: Sandia National Laboratory.

Kallett, Rick. (2003) Sacramento Municipal Utility District. Personal communication via telephone and email. October 2003.

Lerman, David. (2001) Residential Weatherization Program Impact Evaluation. Tacoma Power.

McNaughton, Laura. (2003) National Grid USA. Personal communication via telephone and email, December 2003 – May 2004.

Megdal, Lori et. al. (2001) *Impact Evaluation of NSTAR Electric's Residential High Use Program*, Final Report. September 17, 2001 Prepared for NSTAR Electric.

Moran, Richard. (2003) NSTAR Electric. Personal communication via telephone and email. September –December 2003.

Nadel, Steven, Anna Shipley and R. Neal Elliott. (2004) "The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. – A Meta-Analysis of Recent

Studies," Proceedings of the American Council for an Energy-Efficient Economy Summer Study on Buildings, August. 2004.

Ozog, Michael. (2002) *Impact Evaluation of the 2001 Single-Family Energy Wise Program*. Submitted to National Grid USA. Massachusetts.

Quantum Consulting. (2003) *2002 Statewide Residential Retrofit Single-family Home Energy Efficiency Rebate Program Evaluation*. Prepared for Pacific Gas and Electric Company.

Peters, Jane et al. (2002) Best Practices from Energy Efficiency Organizations and Programs. Prepared for the Energy Trust of Oregon. September 20, 2002.

RLW Analytics. (2000) *NSTAR Process Evaluation of the High Use Program*. Prepared for NSTAR Services Company.

Robert Mowris & Associates. (2003) EM&V Mobile Home Inspection Report for PG&E, SCE and CPUC Representatives. September 9, 2003.

Sacramento Municipal Utility District. (2003) *SMUD Energy Efficiency Loan Program, Program Review and Recommendations.* Sacramento, Calif.: Sacramento Municipal Utility District.

Shallenberger, Steve. (2003) American Synergy Corporation. Personal communication via telephone and email, October 2003.

Teague, Dana. (2003) NSTAR Electric. Personal communication via telephone and email, December 2003.

Thorne, Jennifer. (2003) *Residential Retrofits: Directions in Market Transformation*. Washington, D.C.: American Council for an Energy-Efficient Economy.

APPENDIX R4A – BRIEF INTRODUCTION TO THE NATIONAL ENERGY EFFICIENCY BEST PRACTICES STUDY

INTRODUCTION

This report presents results of a comparative analysis of residential single-family comprehensive weatherization programs included in the National Energy Efficiency Best Practices Study ("Best Practices Study"). The overall Best Practices Study objectives, scope, and methodology are briefly outlined in this Appendix. More details on methods and cross-program findings are provided in separate report volumes.

OBJECTIVE AND SCOPE

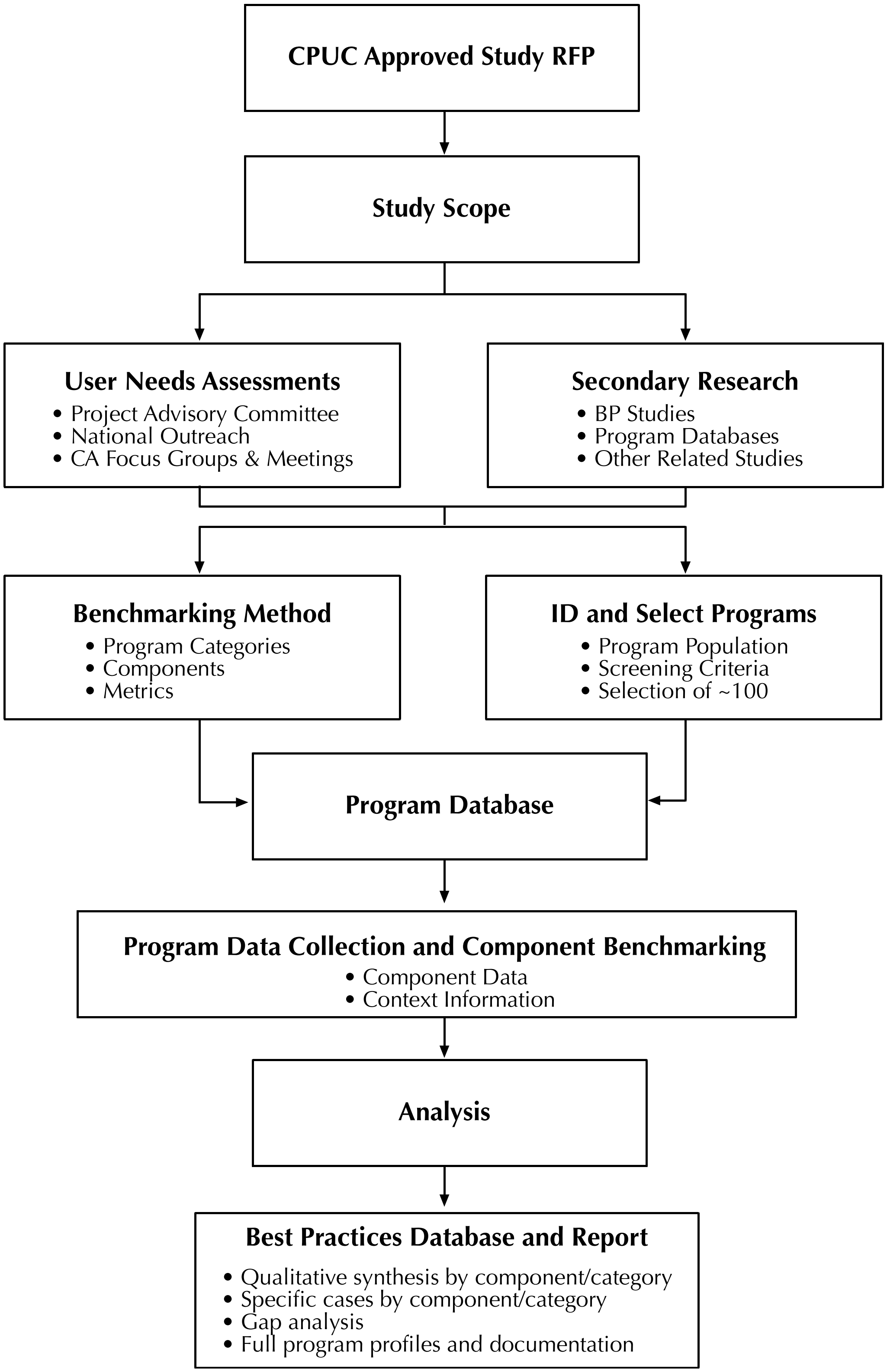
The overall goal of the Best Practices Study is to develop and implement a method to identify and communicate excellent energy efficiency program practices nationwide in order to enhance the design of such programs in California. In particular, program implementers supported through public goods funds are encouraged to use the Best Practices Study's products, along with other resources and their own knowledge and experience, to develop and refine energy efficiency programs.

The Best Practices Study is intended as a first-order effort to identify successful program approaches through systematic cross-program data collection and comparative analyses. It is not intended to produce a census of best practices across all types of programs. Such an approach would be neither practical nor useful given the number of programs that exist; the many differences in policies, goals, and market conditions around the country; the unique needs and market conditions in California; and the importance of encouraging innovation, which by its nature sometimes requires attempting approaches that are not yet proven. If the framework and results of the Best Practices Study prove useful, future phases of the work can expand the number and types of programs covered.

METHODOLOGY

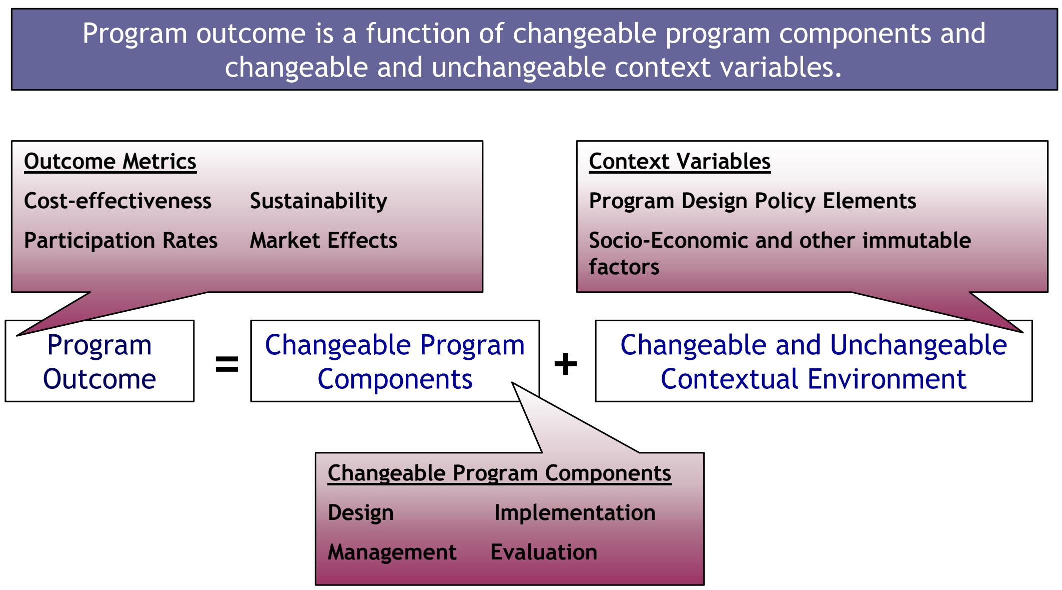
Key aspects of the Best Practices Study include a user needs assessment, secondary research, development of the benchmarking methods, identification and selection of programs to benchmark, development of the program database, data collection and program benchmarking, analysis, and preparation of the best practices report and final database. In addition, outcome metrics will be tracked. An overview of the Best Practices Study key activities is shown in Exhibit R4-8 below.

Exhibit R4-8
Overview of Energy Efficiency Best Practices Study



As shown below in Exhibit R4-9, the outcome of a program – as measured by $ per kWh saved, market penetration or sustainability – can be thought to be a function of changeable program elements, changeable portfolio-level design and programmatic policy decisions, and unchangeable social, economic, demographic, climate, and other factors. All of these factors can influence the ultimate success of an energy efficiency program. Some program elements (such as marketing, tracking or customer service) are directly controllable at the program level and can be modified to affect the success of the program. Other elements (such as the program policy objectives and whether the program has a single- or multi-year funding commitment) may not be changeable at the program level but may be changeable at a policy level. Other elements (such as the physical climate or density of the customer base) are not changeable and cannot be affected by program managers, implementers, or policy-makers.

Exhibit R4-9
Relationship Among Program Outcomes, Components, and Context



PROGRAM CATEGORIES

A program category is defined for the Best Practices Study as the basis for grouping “like” programs to compare across components and sub-components. Program categories may be defined in any number of ways, for example, as a function of target market (e.g., sector, vintage, segment, end use, value chain, urban/rural); approach (e.g., information-focused, incentive-focused [prescriptive; custom/performance based]); objective (e.g., resource acquisition, market transformation, equity), and geographic scope (e.g., local, utility service territory, state, region, nation); among other possible dimensions.)

A number of criteria a good program categorization strategy should address were identified and include user accessibility, benchmarking compatibility, potential, compatibility with policy guidelines, and compatibility with scope directives. The number of program categories was limited to approximately 17 to conform to resource constraints. These are shown in Exhibit R4-10 below. The final scheme separates residential from non-residential programs, and distinguishes between incentive programs, information and training programs and new construction programs. Programs are also segregated based on targeted end-use and customer type. A Crosscutting section is included to address comprehensive programs that do not cleanly fall within the other 16 categories. Each program category has an associated code, which is used throughout the Best Practices Study for identification purposes (e.g., R4 Programs = Residential Single-Family Comprehensive Weatherization Programs reviewed for the Best Practices Study).

Exhibit R4-10
Program Categories & Related Codes

<table>
<tr><th colspan="3">Program Category</th><th>Code</th></tr>
<tr><td rowspan="8">Residential</td><td rowspan="5">Incentives</td><td>Lighting</td><td>R1</td></tr>
<tr><td>Air Conditioning</td><td>R2</td></tr>
<tr><td>Appliance and Plug Load</td><td>R3</td></tr>
<tr><td>Single-Family Comprehensive</td><td>R4</td></tr>
<tr><td>Multi-Family Comprehensive</td><td>R5</td></tr>
<tr><td rowspan="2">Information & Training</td><td>Whole House Audit with no/minimal incentive</td><td>R6</td></tr>
<tr><td>General & Other Comprehensive</td><td>R7</td></tr>
<tr><td colspan="2">New Construction Information & Incentives</td><td>R8</td></tr>
<tr><td rowspan="8">Non-Residential</td><td rowspan="5">Incentives</td><td>Lighting</td><td>NR1</td></tr>
<tr><td>HVAC</td><td>NR2</td></tr>
<tr><td>Refrigeration, Motors, Compressed Air, Process</td><td>NR3</td></tr>
<tr><td>Small Comprehensive</td><td>NR4</td></tr>
<tr><td>Large Comprehensive</td><td>NR5</td></tr>
<tr><td rowspan="2">Information & Training</td><td>End-Users</td><td>NR6</td></tr>
<tr><td>Trade Allies</td><td>NR7</td></tr>
<tr><td colspan="2">New Construction Information & Incentives</td><td>NR8</td></tr>
<tr><td>Other</td><td colspan="2">Cross Cutting</td><td>O1</td></tr>
</table>

PROGRAM SELECTION

Programs reviewed for each of the program categories in the Best Practices Study were selected through a three step process. First, programs were nominated using recent best practice studies, team member recommendations. Next programs were randomly selected from published data on energy programs to complete the roster. The third step involved conducting outreach interviews with the staff of nominated programs to determine if sufficient information was available to conduct the research. With the final set of programs determined, in-depth interviews were conducted.

PROGRAM COMPONENTS

The Best Practices Study approach focuses on analyzing programs primarily from the perspective of their changeable program characteristics. The Best Practices Team developed a method for breaking programs down into components and sub-components in order to systematically identify and compare specific program features of importance to overall program success. The four primary program components are program design, program management, program implementation, and program evaluation. These components and their associated sub-components are briefly summarized below.

- **Program Design** provides the initial foundation for a successful program. The program design category has two sub-components: **program theory** and **program structure** (which includes policies and procedures). Good program design begins with good program theory and a complete understanding of the marketplace. Good program structure, policies and procedures are necessary to translate program design theories and goals into practical and effective management and implementation actions.

- **Program Management** is the command and control center that drives the implementation process, and may be broken down into the sub-components of **project management**, **reporting and tracking**, and **quality control and verification**. Project management includes the structure and relationship among responsible parties. Reporting and tracking focuses on approaches to identifying and tracking useful and appropriate metrics that can be translated efficiently into reporting effective information. Quality control and verification includes accountability and improvement processes that are typically carried out through implementation and evaluation activities.

- **Program Implementation** is defined by the actual activities carried out in the marketplace to increase adoption of energy efficiency products and practices. Its sub-components include **outreach, marketing, and advertising**, the **participation process**, and **installation and incentive** mechanisms. Good outreach, marketing and advertising efforts should result in relatively high program awareness, knowledge of program specifics, and participation levels. The participation process is a critically important element of a program's ultimate success. Standard measures of market penetration and customer satisfaction provide one indication of a program's effectiveness at enrolling customers and processing their applications. Installation and incentives should demonstrate evidence of installation and delivery follow-through on marketing and outreach efforts.

- **Evaluation and Adaptability** of programs should also be analyzed. The Best Practices Study assesses the adequacy of evaluation efforts and how programs use evaluation results or other feedback mechanisms to improve over time.

DATA COLLECTION

Program information was gathered using primary and secondary sources. Primary data was collected largely through surveys of program managers and review of regulatory filings, annual reports, and program evaluations. The Best Practices Team conducted extensive interviews with program managers using a detailed survey instrument to guide the conversations. The survey instrument collected information on three main areas: policy context and environment, outcome metrics, and information about program components. The first set of questions elicited responses on how the program might have been affected by the broader context in which it operates. Next, respondents provided information on outcome metrics, such as program impacts and costs. The remainder of the instrument was devoted to collecting detailed program information for each program component. For each component, respondents were asked to provide factual information on how the program addressed each issue and qualitative judgments about what practices they felt contributed to the success of this program and what practices should have been avoided or could be improved.

STRUCTURE OF REPORTING

Complete project results are provided in project reports and a Web site that allows users to access information at varying levels of depth, including top-line summaries by program type or component, stand-alone chapters on best practices by program area, documentation of project methods, and individual program profiles.

DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix F:
TXU 2003 Report

Control Number: 27541

Item Number: 12

Addendum StartPage: 0

Project No. 27541

Annual Energy Efficiency Report To The Public Utility Commission of Texas In Accordance With Substantive Rule § 25.181(h)(4) and § 25.183(d)(2),(3)

ONCOR ELECTRIC DELIVERY COMPANY

April 1, 2003

12

ONCOR
ANNUAL ENERGY EFFICIENCY REPORT

I. Executive Summary

This Annual Energy Efficiency Report for Calendar Year 2002 is filed by Oncor Electric Delivery Company[1] ("Oncor") in accordance with PUC Substantive Rule §§ 25.181(h)(4) and 25.183(d)(2),(3). Calendar Year 2002 was Oncor's initial year in the implementation of the Market Transformation Programs ("MTPs") and Standard Offer Programs ("SOPs") described in Oncor's April 1, 2002 Annual Energy Efficiency Plan.

Appendix A of this report includes explanations relevant to certain sections of the report.

II. Actual Growth in Demand for 2002

Actual Weather Adjusted Growth in Retail Demand for the Year 2002 was 1,428 MW.

III. Projected Annual Growth & Corresponding Goals (at meter) for 2003

Year	Projected Annual Growth in Demand	kW Goal	KWh Goal
2003	777,480 kW	87,362	317,112,079

IV. Comparison of Projected Savings to Reported Savings (at meter)

CALENDAR YEAR 2002

Program	Projected Savings kW	Projected Savings kWh	Contracted Savings kW	Contracted Savings kWh	Reported Savings kW	Reported Savings kWh
Large Commercial & Industrial SOP	20,471	69,185,687	19,275	101,505,800	19,511	105,129,644
Residential & Small Commercial SOP	5,905	19,957,410	7,618	24,167,534	3,723	12,564,672
Hard-to-Reach SOP	1,968	5,452,470	2,124	7,237,084	1,876	7,365,563
Energy Star® Homes MTP	5,118	17,296,422	5,670	14,395,500	7,431	24,664,500
A/C Distributor MTP	5,905	19,957,410	2,905	3,626,000	1,543	2,510,901
Third Party DSM Contracts*	0	0	5,330	33,559,519	5,330	33,559,519
Total	39,367	131,849,399	42,922	184,491,437	39,414	185,794,799

* Savings are from new energy efficiency measures installed in 2002.

[1] In January 2002, TXU Electric Company changed its name to Oncor Electric Delivery Company.

In Oncor's April 1, 2004 Annual Energy Efficiency Report, the table in this section will include two additional columns that will compare Calendar Year 2002 reported savings to the 2002 verified savings determined by the Independent Measurement & Verification Expert and reported in the report due to be filed by that expert by March, 2004.

V. Baseline and Milestones Achieved by the MTPs

Air Conditioning Distributor MTP

The primary objectives of this program are to increase the market penetration of high-efficiency air conditioning units and to improve installation practices in order to provide cost-effective reduction in peak summer demand. Additional objectives of this program are to achieve customer energy and cost savings and encourage private sector delivery of energy efficiency products and services. Informal interviews were conducted with air conditioning distributors and air conditioning contractors to identify market barriers. Similar utility programs were also reviewed to glean lessons learned and determine any other possible barriers. The results of these investigations revealed that higher first costs to consumers, lack of understanding of energy efficiency by contractors, and a lack of consumer information are market barriers.

The baseline for the Air Conditioning Distributor MTP is being developed by acquiring sales information concerning air conditioning units, by SEER rating. In 2002, an air conditioning unit had to have a SEER rating of 13.0 to qualify for incentives. During the 2002 program year, the seven participating air conditioning distributors reported sales of 15,649 Energy Star® rated units with a SEER of 13.0 or higher. Of these, 3,849 were 14.0 SEER or higher, compared to 1,646 during the 2001 pilot program.[2]

In 2002, the Air Conditioning Distributor MTP resulted in an increase in the market penetration of high efficiency equipment installations above the minimum-qualifying SEER rating of 13.0. This was accomplished through the addition of three new distributors in the program, conducting one-on-one meetings with participating air conditioning distributors to develop strategies to overcome market barriers, and making presentations to contractors at their annual air conditioning distributor meetings to promote the benefits of high efficiency equipment.

[2] In 2001, the minimum baseline for receipt of incentives in this MTP was a SEER rating of 12.0, and contractors reporting sales of units reported sales of units having a SEER rating of 12.0 to 13.9 and units having a SEER rating of 14.0 and higher. Accordingly, Oncor is not able to compare 2002 sales of units with a SEER rating of 13.0 to 13.9 to 2001 sales of such units.

Energy Star® Homes MTP

The primary objective of this program is to achieve peak demand reductions and/or energy savings through increased sales of Energy Star® homes and products. Additionally, the program is designed to condition the market so that consumers are aware of and demand Energy Star® homes and products and builders have the technical capacity to supply them. A baseline study was conducted during the third quarter of 2000. The purpose of the study was to determine the existing level of efficiency typical of new home construction in Oncor's service territory, characterize current market conditions in the residential new construction program area, and characterize the level of customer awareness, interest and perceptions of the Energy Star® label. The study showed that current home construction practices resulted in an average Home Energy Rating System ("HERS") score of 80.2, compared to a minimum Energy Star® HERS score of 86.0. Customer awareness was significantly higher for Energy Star® appliances compared to Energy Star® homes.

During the 2001 pilot program, there were 42,700 homes constructed in the Oncor service territory Metropolitan Statistical Areas (MSAs). Of those, 44 homes received Energy Star® certification through the program. In 2002, there were 43,778 homes constructed in the Oncor service territory MSAs. Of these, 6,492 received Energy Star® certification with an average HERS score of 86.9. Additional milestones that contributed to the Energy Star® certification of 6,492 homes included selecting a new program implementer, training and certifying 55 new HERS Raters, educating and recruiting 23 new builders, training 25 realtors on the advantages of an Energy Star® home, and consumer education. As a result of these accomplishments, Oncor was recognized by the U.S. Environmental Protection Agency and awarded the Energy Star® Partner of the Year – New Homes.

New 2003 MTPs

Oncor had Baseline Studies completed during 2002 that were designed to determine the baseline and market potential for an A/C Installer Information & Training MTP and a High Efficiency Windows MTP. Comparisons of the baseline and milestones for these programs will be reported in the Energy Efficiency Report for Calendar Year 2003.

VI. Program Funding

CALENDAR YEAR 2002

Program	Budget	Funds Expended (Incentives)	Funds Expended (Admin.)	Total Funds Expended	Funds Committed (Not Expended)	Funds Remaining (Not Committed)
Large Commercial & Industrial SOP	$ 9,276,436	$ 3,555,523	$ 482,596	$ 4,038,119	$ 4,364,954	$ 873,363
Residential & Small Commercial SOP	$ 3,822,678	$ 1,074,576	$ 264,697	$ 1,339,273	$ 3,332,279	$ (848,874)
Hard-to-Reach SOP	$ 1,981,247	$ 1,807,989	$ 181,212	$ 1,989,201	$ 429,592	$ (437,546)
Energy Star® Homes MTP	$ 3,313,088	$ 1,649,963	$ 282,218	$ 1,932,181	$ 2,955,851	$ (1,574,944)
A/C Distributor MTP*	$ 3,822,678	$ 536,785	$ 251,231	$ 788,016	$ 0	$ 3,034,662
A/C Installer Info. & Training MTP	$ 0	$ 100,000	$ 119,827	$ 219,827	$ 0	$ (219,827)
High Efficiency Residential Windows MTP	$ 0	$ 0	$ 181,188	$ 181,188	$ 0	$ (181,188)
Third Party DSM Contracts	$ 4,183,735	$ 10,341,142	$ 330,246	$ 10,671,388	$ 0	$ (6,487,653)
General Energy Efficiency Program Administrative Costs	$ 0	$ 0	$ 484,339	$ 484,339	$ 0	$ (484,339)
Total	$ 26,399,862	$ 19,065,978	$ 2,577,554	$ 21,643,532	$ 11,082,676	$ (6,326,346)

* The A/C Distributor MTP did not have any "funds committed but not expended" because Oncor did not set-aside any funds for participants in this program. Rather, incentives were paid on a first-come, first-served basis according to when invoices were received.

VII. Explanation of a Total Program Cost Decrease of More Than 10%

Oncor surpassed its 2002 goal of 39,367 kW while spending less money than was budgeted. As shown on the preceding table in Section VI, funds were committed by contracts with energy efficiency service providers in excess of the 2002 budget amounts for all programs except the Commercial & Industrial SOP in order to ensure attainment of the goal. However, due to lower than anticipated activity in the A/C Distributor MTP and the Residential & Small Commercial SOP, as well as the timing of incentive payments for projects completed late in 2002 that will not actually be paid until 2003, Oncor's actual expenditures in Calendar Year 2002 were $4,756,330 under budget. Oncor requests to roll that amount over to Calendar Year 2003 as those funds will be necessary to fulfill the remaining obligations from Calendar Year 2002 programs. Furthermore, rolling over the $4,756,330 is necessary to successfully implement Oncor's 2003 Energy Efficiency Plan because, as further discussed in that plan, the 2003 budget has increased from $51,055,111 to $55,282,044 as a result of an increase in demand growth beyond what was anticipated in prior Oncor Energy Efficiency Plans.

In addition, the 2002 budget of $26,399,862 was approved in Docket No. 22350 as the first year of a three-year average used to set the annual revenue recovery for energy efficiency program costs for 2002-2004, with the understanding that the difference between the 2002 approved budget amount of $26,399,862 and the 2002 approved revenue recovery amount of $42,663,548 would be rolled over for use in Calendar Years 2003 and 2004. Accordingly, Oncor intends to roll over this amount, which equals $16,263,686, into 2003 for use in implementing the Energy Efficiency Plan for Calendar Years 2003 and 2004.

VIII. Most Current Information Available for Ongoing and Completed Energy Efficiency Programs by Customer Class

CALENDAR YEAR 2002

Customer Class	Number of Customers	Program Expenditures	Reported Savings kW	kWh
Large C & I				
Large Commercial & Industrial SOP	549	$ 4,038,119	19,511	105,129,644
Third Party DSM Contracts	132	$ 10,671,388	5,330	33,559,519
Total	681	$ 14,709,507	24,841	138,689,163
Residential				
A/C Distributor MTP	1,161	$ 632,215	1,265	1,898,597
Residential & Small Commercial SOP	3,489	$ 1,094,059	2,021	5,288,221
Energy Star® Homes MTP	6,492	$ 1,932,181	7,431	24,664,500
Total	11,142	$ 3,658,455	10,717	31,851,318
Small Commercial				
A/C Distributor MTP	199	$ 155,801	278	612,304
Residential & Small Commercial SOP	782	$ 245,214	1,702	7,276,451
Total	981	$ 401,015	1,980	7,888,755
Hard-to-Reach				
Hard-to-Reach SOP	14,918	$ 1,989,201	1,876	7,365,563
Total	14,918	$ 1,989,201	1,876	7,365,563

IX. Description of Proposed Changes in the Energy Efficiency Plan

Please see Oncor's April 1, 2003 Annual Efficiency Plan for proposed changes to the Energy Efficiency Plan for Calendar Years 2003 through 2006.

X. Demand and Energy Reduction by County

Appendix B contains the kW and kWh reduction achieved by the energy efficiency programs implemented by Oncor in Calendar Year 2002, by county. The funding source for all of the kW and kWh savings shown on Appendix B is the Oncor budget for SOPs, MTPs, and existing DSM Contracts.

Oncor Electric Delivery Company
Annual Energy Efficiency Report
for Calendar Year 2002

Appendix A

Explanations

(1) The following explanation is for **Section II:**

In this Section, actual growth in demand is the amount of increase in demand from the year prior to the reporting year compared to the reporting year. It is adjusted for normal weather and is at the system level.

(2) The following explanations are for column values shown in **Section IV:**

Projected Savings – The amount of projected peak demand savings is the amount included in the Oncor Energy Efficiency Plan filed in the preceding year, in addition to the amount of savings projected at that time to be procured by the Texas Department of Housing and Community Affairs (TDHCA).

Contracted Savings – The total energy and peak demand savings that are the subject of contracts between Oncor and energy efficiency service providers during the reporting calendar year.

Reported Savings – The total energy and peak demand savings that have been reported to Oncor by energy efficiency service providers and the TDHCA during the reporting calendar year.

(3) The following explanations are for column values shown in **Section VI:**

Budget – The amount of funding dedicated to the implementation of energy efficiency programs for the reporting calendar year as shown in the Oncor Energy Efficiency Plan filed in the preceding year.

Funds Expended for Incentives – The amount of funds expended by Oncor on incentive payments for energy efficiency programs during the reporting calendar year.

Funds Expended for Administration – The amount of funds expended by Oncor on administrative expenses associated with energy efficiency programs during the reporting calendar year. For Calendar Year 2003, this column will include funds for the independent measurement and verification expert.

Funds Committed but not Expended – The amount of Oncor funds committed by contract with energy efficiency service providers for the reporting calendar year that have not been paid to the provider.

Funds Remaining and not Committed or Expended – The difference between the budgeted amount for an energy efficiency program and the amount of funds that were not expended or committed by contract with energy efficiency service providers during the reporting calendar year.

(4) The following explanations are for column values shown in **Section VIII:**

Number of Customers – A customer is defined as having an Oncor account number.

Program Expenditures – The total of administrative and incentives expended during the reporting calendar year.

Reported Savings – The energy and peak demand savings that have been reported by energy efficiency service providers and the TDHCA during the reporting calendar year.

Appendix B: Demand and Energy Reduction by County

COUNTY	A/C Distributor MT		Hard-to Reach SO		Energy Stars Home MT		Commercial & Industrial SO		Existing DSM Contracts		Residential & Small Commercial SO	
ANDERSON	kW impact	10.6	kW impact	38.7	kW impact		kW impact	45	kW impact	9 4	kW impact	10.6
	kWh impact	15,624	kWh impact	190,721	kWh impact		kWh impact	291,153	kWh impact	97,062	kWh impact	45,403
ANDREWS	kW impact	0.8	kW impact	5.8	kW impact		kW impact		kW impact		kW impact	
	kWh impact	1,036	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
ANGELINA	kW impact		kW impact	1.7	kW impact		kW impact	52	kW impact	9.4	kW impact	10.7
	kWh impact		kWh impact		kWh impact		kWh impact	332,850	kWh impact	97,062	kWh impact	34,199
ARCHER	kW impact		kW impact	12.3	kW impact		kW impact		kW impact		kW impact	1.0
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	2,519
BASTROP	kW impact		kW impact	0.7	kW impact		kW impact		kW impact		kW impact	3 4
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	12,095
BELL	kW impact	42.8	kW impact	18.3	kW impact	90	kW impact	280	kW impact	18.7	kW impact	124.6
	kWh impact	64,967	kWh impact		kWh impact	185,416	kWh impact	1,283,122	kWh impact	194,123	kWh impact	293,180
BROWN	kW impact		kW impact	2.0	kW impact		kW impact	39	kW impact	9.4	kW impact	3.8
	kWh impact		kWh impact		kWh impact		kWh impact	269,116	kWh impact	97,062	kWh impact	6,735
CHEROKEE	kW impact		kW impact	87.2	kW impact		kW impact		kW impact		kW impact	3.7
	kWh impact		kWh impact	471,744	kWh impact		kWh impact		kWh impact		kWh impact	15,685
CLAY	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	12.2
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	30,001
COLLIN	kW impact	169.5	kW impact	4.4	kW impact	2,218	kW impact	538	kW impact	28.1	kW impact	332.4
	kWh impact	307,449	kWh impact		kWh impact	8,007,810	kWh impact	2,845,300	kWh impact	291,185	kWh impact	1,062,201
COMANCHE	kW impact		kW impact	4.3	kW impact		kW impact	39	kW impact		kW impact	
	kWh impact		kWh impact		kWh impact		kWh impact	97,589	kWh impact		kWh impact	
COOKE	kW impact	25.3	kW impact	1.8	kW impact		kW impact	8	kW impact	9.4	kW impact	11.8
	kWh impact	40,213	kWh impact		kWh impact		kWh impact	32,130	kWh impact	97,062	kWh impact	50,405
CORYELL	kW impact		kW impact	1.6	kW impact	55	kW impact	8	kW impact	9.4	kW impact	1.5
	kWh impact		kWh impact		kWh impact	109,799	kWh impact	31,692	kWh impact	97,062	kWh impact	2,988
CRANE	kW impact		kW impact	1.2	kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
DALLAS	kW impact	370.6	kW impact	940.9	kW impact	1,017	kW impact	11,130	kW impact	4,814.6	kW impact	1,205.4
	kWh impact	602,078	kWh impact	4,179,894	kWh impact	3,416,076	kWh impact	53,958,686	kWh impact	28,221,134	kWh impact	4,093,744
DAWSON	kW impact		kW impact	21.1	kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
DENTON	kW impact	15.3	kW impact	3.6	kW impact	1,045	kW impact	8	kW impact	9.4	kW impact	32.7
	kWh impact	23,436	kWh impact		kWh impact	3,418,496	kWh impact	33,134	kWh impact	97,062	kWh impact	59,650
EASTLAND	kW impact		kW impact	0.2	kW impact		kW impact		kW impact		kW impact	7.8
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	13,529
ECTOR	kW impact	38.4	kW impact	5.1	kW impact		kW impact	30	kW impact	18.7	kW impact	9.9
	kWh impact	51,703	kWh impact		kWh impact		kWh impact	124,342	kWh impact	194,123	kWh impact	13,290
ELLIS	kW impact	19.1	kW impact	10.2	kW impact	6	kW impact	46	kW impact	9.4	kW impact	32.7
	kWh impact	27,574	kWh impact		kWh impact	20,798	kWh impact	305,023	kWh impact	97,062	kWh impact	130,336

ERATH	kW impact	1.8	kW impact	0.6	kW impact		kW impact	35	kW impact	9.4	kW impact	9.2
	kWh impact	2,605	kWh impact		kWh impact		kWh impact	245,737	kWh impact	97,062	kWh impact	34,977
FALLS	kW impact	0.8	kW impact	4.1	kW impact		kW impact		kW impact		kW impact	1.8
	kWh impact	1,102	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	2,216
FANNIN	kW impact	6.0	kW impact	4.9	kW impact		kW impact		kW impact	9.4	kW impact	3.6
	kWh impact	9,195	kWh impact		kWh impact		kWh impact		kWh impact	97,062	kWh impact	15,549
FREESTONE	kW impact		kW impact	0 7	kW impact		kW impact		kW impact		kW impact	0.8
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	1,746
GLASSCOCK	kW impact	2.2	kW impact		kW impact		kW impact		kW impact		kW impact	
	kWh impact	3,624	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
GRAYSON	kW impact	0.5	kW impact	90.4	kW impact	125	kW impact	8	kW impact	28 1	kW impact	59.0
	kWh impact	592	kWh impact	63,505	kWh impact	355,864	kWh impact	32,438	kWh impact	291,185	kWh impact	237,318
HARRIS	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	1 0
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	2,756
HENDERSON	kW impact	1.1	kW impact	78.2	kW impact		kW impact	10	kW impact	18.7	kW impact	17.9
	kWh impact	1,625	kWh impact	390,382	kWh impact		kWh impact	43,777	kWh impact	194,123	kWh impact	69,549
HILL	kW impact		kW impact	22.4	kW impact		kW impact	3	kW impact	9.4	kW impact	20.8
	kWh impact		kWh impact		kWh impact		kWh impact	16,869	kWh impact	97,062	kWh impact	60,312
HOOD	kW impact	2.8	kW impact		kW impact	7	kW impact		kW impact		kW impact	1.4
	kWh impact	4,225	kWh impact		kWh impact	20,181	kWh impact		kWh impact		kWh impact	2,947
HOPKINS	kW impact	1.1	kW impact	0.6	kW impact		kW impact		kW impact	9.4	kW impact	4.3
	kWh impact	1,542	kWh impact		kWh impact		kWh impact		kWh impact	97,062	kWh impact	8,537
HOUSTON	kW impact	4.7	kW impact		kW impact		kW impact		kW impact	9.4	kW impact	4.0
	kWh impact	8,520	kWh impact		kWh impact		kWh impact		kWh impact	97,062	kWh impact	17,106
HOWARD	kW impact	24.7	kW impact	9.5	kW impact		kW impact	10	kW impact	9.4	kW impact	3.7
	kWh impact	38,931	kWh impact		kWh impact		kWh impact	44,848	kWh impact	97,062	kWh impact	5,583
HUNT	kW impact	1.0	kW impact	10.6	kW impact		kW impact		kW impact		kW impact	0.5
	kWh impact	1,183	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	2,005
JACK	kW impact		kW impact	2.3	kW impact		kW impact		kW impact		kW impact	2.9
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	3,675
JOHNSON	kW impact	4.3	kW impact	1.8	kW impact	59	kW impact	74	kW impact	18.7	kW impact	35.7
	kWh impact	5,495	kWh impact		kWh impact	216,614	kWh impact	450,751	kWh impact	194,123	kWh impact	128,317
KAUFMAN	kW impact	33.5	kW impact	4.9	kW impact	259	kW impact		kW impact	9.4	kW impact	9.5
	kWh impact	82,410	kWh impact		kWh impact	861,937	kWh impact		kWh impact	97,062	kWh impact	35,306
LAMAR	kW impact	1.1	kW impact	3.3	kW impact		kW impact		kW impact	9.4	kW impact	33.4
	kWh impact	2,099	kWh impact		kWh impact		kWh impact		kWh impact	97,062	kWh impact	118,629
LAMPASSAS	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	1.0
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	1,184
LEON	kW impact	0.8	kW impact	1.2	kW impact		kW impact		kW impact		kW impact	0.8
	kWh impact	1,052	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	1,746
LIMESTONE	kW impact		kW impact	0.2	kW impact		kW impact		kW impact		kW impact	11.0
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	37,854

MARTIN	kW impact	3.5	kW impact	0.7	kW impact		kW impact		kW impact		kW impact	
	kWh impact	5,808	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
MCLENNAN	kW impact	43.1	kW impact	1.8	kW impact		kW impact	675	kW impact	28.1	kW impact	175.0
	kWh impact	56,879	kWh impact		kWh impact		kWh impact	2,954,720	kWh impact	291,185	kWh impact	674,915
MIDLAND	kW impact	351.0	kW impact	0.9	kW impact		kW impact	429	kW impact	18.7	kW impact	17.3
	kWh impact	553,382	kWh impact		kWh impact		kWh impact	2,005,809	kWh impact	194,123	kWh impact	27,342
MILAM	kW impact	3.4	kW impact	0.6	kW impact		kW impact		kW impact		kW impact	4.5
	kWh impact	4,423	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	8,172
NACODOCHES	kW impact		kW impact	47.3	kW impact		kW impact	30	kW impact	9.4	kW impact	47.9
	kWh impact		kWh impact	247,960	kWh impact		kWh impact	148,434	kWh impact	97,062	kWh impact	182,368
NAVARRO	kW impact	1.2	kW impact	8.4	kW impact		kW impact	106	kW impact		kW impact	24.6
	kWh impact	1,479	kWh impact		kWh impact		kWh impact	661,693	kWh impact		kWh impact	99,785
NOLAN	kW impact		kW impact	3.7	kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
PALO PINTO	kW impact		kW impact	3.7	kW impact		kW impact	10	kW impact		kW impact	5.8
	kWh impact		kWh impact		kWh impact		kWh impact	41,831	kWh impact		kWh impact	19,821
PARKER	kW impact	5.7	kW impact	1.3	kW impact	8	kW impact	3	kW impact		kW impact	8.2
	kWh impact	7,840	kWh impact	4,244	kWh impact	23,808	kWh impact	13,016	kWh impact		kWh impact	23,514
RED RIVER	kW impact	1.9	kW impact	2.4	kW impact		kW impact	13	kW impact		kW impact	
	kWh impact	2,398	kWh impact		kWh impact		kWh impact	55,165	kWh impact		kWh impact	
ROCKWALL	kW impact	4.3	kW impact	1.5	kW impact	174	kW impact	36	kW impact	9.4	kW impact	11.1
	kWh impact	6,219	kWh impact		kWh impact	590,069	kWh impact	249,912	kWh impact	97,062	kWh impact	34,772
RUSK	kW impact		kW impact	1.2	kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
SCURRY	kW impact	1.4	kW impact	0.9	kW impact		kW impact	15	kW impact		kW impact	26.7
	kWh impact	2,305	kWh impact		kWh impact		kWh impact	64,340	kWh impact		kWh impact	44,102
SMITH	kW impact	46.1	kW impact	92.7	kW impact		kW impact	36	kW impact	18.7	kW impact	67.9
	kWh impact	72,558	kWh impact	466,800	kWh impact		kWh impact	140,952	kWh impact	194,123	kWh impact	297,653
STEPHENS	kW impact		kW impact	0.2	kW impact		kW impact		kW impact		kW impact	6.3
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	9,212
TARRANT	kW impact	290.3	kW impact	293.8	kW impact	1,858	kW impact	5,465	kW impact	93.7	kW impact	1,027.5
	kWh impact	480,383	kWh impact	1,327,033	kWh impact	6,274,841	kWh impact	37,114,549	kWh impact	970,615	kWh impact	3,691,796
TAYLOR	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	2.2
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	3,480
TRAVIS	kW impact	1.6	kW impact	3.8	kW impact	389	kW impact	81	kW impact		kW impact	11.1
	kWh impact	2,632	kWh impact		kWh impact	884,572	kWh impact	201,997	kWh impact		kWh impact	16,174
UPTON	kW impact		kW impact	0.7	kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
VAN ZANDT	kW impact	2.2	kW impact	1.8	kW impact		kW impact		kW impact	9.4	kW impact	13.8
	kWh impact	4,494	kWh impact		kWh impact		kWh impact		kWh impact	97,062	kWh impact	58,985
WARD	kW impact	7.7	kW impact	3.1	kW impact		kW impact		kW impact		kW impact	0.7
	kWh impact	10,667	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	984

WICHITA	kW impact		kW impact	4.8	kW impact		kW impact	15	kW impact	28.1	kW impact	42.0
	kWh impact		kWh impact		kWh impact		kWh impact	58,469	kWh impact	291,185	kWh impact	130,858
WILLIAMSON	kW impact	0.8	kW impact	3.1	kW impact	116	kW impact	63	kW impact	18.7	kW impact	171.2
	kWh impact	1,157	kWh impact		kWh impact	258,479	kWh impact	383,246	kWh impact	194,123	kWh impact	462,737
WISE	kW impact		kW impact	0.5	kW impact	5	kW impact	41	kW impact	9.4	kW impact	19.2
	kWh impact		kWh impact	3,260	kWh impact	19,739	kWh impact	266,992	kWh impact	97,062	kWh impact	85,808
YOUNG	kW impact		kW impact		kW impact		kW impact	131	kW impact		kW impact	14.2
	kWh impact		kWh impact		kWh impact		kWh impact	329,962	kWh impact		kWh impact	38,921
Total Sum of kW impact		1,543		1,876		7,431		19,511		5,330		3,723
Total Sum of kWh impact		2,510,901		7,365,563		24,664,500		105,129,644		33,559,519		12,564,672

DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix G:
TXU 2004 Report

Control Number: 29440

Item Number: 7

Addendum StartPage: 0

2004 APR -1 PM 1:11

PUBLIC UTILITY COMMISSION
FILING CLERK

Project No. 29440

Annual Energy Efficiency Report To The Public Utility Commission of Texas In Accordance With Substantive Rule §25.181(h)(4) and §25.183(d)(2),(3)

ONCOR ELECTRIC DELIVERY COMPANY

April 1, 2004

7

ONCOR ELECTRIC DELIVERY COMPANY
ANNUAL ENERGY EFFICIENCY REPORT

I. Executive Summary

This Annual Energy Efficiency Report for Calendar Year 2003 is filed by Oncor Electric Delivery Company ("Oncor") in accordance with Substantive Rule §§25.181(h)(4) and 25.183(d)(2),(3). Calendar Year 2003 was Oncor's second year in the implementation of the Market Transformation Programs ("MTPs") and Standard Offer Programs ("SOPs") required by PURA §39.905 and Substantive Rule §25.181, and was the first year Oncor was required to meet the 10% demand reduction goal. Oncor's 10% energy efficiency goal for 2003, as stated in Oncor's Energy Efficiency Plan filed in Project No. 27541 on April 1, 2003, was 87,362 kW. Oncor exceeded its goal by procuring 89,289 kW in demand savings.

Appendix A of this report includes explanations relevant to certain sections of the report.

II. Actual Growth in Demand for 2003

Actual Weather Adjusted Growth in Retail Demand for the Year 2003 was 1,217 MW.

III. Projected Annual Growth & Corresponding Goals (at meter)

Year	Projected Annual Growth in Demand	kW Goal	KWh Goal
2004	962,000 kW	100,721	238,979,032

IV. Comparison of Projected Savings to Reported Savings (at meter)

CALENDAR YEAR 2003

Program	Projected Savings		Contracted Savings		Reported Savings	
	kW	kWh	kW	kWh	kW	kWh
Large Commercial & Industrial SOP	21,930	114,325,935	16,571	63,685,852	16,598	66,483,151
Residential & Small Commercial SOP	11,379	41,224,570	9,977	34,540,128	10,186	44,285,236
Hard-to-Reach SOP	4,209	15,855,604	6,841	30,559,934	6,372	30,354,007
Energy Star® Homes MTP	14,005	50,737,933	23,650	19,756,000	27,701	23,138,578
A/C Distributor MTP	8,753	31,711,208	8,753	31,711,208	10,800	13,478,000
A/C Installer Info. & Training MTP	5,252	19,026,724	4,800	9,550,000	1,790	2,643,000
Emergency Load Management Pilot SOP	13,129	0	10,917	0	13,129	0
Third Party DSM Contracts*	8,705	44,230,105	8,705	44,230,105	2,713	12,800,527
Total	87,362	317,112,079	90,214	234,033,227	89,289	193,182,499

* Savings are from new energy efficiency measures installed in 2003.

V. Baseline and Milestones Achieved by the MTPs

Air Conditioning Distributor MTP

The primary objectives of this program are to increase the market penetration of high-efficiency air conditioning units and to improve installation practices in order to provide cost-effective reduction in peak summer demand. Additional objectives of this program are to achieve customer energy and cost savings and encourage private sector delivery of energy efficiency products and services. Informal interviews were conducted with air conditioning distributors and air conditioning contractors to identify market barriers. Similar utility programs were also reviewed to glean lessons learned and determine any other possible barriers. The results of these investigations revealed that higher first costs to consumers, lack of understanding of energy efficiency by contractors, and a lack of consumer information are market barriers.

Air conditioning distributors who participate in the program are required to provide baseline information concerning previous sales. During the 2003 program year, the seven participating air conditioning distributors reported sales of 29,795 units with a SEER of 13.0 or higher, compared to 15,649 Energy Star® rated units in 2002. Of the units reported in 2003, 3,475 were 14.0 SEER or higher. Program market impacts of 10.8 MW were reported for 2003, based upon a Market Effects Study of participating air conditioning distributors and both participating and non-participating air conditioning contractors. The market impacts were derived by combining the study results with deemed savings values and installation data from residential and small commercial units reported in 2003. Therefore, the market impact savings include units whose installation was influenced by the program, but that were not submitted for incentive payments. This resulted in higher savings, but lower program incentive payments, than were projected in the April 1, 2003 Annual Energy Efficiency Plan.

Program goals and milestones for 2004 are to continue implementing strategies to overcome the market barriers, increase outreach to new home builders, increase the penetration rate of quality installations of high efficiency units and realize savings impacts of 14 MW.

Energy Star® Homes MTP

The primary objective of this program is to achieve peak demand reductions and/or energy savings through increased sales of Energy Star® homes and products. Additionally, the program is designed to condition the market so that consumers are aware of and demand Energy Star® homes and products and builders have the technical capacity to supply them. A baseline study was conducted during the third quarter of 2000 to determine the existing level of efficiency typical of new home construction in Oncor's service territory. The study showed that current home construction practices resulted in an average Home Energy Rating System ("HERS") score of 80.2, compared to a minimum

Energy Star® HERS score of 86.0. The baseline used in 2003 accounts for the implementation of the new State Energy Code and requirements defined by the International Energy Conservation Code (IECC). A new baseline study will be conducted in 2005, when historical data is available, to determine the actual affects of the new code.

During 2001, there were 42,700 homes constructed in the Oncor service territory Metropolitan Statistical Areas (MSAs). Of these, 44 homes received Energy Star® certification through the program. In 2002, there were 43,778 homes constructed in the Oncor service territory MSAs, with 6,492 receiving Energy Star® certification. As a result of these accomplishments, Oncor was recognized by the U.S. Environmental Protection Agency and awarded the Energy Star® Partner of the Year – New Homes. In 2003, there were 44,319 homes constructed in the Oncor service territory MSAs, with 13,555 achieving Energy Star® certification. This is a result of training and certifying HERS raters, educating and recruiting builders, consumer education and involving market actors associated with new home sales. The milestones for 2004 are to certify 14,000 Energy Star® homes, train and certify 30 new HERS raters, train 200 realtors on the advantages of Energy Star® homes and continue building consumer awareness of the Energy Star® label through radio, collateral materials, print and outdoor media.

Air Conditioning Installer Information & Training MTP

Oncor implemented the Air Conditioning Installer Information & Training Market Transformation Program in 2003. The program is designed to encourage improved installation practices for heating, ventilation and air conditioning ("HVAC") equipment, including measures designed to reduce leakage in air ducts. A baseline study was conducted during the second quarter of 2002 to determine current air conditioner installation standards and practices and to identify practices that, if modified, would improve the overall efficiency of HVAC systems throughout the service territory, resulting in lower peak demand and energy savings. Results of the study identified the need for consumer education, training for contractors, certifying qualifying contractors, best-practices incentives and the implementation of a formal program.

The 2003 program was administered by Texas Air Conditioning Contractors of America ("TACCA") and Air Conditioning Contractors of America – North Texas ("ACCA-NT"). The first year program milestone to train 500 individuals actively employed by a licensed contracting company doing business in the Oncor Service territory resulted in 466 individuals completing the training during 2003. Training was conducted in both English and Spanish, covering new and replacement HVAC installation, system design, duct sealing and sales training for high efficiency equipment. HVAC technicians certified by TACCA and ACCA-NT can qualify for incentives for installations meeting program specifications and passing inspections. Consumer education on a proper HVAC installation was also conducted through the distribution of collateral materials, home shows, print media, billboards and a dedicated web-site. Even as a start-up program, savings impacts were 1.8 MW in 2003.

Milestones for 2004 are to train an additional 200 air conditioning employees, increase outreach to new home builders, increase the penetration rate of "high performance" installations in the retrofit market and realize savings impacts of 4 MW.

High Efficiency Windows MTP

Oncor conducted a baseline study for the Residential Windows Market Transformation Program in 2002. The purpose of the program was to promote the sale of Energy Star® rated windows and transform the market to one in which Energy Star® windows become the market standard, resulting in peak demand reductions and/or energy savings from the increased sales of high efficiency windows. The decision of whether to implement the program was based on the results of the study.

The study indicated a thorough penetration of Low E glass technology in the Oncor service area. Any additional demand and energy savings would require the incorporation of higher efficiency window frames in the retrofit market. Based on the study results, Oncor determined that with the new Statewide Energy Code and the limited amount of incremental savings that could be realized from the program, it could not be economically and effectively implemented in the service area and was not included in the 2003 program set.

VI. Program Funding

CALENDAR YEAR 2003

Program	Budget	Funds Expended (Incentives)	Funds Expended (Admin.)	Total Funds Expended	Funds Committed (Not Expended)	Funds Remaining (Not Committed)
Large Commercial & Industrial SOP	$ 12,830,416	$ 5,534,881	$ 426,949	$ 5,961,830	$ 591,592	$ 6,276,994
Residential & Small Commercial SOP	$ 7,650,670	$ 8,013,255	$ 415,464	$ 8,428,719	$ 0	$ (778,049)
Hard-to-Reach SOP	$ 5,206,147	$ 6,433,171	$ 392,711	$ 6,825,882	$ 0	$ (1,619,735)
Energy Star® Homes MTP	$ 9,416,232	$ 9,493,297	$ 302,955	$ 9,796,252	$ 0	$ (380,020)
A/C Distributor MTP*	$ 5,885,108	$ 2,302,890	$ 199,651	$ 2,502,541	$ 0	$ 3,382,567
A/C Installer Info. & Training MTP	$ 3,531,124	$ 454,690	$ 119,544	$ 574,234	$ 2,603,778	$ 353,112
Emergency Load Management Pilot SOP	$ 233,404	$ 174,677	$ 48,265	$ 222,942	$ 0	$ 10,462
Third Party DSM Contracts	$ 10,528,943	$ 3,366,969	$ 459,813	$ 3,826,782	$ 2,953,521	$ 3,748,640
General Energy Efficiency Program Administrative Costs	$ 0	$ 0	$ 277,506	$ 277,506	$ 0	$ (277,506)
Total	$ 55,282,044	$ 35,773,830	$ 2,642,858	$ 38,416,688	$ 6,148,891	$10,716,465

* The A/C Distributor MTP did not have any "funds committed but not expended" because Oncor did not set-aside any funds for participants in this program. Rather, incentives were paid on a first-come, first-served basis according to when invoices were received.

VII. Explanation of a Total Program Cost Decrease of More Than 10%

Oncor met its 2003 goal of 87,362 kW while spending less money than was budgeted. As shown on the preceding table in Section VI, funds were either spent or committed by contracts with energy efficiency service providers in excess of the 2003 budget amounts for many programs in order to ensure attainment of the goal. However, due to lower than anticipated activity in the A/C Distributor MTP, A/C Installer MTP, Large Commercial & Industrial SOP, and Third Party DSM contracts, Oncor's actual expenditures in Calendar Year 2003 were $16,865,356 less than projected.

Oncor believes that the primary reason participation in the A/C Distributor MTP, Large Commercial & Industrial SOP and Third Party DSM contracts was less than anticipated in 2003 is because of the weak economy, wherein commercial and industrial customers were less likely to invest in discretionary items such as energy efficiency measures. Although there are signs that the service area economy is on the rise in 2004, the Texas economy has not rebounded at the rate of the nation as a whole. Telecommunications and other high tech sectors important to the local economy have not recovered fully from the recession. Manufacturing employment continues to decrease, and the travel industry remains in a slump. Almost 50 million square feet of office space was available for rent in the DFW area at the end of 2003, resulting in an occupancy rate close to 30%. Oncor has responded to this situation by adjusting its customer class ratio for 2004 to shift more funding to residential programs, which were well received in 2003.

With regard to the A/C Installer Information and Training Program, the lower than anticipated spending and achieved savings is due to the fact that this was the first year for this program and it took longer than anticipated to complete training of the installers. Accordingly, while training was successful, the installers did not actually implement their training through many actual installations of higher efficiency measures in 2003. Oncor does expect a higher return from this MTP in 2004 as the trained installers put their training to use.

Although participation in several of Oncor's energy efficiency programs caused the Company to be under-budget, it was nevertheless able to surpass its energy efficiency goal. This achievement was primarily due to the greater-than-anticipated success of its Energy Star® Homes MTP. This program produced over 13,000 kW more savings than were expected for approximately the same amount of money as was budgeted. This was primarily possible because, although funds spent to promote the building and rating of Energy Star® Homes remained on-budget, many more Energy Star® Homes were built than was expected because of a new-home housing boom that occurred in the DFW area in 2003. With mortgage rates at all time lows, new home construction in the Dallas-Fort Worth Metroplex continued to set records in 2003. For the year 2003, new housing starts in the Metroplex were 39,608 as compared to 37,753 in 2002 and 36,619 in 2001.

Another reason for Oncor's success in achieving its goal under budget was the ability of the A/C Distributor MTP to procure more than 2,000 kW in additional savings, while expenditures in that program were less than half of the budgeted amount. This was the result of a Market Effects Study that enabled the Company to identify additional savings without increasing incentive payments. This Market Effects Study is discussed in more detail in Section V of this Report. Oncor has, therefore, adjusted its expectations from this program in future years by decreasing its budget and increasing its projected savings.

VIII. Request to Roll Over Unspent Funds to Future Program Years

Oncor currently has approximately $25 million in unexpended energy efficiency funding. Pursuant to Substantive Rule §25.181(i)(7), Oncor requests that the Commission allow it to roll over the remaining amount of unexpended energy efficiency funding into Calendar Year 2004. Some of that amount is the portion of funding intended to be used in 2004 as a result of the three-year average funding mechanism approved by the Commission in Docket No. 22350. In

Docket No. 22350, Oncor's 2002 budget (which was based on a 5% demand savings goal) was averaged with the Company's 2003 and 2004 budgets (which were based on a 10% demand savings goal), with the understanding that the difference between the 2002 budget amount and the annual approved revenue recovery amount of $42,663,548 would be rolled over for use in Calendar Years 2003 and 2004. The other portion of the unexpended funds should also be rolled over into 2004 because they will be necessary to successfully implement Oncor's future energy efficiency programs. As further discussed in Oncor's 2004 Energy Efficiency Plan, the budget for year 2004 is larger than that included in Docket No. 22350 as a result of an increase in demand growth beyond what was anticipated by Oncor at the time of that Docket. Moreover, the funds will be necessary to successfully implement energy efficiency plans for Calendar Years 2005 through 2007 because the projected budgets for those years remain in line with the budget for 2004, and are significantly larger than the current approved annual revenue recovery amount of $42,663,548 to be used on energy efficiency programs.

IX. Most Current Information Available for Ongoing and Completed Energy Efficiency Programs by Customer Class

CALENDAR YEAR 2003

Customer Class	Number of Customers	Program Expenditures	Reported Savings	
			kW	kWh
Large C & I				
Large Commercial & Industrial SOP	376	$ 5,961,830	16,598	66,483,151
Third Party DSM Contracts	41	$ 3,826,782	2,713	12,800,527
Emergency Load Management SOP*	11	$ 222,942	13,129	0
Total	428	$ 10,011,554	32,440	79,283,678
Residential				
A/C Distributor MTP	11,200	$ 2,322,265	10,022	11,901,333
Residential & Small Commercial SOP	21,404	$ 7,392,299	8,933	39,058,878
Energy Star® Homes MTP	13,558	$ 9,796,252	27,701	23,138,578
A/C Installer Info. & Training MTP	2,045	$ 574,234	1,790	2,643,000
Total	48,207	$ 20,085,050	48,446	76,741,789
Small Commercial				
A/C Distributor MTP	549	$ 180,276	778	1,576,667
Residential & Small Commercial SOP	541	$ 1,036,420	1,253	5,226,358
Total	1,090	$ 1,216,696	2,031	6,803,025
Hard-to-Reach				
Hard-to-Reach SOP	18,453	$ 6,825,882	6,372	30,354,007
Total	18,453	$ 6,825,882	6,372	30,354,007

* The Emergency Load Management Pilot SOP Program actually achieved 56,228 in kW savings for the year as three participants contributed more kW than their contract obligation. However, Oncor is only reporting 13,129 kW savings because of the restriction in Substantive Rule §25.181(h)(2)(I) that limits savings achieved through load management programs to 15% of the utility's total demand reduction goal.

X. Description of Proposed Changes in the Energy Efficiency Plan

Please see Oncor's April 1, 2004 Annual Efficiency Plan for proposed changes to the Energy Efficiency Plan for Calendar Years 2004 through 2007.

XI. Demand and Energy Reduction by County

Appendix B contains the kW and kWh reduction achieved by the energy efficiency programs implemented by Oncor in Calendar Year 2003, by county. The funding source for all of the kW and kWh savings shown on Appendix B is the Oncor budget for SOPs, MTPs, and existing DSM Contracts.

Oncor Electric Delivery Company
Annual Energy Efficiency Report
for Calendar Year 2003

Appendix A

Explanations

(1) The following explanation is for **Section II:**

In this Section, actual growth in demand is the amount of increase in demand from the year prior to the reporting year compared to the reporting year. It is adjusted for normal weather and is at the system level.

(2) The following explanations are for column values shown in **Section IV:**

Projected Savings – The amount of projected peak demand savings is the amount included in the Oncor Energy Efficiency Plan filed in the preceding year.

Contracted Savings – The total energy and peak demand savings that are the subject of contracts between Oncor and energy efficiency service providers during the reporting calendar year.

Reported Savings – The total energy and peak demand savings that have been reported to Oncor by energy efficiency service providers.

(3) The following explanations are for column values shown in **Section VI:**

Budget – The amount of funding dedicated to the implementation of energy efficiency programs for the reporting calendar year as shown in the Oncor Energy Efficiency Plan filed in the preceding year.

Funds Expended for Incentives – The amount of funds expended by Oncor on incentive payments for energy efficiency programs during the reporting calendar year.

Funds Expended for Administration – The amount of funds expended by Oncor on administrative expenses associated with energy efficiency programs during the reporting calendar year.

Funds Committed but not Expended – The amount of Oncor funds committed by contract with energy efficiency service providers for the reporting calendar year that have not been paid to the provider.

Funds Remaining and not Committed or Expended – The difference between the budgeted amount for an energy efficiency program and the amount of funds that were not expended or committed by contract with energy efficiency service providers during the reporting calendar year.

(4) The following explanations are for column values shown in **Section VIII:**

Number of Customers – A customer is defined as having an Oncor account number.

Program Expenditures – The total of administrative and incentives expended during the reporting calendar year.

Reported Savings – The energy and peak demand savings that have been reported by energy efficiency service providers during the reporting calendar year.

Appendix B: Demand and Energy Reduction by County

COUNTY	A/C Distributor & A/C Installer MTP		Hard-to Reach SOP		Energy Stars Home MTP		Commercial & Industrial SOP		Existing DSM Contracts		Emergency Load Management SOP		Residential & Small Commercial Sop	
ANDERSON	kW impact	1 7	kW impact	75.3	kW impact		kW impact		kW impact		kW impact		kW impact	4 5
	kWh impact	2,589	kWh impact	401,945	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	15,485
ANDREWS	kW impact		kW impact	15.0	kW impact		kW impact		kW impact		kW impact		kW impact	13 0
	kWh impact		kWh impact	67,895	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	60,038
ANGELINA	kW impact		kW impact	2.1	kW impact		kW impact	2	kW impact		kW impact		kW impact	115 6
	kWh impact		kWh impact	6,543	kWh impact		kWh impact	50,585	kWh impact		kWh impact		kWh impact	594,016
ARCHER	kW impact	14.3	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	0.9
	kWh impact	15,370	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	888
BASTROP	kW impact		kW impact	4.7	kW impact		kW impact		kW impact		kW impact		kW impact	0 8
	kWh impact		kWh impact	17,518	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	2,860
BELL	kW impact	71.5	kW impact	163.1	kW impact	741	kW impact	697	kW impact	1,060.9	kW impact		kW impact	635.4
	kWh impact	99,758	kWh impact	629,704	kWh impact	657,654	kWh impact	1,519,239	kWh impact	4,509,152	kWh impact		kWh impact	2,759,709
BROWN	kW impact		kW impact	123.2	kW impact		kW impact		kW impact		kW impact		kW impact	15 9
	kWh impact		kWh impact	660,054	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	61,623
CHEROKEE	kW impact	5 0	kW impact	21.4	kW impact	1	kW impact	45	kW impact		kW impact		kW impact	38.5
	kWh impact	6,270	kWh impact	83,071	kWh impact	1,050	kWh impact	330,400	kWh impact		kWh impact		kWh impact	199,424
CLAY	kW impact	12.7	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	3.0
	kWh impact	25,379	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	4,524
COLLIN	kW impact	2320.6	kW impact	205.5	kW impact	9,627	kW impact	945	kW impact		kW impact	203.0	kW impact	882 4
	kWh impact	3,043,505	kWh impact	733,553	kWh impact	7,951,753	kWh impact	3,154,612	kWh impact		kWh impact		kWh impact	3,651,843
COMANCHE	kW impact		kW impact	10 6	kW impact		kW impact		kW impact		kW impact		kW impact	14 9
	kWh impact		kWh impact	56,942	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	23,531
COOKE	kW impact	35.5	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	22.2
	kWh impact	52,490	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	94,967
CORYELL	kW impact	2.5	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	21 3
	kWh impact	2,769	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	75,652
DALLAS	kW impact	3063.1	kW impact	1,644 4	kW impact	4,706	kW impact	9,093	kW impact	558.4	kW impact	5,499 0	kW impact	2,681.2
	kWh impact	4,245,436	kWh impact	6,643,154	kWh impact	3,868,696	kWh impact	30,887,999	kWh impact	2,868,681	kWh impact		kWh impact	11,321,469
DAWSON	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	5 0
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	18,024
DELTA	kW impact		kW impact	8 7	kW impact	2	kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact	49,464	kWh impact	1,483	kWh impact		kWh impact		kWh impact		kWh impact	
DENTON	kW impact	371.1	kW impact	13.0	kW impact	2,614	kW impact	15	kW impact		kW impact		kW impact	372.3
	kWh impact	457,852	kWh impact	81,730	kWh impact	2,181,395	kWh impact	89,589	kWh impact		kWh impact		kWh impact	1,773,458
EASTLAND	kW impact		kW impact	2.1	kW impact		kW impact		kW impact		kW impact		kW impact	10.1
	kWh impact		kWh impact	14,210	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	35,423
ECTOR	kW impact		kW impact	641.9	kW impact		kW impact		kW impact		kW impact		kW impact	245.2
	kWh impact		kWh impact	3,668,156	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	1,044,089
ELLIS	kW impact	184.9	kW impact	101.5	kW impact	214	kW impact	696	kW impact		kW impact	4,838.0	kW impact	100.2
	kWh impact	228,647	kWh impact	506,169	kWh impact	188,204	kWh impact	1,601,400	kWh impact		kWh impact		kWh impact	474,562

ERATH	kW impact	2.8	kW impact	23.7	kW impact		kW impact	19	kW impact		kW impact		kW impact	19 1
	kWh impact	3,519	kWh impact	125,083	kWh impact		kWh impact	87,651	kWh impact		kWh impact		kWh impact	84,779
FALLS	kW impact		kW impact	29.9	kW impact		kW impact		kW impact		kW impact		kW impact	9 9
	kWh impact		kWh impact	96,864	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	39,833
FANNIN	kW impact	21.3	kW impact	36.6	kW impact		kW impact	208	kW impact		kW impact		kW impact	
	kWh impact	29,695	kWh impact	200,608	kWh impact		kWh impact	482,506	kWh impact		kWh impact		kWh impact	
FREESTONE	kW impact		kW impact	8.6	kW impact		kW impact		kW impact	179	kW impact		kW impact	1 0
	kWh impact		kWh impact	46,148	kWh impact		kWh impact		kWh impact	468,481	kWh impact		kWh impact	4,328
GLASSCOCK	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
GRAYSON	kW impact	115.2	kW impact	151.6	kW impact	129	kW impact	72	kW impact		kW impact		kW impact	244.3
	kWh impact	143,091	kWh impact	496,174	kWh impact	113,941	kWh impact	560,748	kWh impact		kWh impact		kWh impact	1,267,345
HARRIS	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
HENDERSON	kW impact	13 1	kW impact	180.2	kW impact		kW impact		kW impact		kW impact		kW impact	100 6
	kWh impact	15,145	kWh impact	958,733	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	493,372
HILL	kW impact	4 7	kW impact	24.1	kW impact		kW impact		kW impact		kW impact		kW impact	25.2
	kWh impact	5,421	kWh impact	106,487	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	68,027
HOOD	kW impact	7.3	kW impact		kW impact	6	kW impact		kW impact		kW impact		kW impact	
	kWh impact	8,988	kWh impact		kWh impact	5,458	kWh impact		kWh impact		kWh impact		kWh impact	
HOPKINS	kW impact	1.3	kW impact	1.4	kW impact		kW impact		kW impact		kW impact		kW impact	0 6
	kWh impact	1,624	kWh impact	9,464	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	3,117
HOUSTON	kW impact		kW impact	15.1	kW impact		kW impact		kW impact		kW impact		kW impact	4.2
	kWh impact		kWh impact	78,805	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	7,580
HOWARD	kW impact	8.8	kW impact	5 1	kW impact		kW impact		kW impact		kW impact		kW impact	12.3
	kWh impact	9,472	kWh impact	6,386	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	52,360
HUNT	kW impact	15.6	kW impact	58.2	kW impact		kW impact		kW impact		kW impact		kW impact	0.7
	kWh impact	18,538	kWh impact	306,637	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	888
JACK	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	1.9
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	2,724
JOHNSON	kW impact	124 0	kW impact	114 1	kW impact	245	kW impact	39	kW impact		kW impact		kW impact	64.8
	kWh impact	151,666	kWh impact	607,030	kWh impact	211,243	kWh impact	67,798	kWh impact		kWh impact		kWh impact	291,321
KAUFMAN	kW impact	113 2	kW impact	107.5	kW impact	230	kW impact	44	kW impact		kW impact		kW impact	13.6
	kWh impact	130,414	kWh impact	508,191	kWh impact	195,328	kWh impact	329,841	kWh impact		kWh impact		kWh impact	58,018
LAMAR	kW impact	6 8	kW impact	52 3	kW impact		kW impact	3	kW impact		kW impact		kW impact	8 0
	kWh impact	11,464	kWh impact	252,219	kWh impact		kWh impact	17,207	kWh impact		kWh impact		kWh impact	26,715
LAMPASSAS	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
LIMESTONE	kW impact		kW impact	28.9	kW impact		kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact	155,353	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
MARTIN	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	0 7
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	888

MCLENNAN	kW impact	371.6	kW impact	41.5	kW impact	3	kW impact	233	kW impact		kW impact		kW impact	209 1
	kWh impact	504,101	kWh impact	212,516	kWh impact	2,557	kWh impact	1,204,365	kWh impact		kWh impact		kWh impact	1,011,376
MIDLAND	kW impact	16.0	kW impact	673.5	kW impact		kW impact	529	kW impact		kW impact		kW impact	639.9
	kWh impact	19,820	kWh impact	3,820,075	kWh impact		kWh impact	3,000,948	kWh impact		kWh impact		kWh impact	3,318,269
MILAM	kW impact	25 2	kW impact	3.5	kW impact		kW impact		kW impact		kW impact		kW impact	3 6
	kWh impact	33,443	kWh impact	9,375	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	10,979
MITCHELL	kW impact		kW impact	3 6	kW impact		kW impact		kW impact		kW impact		kW impact	3 1
	kWh impact		kWh impact	5,230	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	10,547
NACODOCHES	kW impact		kW impact	120.7	kW impact		kW impact	192	kW impact		kW impact		kW impact	239 1
	kWh impact		kWh impact	653,576	kWh impact		kWh impact	391,084	kWh impact		kWh impact		kWh impact	1,282,478
NAVARRO	kW impact		kW impact	55.4	kW impact		kW impact		kW impact		kW impact		kW impact	26.5
	kWh impact		kWh impact	302,799	kWh impact		kWh impact	109,901	kWh impact		kWh impact		kWh impact	102,662
NOLAN	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	8.2
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	34,982
PALO PINTO	kW impact		kW impact		kW impact		kW impact	26	kW impact		kW impact	577.0	kW impact	5 6
	kWh impact		kWh impact		kWh impact		kWh impact	215,042	kWh impact		kWh impact		kWh impact	18,636
PARKER	kW impact	38 6	kW impact	18.5	kW impact	17	kW impact		kW impact		kW impact		kW impact	12 4
	kWh impact	46,149	kWh impact	100,193	kWh impact	15,017	kWh impact		kWh impact		kWh impact		kWh impact	34,973
RED RIVER	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	0 0
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	137
ROCKWALL	kW impact	260.3	kW impact		kW impact	736	kW impact	92	kW impact		kW impact		kW impact	2.0
	kWh impact	293,140	kWh impact		kWh impact	625,942	kWh impact	228,063	kWh impact		kWh impact		kWh impact	7,552
RUSK	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
SCURRY	kW impact		kW impact	0.8	kW impact		kW impact		kW impact		kW impact		kW impact	37 2
	kWh impact		kWh impact	2,269	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	82,255
SMITH	kW impact	82.8	kW impact	526.4	kW impact		kW impact	51	kW impact		kW impact		kW impact	240.9
	kWh impact	96,533	kWh impact	2,153,035	kWh impact		kWh impact	356,179	kWh impact		kWh impact		kWh impact	1,024,700
STEPHENS	kW impact	1 4	kW impact	10.1	kW impact		kW impact		kW impact		kW impact		kW impact	13.5
	kWh impact	1,454	kWh impact	56,316	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	25,262
TARRANT	kW impact	5175.0	kW impact	752.3	kW impact	7,502	kW impact	2,944	kW impact	915.0	kW impact	2,012.0	kW impact	2,605.7
	kWh impact	6,293,855	kWh impact	3,899,038	kWh impact	6,301,340	kWh impact	18,289,235	kWh impact	4,954,213	kWh impact		kWh impact	10,977,063
TERRY	kW impact		kW impact		kW impact	3	kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact		kWh impact	2,703	kWh impact		kWh impact		kWh impact		kWh impact	
TRAVIS	kW impact	1 4	kW impact		kW impact	408	kW impact	34	kW impact		kW impact		kW impact	110.7
	kWh impact	1,454	kWh impact		kWh impact	351,131	kWh impact	172,442	kWh impact		kWh impact		kWh impact	539,525
UPTON	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	
VAN ZANDT	kW impact	7 0	kW impact	37 1	kW impact		kW impact	14	kW impact		kW impact		kW impact	9.1
	kWh impact	8,664	kWh impact	137,801	kWh impact		kWh impact	83,159	kWh impact		kWh impact		kWh impact	37,727
WARD	kW impact		kW impact		kW impact		kW impact		kW impact		kW impact		kW impact	1.0
	kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact		kWh impact	4,322

WICHITA	kW impact	26.9	kW impact	181.5	kW impact		kW impact	564	kW impact		kW impact		kW impact	88 4
.	kWh impact	32,051	kWh impact	1,027,466	kWh impact		kWh impact	3,054,134	kWh impact		kWh impact		kWh impact	337,453
WILLIAMSON	kW impact	1.3	kW impact	66.8	kW impact	502	kW impact	16	kW impact		kW impact		kW impact	230 4
	kWh impact	2,295	kWh impact	351,965	kWh impact	451,250	kWh impact	86,550	kWh impact		kWh impact		kWh impact	779,091
WISE	kW impact	65 4	kW impact	11 1	kW impact	15	kW impact		kW impact		kW impact		kW impact	0 9
	kWh impact	78,940	kWh impact	47,867	kWh impact	12,431	kWh impact		kWh impact		kWh impact		kWh impact	1,184
YOUNG	kW impact		kW impact		kW impact		kW impact	25	kW impact		kW impact		kW impact	9 4
	kWh impact		kWh impact		kWh impact		kWh impact	112,474	kWh impact		kWh impact		kWh impact	31,183
Total Sum of kW impact		12,590		6,372		27,701		16,598		2,713		13,129		10,186
Total Sum of kWh impact		16,121,000		30,354,007		23,138,578		66,483,151		12,800,527		-		44,285,236

DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix H:
Megdal & Associates Presentation Slides

The Consumer Lighting Market

Consumer Goal #4:

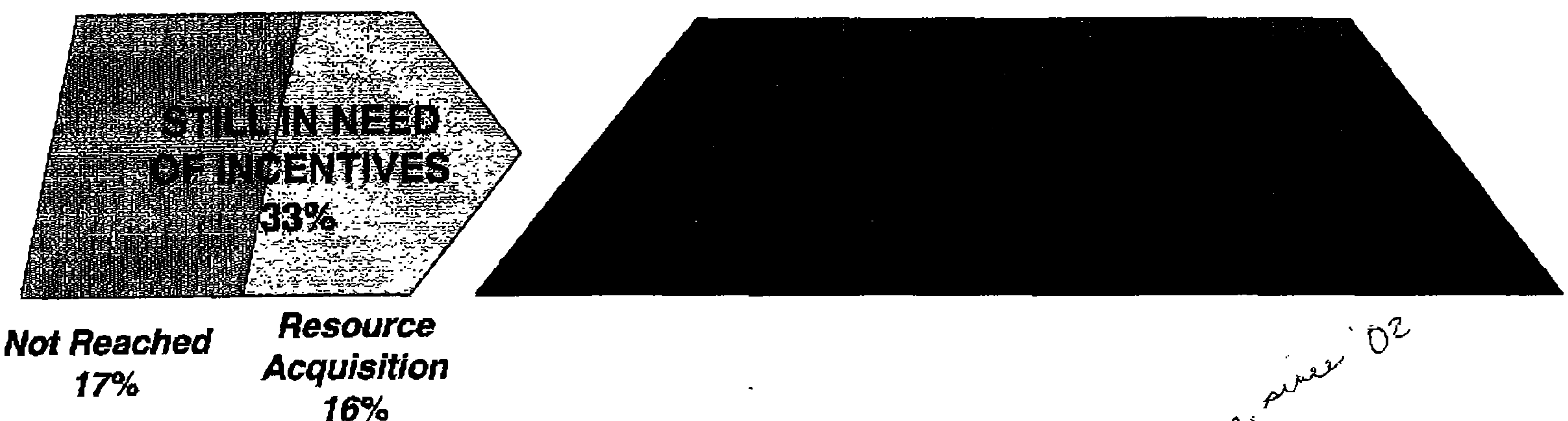
INCREASE FUTURE PURCHASES
OF ENERGY EFFICIENT LIGHTING

most who had purchase recently

The Consumer Lighting Market

given info on payback & quality

- » 58% of the market indicate a *willingness* to purchase ENERGY STAR bulbs in the future on their own.
- » Over one-third of residential customers are still in need of education or financial incentives



need incentive

no change since '02

The Consumer Lighting Market

SNAPSHOT
OF
THE CONSUMER LIGHTING MARKET

The Consumer Lighting Market

only looked at SF, i.e. ≤ 4 units

» 55% of households have at least one CFL

» "Users" have an average of 6.2 bills per household

Result: **8 million CFLs** in use in Massachusetts IOU, SF @ 2.3 m households, 3.4 units/household

~~∴ 4.3 m households~~

» 2.34 million households within Massachusetts IOU territory, SF

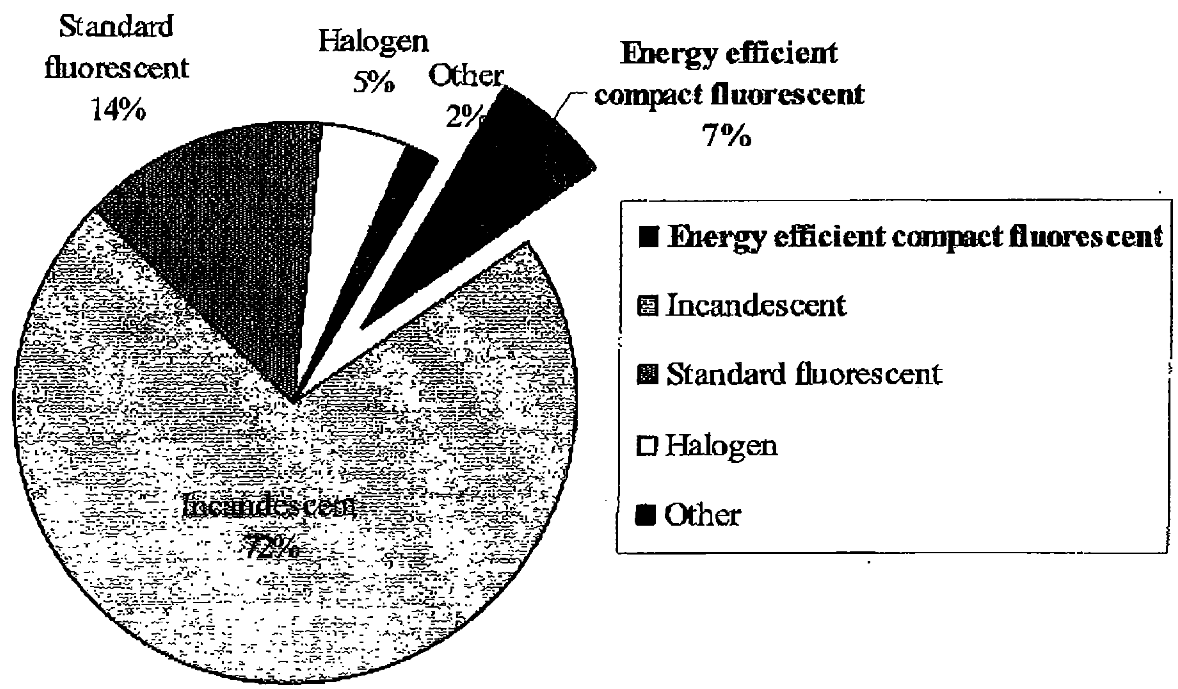
» 52 sockets or bulbs per home → result from in-home visits

Result: **121.7 million sockets** in Massachusetts

7% of all sockets filled with CFLs

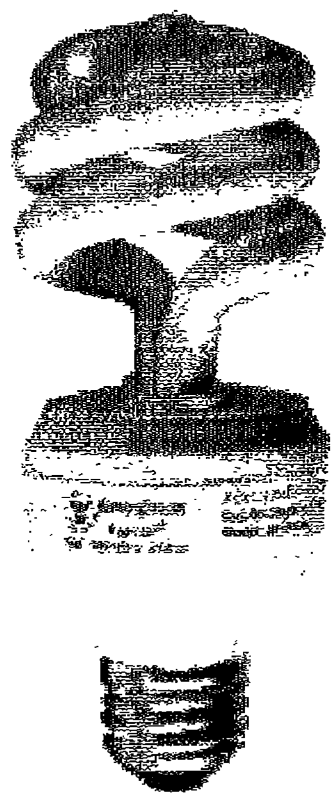
The Consumer Lighting Market

7% saturation of CFLs within Massachusetts households



The Consumer Lighting Market

% of sockets filled w/ CFLs

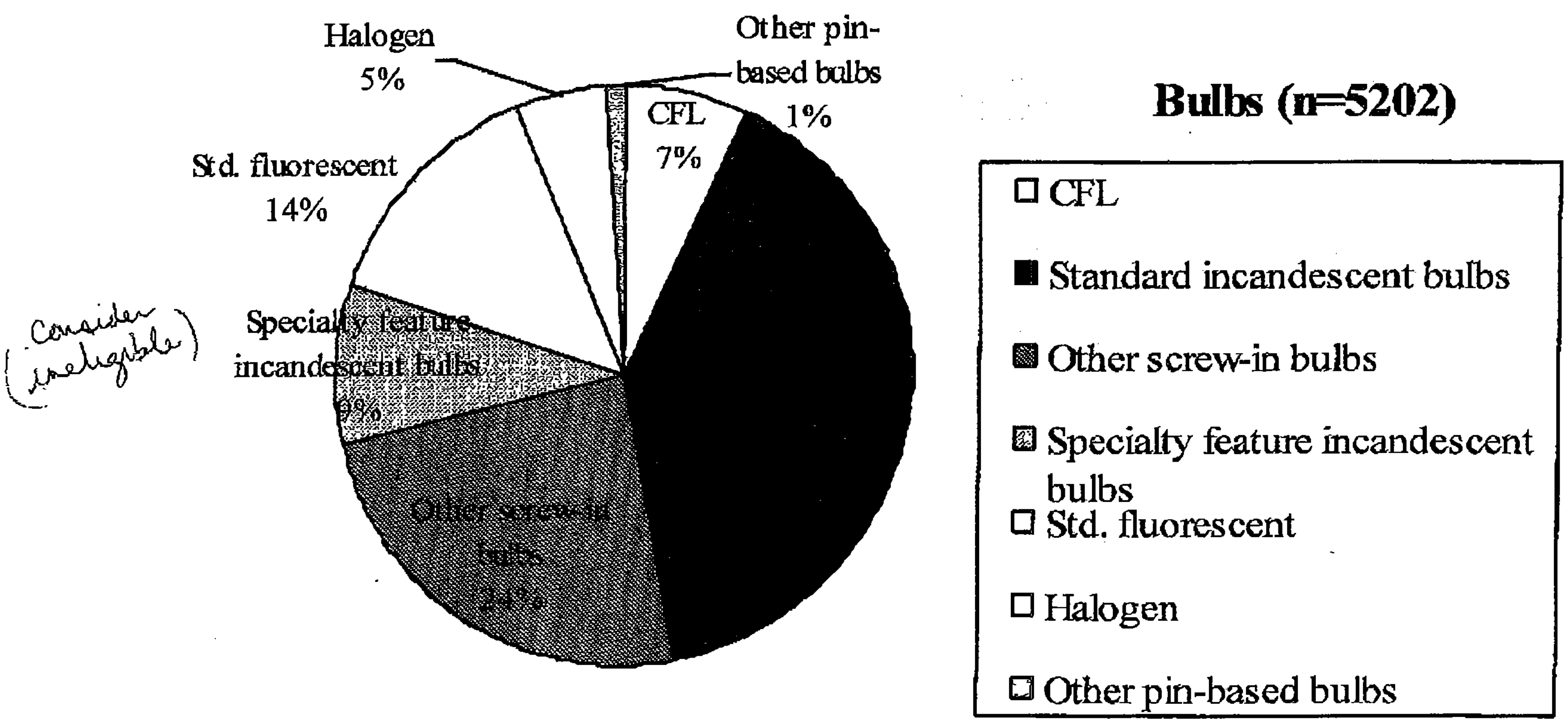


» Location of CFLs — Saturation

- › 18% Bedrooms — 8%
- › 17% Living/family room — 8%
- › 17% Kitchen — 9%
- › 11% Basement — 6%
- › 9% Other
- › 9% Hallway/stair
- › 6% Exterior — 7%
- › 5% Bathroom — 3%
- › 3% Office — 8%
- › 3% Dining room — 3%
- › 2% Garage

The Consumer Lighting Market

64% of sockets can be retrofitted through bulb changes



DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix I:
Ecos Consulting 80+ Prospectus

ecos CONSULTING

Ecos Consulting presents:

80 Plus Program Utility Prospectus

Sam Sirkin
Program Development Director
Ecos Consulting
309 SW Stark, Suite 1000
Portland, OR 97204
(503) 525.2700 ext. 110
(503) 525.4800 fax
ssirkin@ecosconsulting.com

Making a World of Difference

Table of Contents

80 Plus Program Description

Program Concept

Ecos Consulting (Ecos) is proposing an immediate opportunity to secure energy and peak savings for less than 3 cents per lifetime kWh, and actively influence the next ENERGY STAR® computer specification. The program enlists utilities and computer manufactures to participate in an innovative buy-down program to get more energy-efficient power supplies into desktop computers and desktop-derived servers.

View of a power supply in a desktop PC

The 80 Plus program offers enormous potential for energy savings over the long run, with a very cost-effective short-term program. The program is built around a very simple concept: recognize and reward any desktop computer or desktop-derived server containing a power supply that meets the following specification:

- 80% or greater efficiency at 20%, 50% and 100% of rated load
- True power factor of 0.9 or greater

The 80 Plus Program will offer a $5 manufacturer buy-down for each desktop computer and a $10 manufacturer buy-down for each desktop-derived server containing a qualifying power supply that is sold in the service territory of a participating utility (more details below).

Each efficient desktop computer represents 85 kWh savings per year over four years and a demand reduction of 16 watts per unit. Each efficient desktop-derived server represents 301 kWh savings per year, with a four-years life and a demand reduction of 34 watts per unit.

Utility Benefits

The 80 Plus Program offers utilities the opportunity to:

- **Acquire resources cheaply** – roughly 2.5 to 2.6 cents/lifetime kWh
- **Achieve savings from an end use that has not been addressed** – the opportunity is within plug loads, whereas energy efficiency programs have traditionally focused on lighting and HVAC.
- **Powerfully transform the market** by educating customers about the importance of selecting efficient consumer electronics and office equipment, which will impact the success of future program offerings that could include a broader commercial plug-load reduction program.
- **Capture lost opportunities for savings** until and after the ENERGY STAR specification is revised since savings occur over the lifetime of the computers
- **Obtain considerable secondary benefits**, including on-peak savings, reductions in cooling load and improvements in power quality
- **Participate in a nationwide program** that greatly leverages the investment of individual companies

80 Plus – Why Now?

The following factors demonstrate that the moment is ripe to implement the 80 Plus Program:

- Current inefficiency in power supplies creates enormous energy savings opportunity
- Ability to overcome the primary market barrier
- ENERGY STAR has announced it is revising its desktop computer specification
- Intel is focusing on power supply efficiency
- Numerous utilities and market transformation organizations are interested in the program

Enormous Energy Savings Opportunity

All desktop computers and desktop-derived servers contain power supplies that convert high-voltage alternating current (ac) to low-voltage direct current (dc) for use by the microprocessor, hard drive and other electronic components. These power supplies are sized to provide up to 200 to 600 watts of dc output, but can require up to 300 to 850 watts of maximum ac input, converting the rest to heat.[1]

Typical current desktop computer power supplies waste about 30% to 45% of all the electricity that passes through them, consuming about 125 to 150 kWh/year by themselves. In office buildings, much of this usage occurs on or near the commercial peak, increasing demand charges and the need for additional generating capacity.

With 40 million new desktop computers sold each year in the U.S. and roughly 205 million in use,[2] the energy savings opportunity is enormous. Installing the most efficient commercially available power supply in each desktop computer sold in 2005 and early 2006 would save about 19 billion lifetime kWh and reduce national energy bills by nearly $1.6 billion.

Less than 10% of the roughly 2.1 million servers sold per year in the U.S. are the high-end designs typically found in data centers. About 90% are desktop-derived servers found in a standard tower configuration (a form factor called EPS12V) or in a low profile, rack-mountable configuration (a form factor called EPS1U). These units are in widespread use in office buildings for managing network traffic, routing e-mail and centralizing printing and file storage resources. Low-end servers' existing power supply efficiencies are typically nearly as low as desktop PC power supply efficiencies, but their power rating and consumption is typically higher, due to the use of multiple processors and high-capacity data storage. Most are already power factor corrected, so these power supplies only need to improve efficiency to qualify for 80 Plus.

Most importantly, desktop-derived servers generally run 24 hours a day, seven days a week, with no sleep modes or power management, so energy savings per unit can be significantly higher than in desktop PCs. These power supplies can consume about 450 to 720 kWh/year, so each one represents a savings opportunity of about 300 kWh/year (based on current efficiencies of 55% to 70%). As a result, these servers provide a complementary element of the 80 Plus Program, enhancing overall cost-effectiveness and expanding the program's reach in its target markets. They have higher base prices than PC power supplies, and they are sold in more specialized form factors, so the incremental cost of achieving 80 Plus levels is higher – Ecos has calculated $10 per unit as the buy-down level for power supplies in desktop-derived servers.

Ability to Overcome the Primary Market Barrier

Most computer manufacturers are continually seeking ways to reduce component costs by pennies or even fractions of pennies. For them, the $5 or $10 incremental cost of a better power supply is substantial, because most competition occurs over purchase price and performance, rather than total cost of ownership. Computer and server manufacturers will be tentative about incorporating more efficient power supplies until such designs offer them a compelling market advantage or the price premium can be overcome through economies of scale.

---

[1] Most computers operate at partial power supply load most of the time, causing dc output and ac input to be proportionally lower.

[2] Daoud, D., A. Promisel, L. Loverde, "Worldwide PC 3Q03 Forecast Update, 2003 – 2007," IDC, Doc # 30607, January 2004.

The 80 Plus program overcomes this barrier by taking away the financial risk and creating a "win-win" situation: computer/server manufacturers are able to offer a better product and utilities acquire cost-effective energy savings.

ENERGY STAR® Desktop Computer Specification Revision

The U.S. Environmental Protection Agency (EPA) has announced the addition of a power supply efficiency specification to its existing labeling program for computers, but the timing and stringency of that specification are uncertain. EPA is also considering adding some server models to the ENERGY STAR specification.[3] In all likelihood, the initial specification language revision will be complete by early 2005, the formal process with stakeholders will take place throughout 2005, and the new specification will take effect early 2006. The highest specification currently available for consideration is Intel's "recommended" specification (see Table 1 below). ***Electric utilities can make a compelling case for those higher efficiency levels by acting now to expand the market share of computers containing highly efficient power supplies.*** This can also lead to a simplified means of promoting highly efficient computers over the long term. It also means that an 80 Plus power supply will likely remain an ENERGY STAR qualified product for some time.

Intel's Focus on Power Supply Efficiency

Between late 2002 and early 2004, the Natural Resources Defense Council (NRDC) and Ecos worked closely with Intel Corporation to develop a set of specifications that will encourage computer manufacturers to use more efficient power supplies. This "PC Design Guide Specification" (www.formfactors.org) pushes power supply manufacturers to achieve efficiencies of 60% to 70% across a range of load conditions in the near term (Intel's "required" levels), and 67% to 80% across a range of load conditions in the long term (Intel's "recommended" levels).[4] Table 1 illustrates the impacts of Intel's specifications relative to the efficiencies achievable by the best new power supply designs.[5] Intel has also indicated it might increase efficiency levels in 2005. An 80 Plus qualified power supply will like exceed both Intel's requirements and ENERGY STAR requirements for some time.

Table 1 – Estimated Program Impacts

Specification	Efficiency Measurements			Maximum heat output in a 250 watt power supply	Typical power supply energy consumption[6]
	20% Load	50% Load	100% Load		
2004 Intel required spec	60%	70%	70%	107 watts	149 kWh/yr
2004 Intel recommended spec	67%	80%	75%	83 watts	113 kWh/yr
80 Plus power supply	82%	87%	85%	44 watts	61 kWh/yr

Significant Interest in the 80 Plus Program

Utilities and market transformation organizations whose service territories contain roughly 25% of the U.S. population are either supporting or seriously evaluating involvement in the 80 Plus Program. As of October 22, 2004, the Northwest Energy Efficiency Alliance, Pacific Gas & Electric, San Diego Gas & Electric, Sacramento Municipal Utility District and Efficiency Vermont had either approved funding or had committed to participate. Some program activity will occur 2004, but incentives will be delivered

---

[3] Contact Craig Hershberg at 202.343.9120 or hershberg.craig@epa.gov with questions about specification revisions to desktop computers and the addition of desktop-derived servers to the specification.

[4] See Jim Carlton, "Intel Backs a More-Efficient PC Power Supply," *Wall Street Journal*, February 26, 2004, p. B4.

[5] EPRI PEAC's 2003 measurements of typical power supply efficiencies are nearly identical to Intel's 2004 required spec.

[6] Power supply consumption = AC kWh in – DC kWh out during a typical commercial duty cycle.

2005 and 2006. The program will run throughout 2005 and as far into 2006 as the sponsors desire, adding new manufacturers and sponsors as they commit. Once the ENERGY STAR specification revision occurs, the 80 Plus Program could either continue as a complement to ENERGY STAR (if 80 Plus is more stringent) or be subsumed by it in 2006 or 2007 (if the two levels are identical).

How Will the Program Work?

The 80 Plus program can be divided into three phases: recruitment, qualification and implementation.

The 80 Plus Program can be divided into three primary phases: recruitment, qualification and implementation. Although part of implementation, we discuss verification and qualification in a separate section. Specifically, we will implement the following scope of work:

Recruitment Phase

Although some activities in the recruitment phase will occur simultaneously, we have outlined these key activities in a step-by-step process. Figure 1 illustrates the recruitment phase.

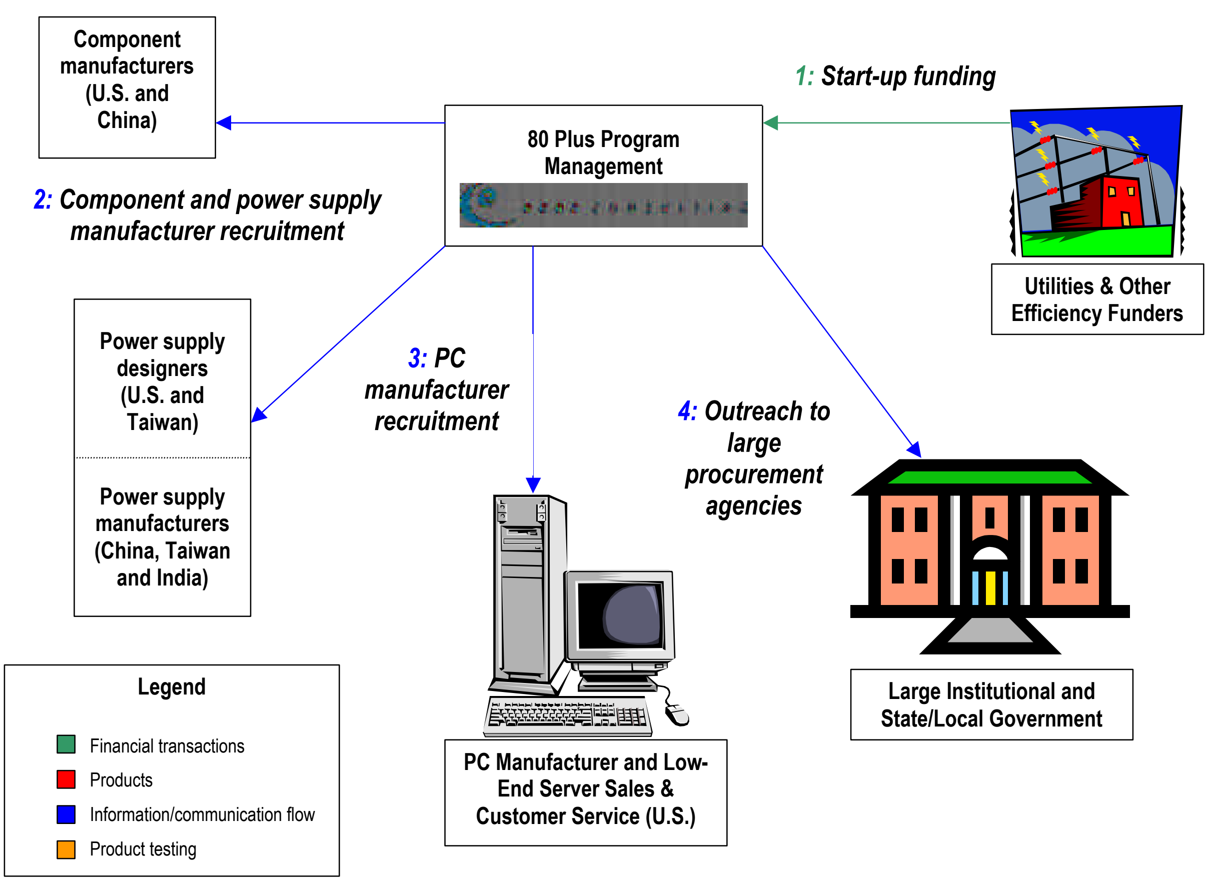
Step 1: Utilities provides startup funding to Ecos for the 80 Plus Program (this includes infrastructure costs and final program design costs).

Step 2: The program will continue outreach to desktop PC and desktop-derived server component manufacturers, power supply designers and power supply manufacturers.

Step 3: The program will continue outreach to desktop PC and desktop-derived server manufacturers, as well as their retail sector outlets (e.g., Fry's Electronics).

Step 4: The program will work with large institutional buyers, including state and local government procurement agencies, to specify 80 Plus power supplies in their procurement processes.

Figure 1. Recruitment Phase



Qualification Phase

Step 1: Interested component manufacturers, power supply designers and power supply manufacturers will be required to submit prototypes of their products. Ecos' research partner, the EPRI Power Electronics Applications Center (EPRI PEAC) will bench test these products to ensure they meet the 80 Plus specification.

Step 2: Interested desktop PC and desktop-derived server manufacturers will be required to submit prototypes with qualified 80 Plus power supplies to EPRI PEAC for bench testing to ensure they meet the specification.

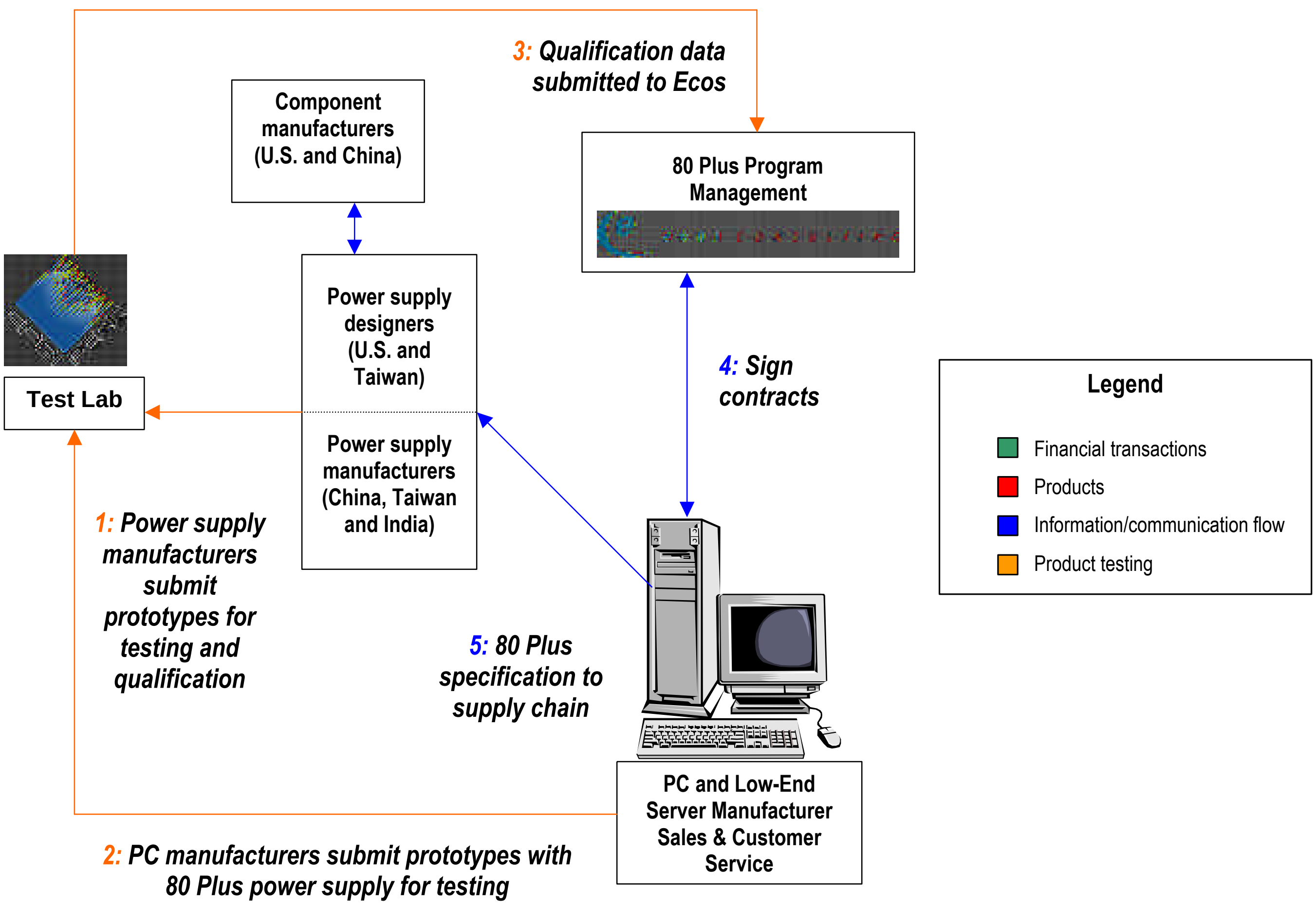
Step 3: Qualification data is sent to Ecos.

Step 4: Products that meet the 80 Plus specification are eligible to participate in the program. Ecos will sign contracts with the power supply and/or computer and/or desktop-derived server manufacturers. Qualified products will be given the rights for 80 Plus labeling.

Step 5: Manufacturers send the 80 Plus power supply specification to their supply chain.

Figure 2 illustrates the qualification phase.

Figure 2. Qualification Phase



Implementation Phase

Step 1: Ecos and utilities begin to actively market the program to customers (see Marketing section for the marketing plan).

Step 2: Customer purchases the 80 Plus qualified desktop computer and/or desktop-derived server

Step 3: Component manufacturers provide integrated circuits and circuit components to power supply designers and manufacturers.

Step 4: Power supply manufacturers deliver 80 Plus power supply to chassis assemblers (or to retail and Value Added Reseller (VAR) channels).

Step 5: Chassis assemblers deliver chassis to desktop PC or desktop-derived server manufacturers.

Step 6: Desktop PC or desktop-derived server manufacturer customizes the PC with the CPU, HDD, video card, monitor, peripherals and software, and then ship to the customer.

Step 7: Desktop PC or desktop-derived server manufacturers provides shipment data to Ecos.

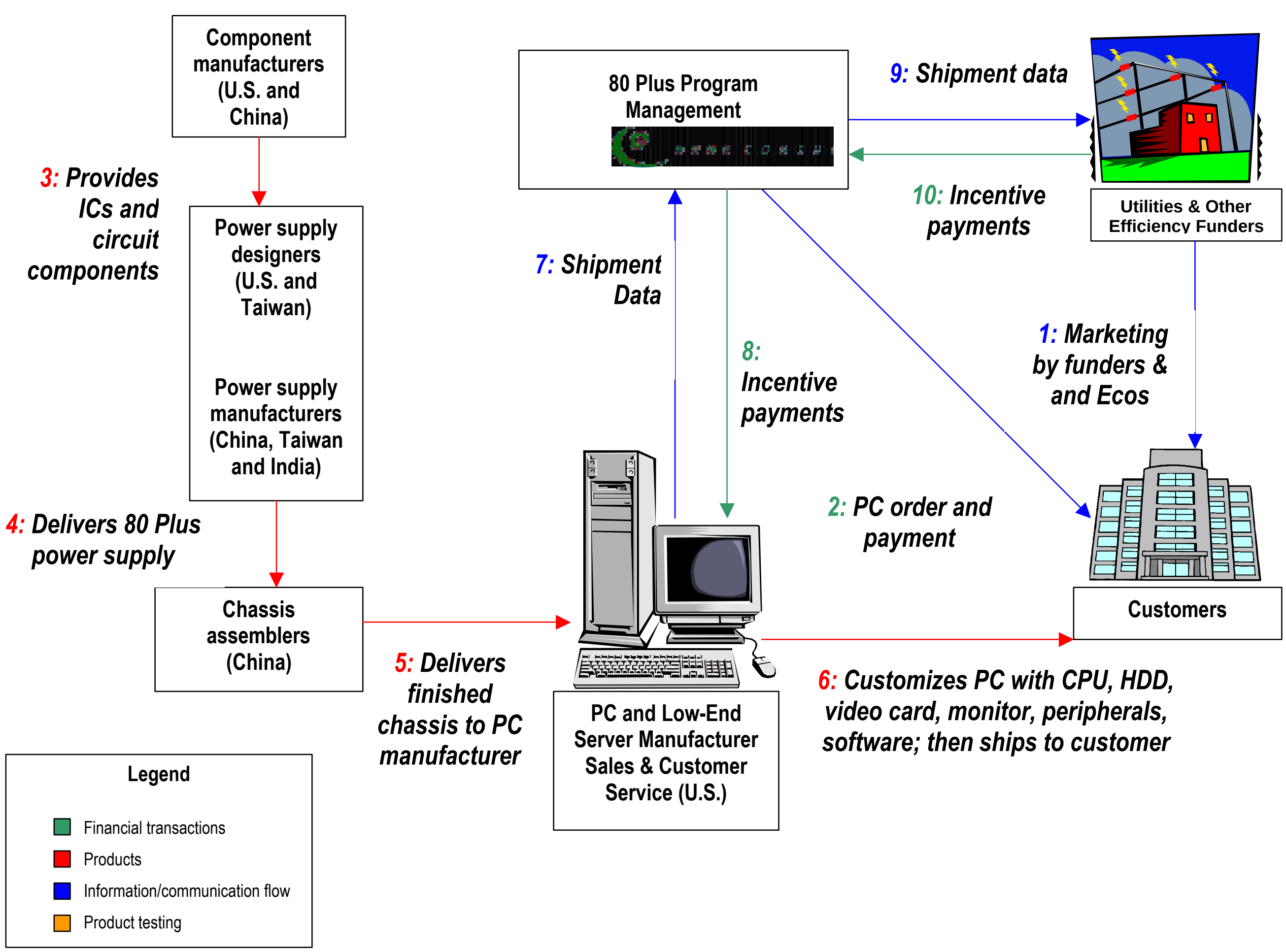
Step 8: Ecos makes the buy-down incentive payment to the manufacturer.

Step 9: Shipment data by ZIP code of final purchaser is reported and invoiced to utilities monthly.

Step 10: Utilities compensates Ecos for units delivered.

Figure 3 illustrates the implementation phase.

Figure 3. Implementation Phase



Marketing

While the 80 Plus program is open to any customer, the target markets are large commercial and institutional customers who purchase substantial volumes of computers. The computer manufacturers have indicated that the models targeted at this market would benefit from this technology. The marketing efforts for this program includes the following:

Marketing through computer manufacturers: There are four distinct market channels through computer manufacturers, they are:

- Build-to-order model – The computer or server is custom made and shipped directly to the customer (e.g., Dell).
- Shipped to stock model – The customer purchases a computer at the retail level (e.g., HP).
- Value Added Reseller (VAR) – VARs acquire product and sell to organizations, usually near their own physical location.
- Retail – Single-circuit power supplies are sold (e.g., at Fry's electronics) to individuals who build their own desktop computers.

Table 2 below provides a summary of the various channels and the tracking mechanism used to verify product sold in a utility's service territory.

Table 2. Market Channels and Tracking Levels

	Market Channel	Distributor	Tracking Level
Systems	Build to Order	Dell, Alienware	Individual address or corporate drop shipment
	Build to Stock	HP, IBM, Apple	Retail location or corporate drop shipment
Component	Small Custom Orders – Build to Stock	VAR (Value added reseller)	Assembly location
	Ship to store individual purchase	Retail local level	Retail location

Ecos has created an easily recognizable 80 Plus logo for all qualifying power supplies. A Web site, www.80plus.org, will list qualifying power supply models, test procedures, verification data, and the names of computer manufacturers and models that offer 80 Plus power supplies as an option. Ecos will also maintain an updated map on www.80plus.org of regions of the country where the program is available, the names of sponsors in each region, and the national results of the program to date. Ecos will develop program marketing and branding materials, encouraging targeted cooperative advertising by participating computer partners and local utility partners.

The 80 Plus logo will be used on the power supply in a similar manner

Sales Outreach

Although the program is available to all of a utility's customers (i.e., residential, commercial and industrial), the program's principal marketing and sales focus will be directed primarily to the large corporate and institutional customer category, given the size and computer purchasing power of this target market. The utilities' commercial account representatives will work with the program to promote qualifying product to the decision makers responsible for the volume purchases of desktop computers and desktop-derived servers.

Public Relations

Ecos will conduct media outreach to the following outlets to promote the program:

- Technology publications and Web sites used by IT managers
- Prominent national and regional newspapers
- Business and other popular periodicals
- Industry newsletters

Program Contact

Sam Sirkin, Program Development Director, 503.525.2700 ext 110, ssirkin@ecosconsulting.com

About Ecos Consulting

Ecos Consulting (Ecos) was founded in 1997 by four principals from the utility industry, environmental community, government, and academia. The company specializes in researching opportunities for energy efficiency in the marketplace and applying market-based methods to encourage increased use of environmentally beneficial technologies. Ecos is an industry leader in designing and implementing residential and commercial energy efficiency programs, and its research team has an established track record of pioneering energy savings opportunities in new end uses and technologies. This experience, combined with our unparalleled expertise in the power supplies market, positions Ecos to successfully implement this truly innovative program. Please visit www.ecosconsulting.com for more information about Ecos and www.efficientpowersupplies.org for more information on our joint power supply research activities with EPRI PEAC.

About EPRI PEAC

Located in Knoxville, Tennessee, EPRI PEAC Corporation has been providing engineering and management consulting services to the electric utility industry and its customers for over 16 years. The company specializes in providing high-value solutions that enhance the value of electricity – from the distribution system to the point of use. The EPRI PEAC staff of distinguished engineers and technicians are dedicated to supporting electric utilities and their customers in their efforts to understand, resolve, and prevent costly power quality and reliability problems, thereby helping to increase the profitability experienced by end-use customers and decrease downtime.

80 Plus Program Technical Details

The following information provides the technical details necessary for utilities to determine their ability to participate in the program. Specifically, this section documents the per-unit energy and demand savings and methodology, as well as the additional power quality benefits. It also documents the program participation assumptions necessary to calculate program impact and costs for a utility service territory based on the per unit savings, and concludes with a brief explanation of the verification and evaluation activities.

Energy (kWh) Savings for Desktop Computers

It is not possible to calculate energy savings from a more efficient desktop computer power supply by simply subtracting the conventional power supply efficiency (E_c) from the 80 Plus power supply efficiency (E80) and then multiplying the efficiency difference by typical power consumption and hours of use. In reality, computer power supply efficiency varies with the load (or state of operation) of the computer. In other words, the efficiency of the power supply changes depending on the mode of operation of the computer (e.g., standby, sleep or active mode). Therefore, the unit energy savings generated by the 80 Plus power supply must be calculated based on the measured efficiency at a range of loads and multiplied by the hours of operation at each of these load levels.

The total unit energy savings is the sum of the differences between input power of the conventional power supply and the input power of the 80 Plus power supply multiplied by the time at the respective loading level, 10% through 100%.

$$\text{Unit Savings} = \sum_{n=0\%load}^{n=100\%load} P_{out}\left(\frac{1}{E_{C\,n}} - \frac{1}{E_{80\,n}}\right) * T_n$$

- E_c is the efficiency of the conventional power supply at a specific load (0% to 100% load).
- E_{80} is the efficiency of the 80 Plus power supply at the same load level.
- P_{out} is the output power of the power supply.
- T is the time in hours per year spent at each loading level.

The baseline is the Intel 2004 required efficiency levels, and therefore the savings per unit is the difference in consumption between the Intel 2004 required and a minimum qualifying 80 Plus power supply. The energy savings calculation varies between commercial and residential because of the difference in the hours of use between the two applications.

Tables 3 and 4 outline the data necessary to calculate the energy and demand savings for the commercial application. The energy savings is the difference between the power consumption of the baseline unit, which is set at the Intel 2004 requirement (362 kWh/year) and the 80 Plus design (274 kWh/year), or 88 kWh/year. Tables 5 and 6 outline the data to calculate consumption of the residential application. The residential baseline unit consumes 318 kWh/year whereas the 80 Plus unit consumes 243 kWh/year for annual savings of 75 kWh/year. Table 7 illustrates the desktop-derived server baseline where the 80 Plus unit consumes between 458 and 556 kWh/year for annual savings between 274 and 332 kWh/year or a melded average of 301 kWh/year.

Table 3. Intel 2004 Required (Baseline) Desktop Power Supply Consumption, Commercial Application

	Off	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	Totals
Efficiency	-	57%	60%	63%	67%	70%	70%	70%	70%	70%	70%	
Proportion of Year	37%	40%	15%	6%	1%	1%						100%
Operating Time (hr/yr)	3,243	3,506	1,315	526	88	88	-	-	-	-	-	8766
Output (Watts)	-	25	50	75	100	125	150	175	200	225	250	
Input (Watts)	2.00	44	83	118	150	179	214	250	286	321	357	64.3
Power Supply Consumption (kwh/yr)	6	67	44	23	4	5	-	-	-	-	-	149
Total Computer Consumption (kwh/yr)	6	155	110	62	13	16	-	-	-	-	-	362

Table 4. 80 Plus Power Supply Consumption Desktop, Commercial Application

	Off	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	Totals
Efficiency	-	75%	82%	83%	85%	87%	87%	86%	86%	85%	85%	
Proportion of Year	37%	40%	15%	6%	1%	1%						100%
Operating Time (hr/yr)	3,243	3,506	1,315	526	88	88	-	-	-	-	-	8766
Output (Watts)	-	25	50	75	100	125	150	175	200	225	250	
Input (Watts)	2.00	33	61	90	118	144	172	203	233	265	294	48.4
Power Supply Consumption (kwh/yr)	6	29	14	8	2	2	-	-	-	-	-	61
Total Computer Consumption (kwh/yr)	6	117	80	48	10	13	-	-	-	-	-	274

Table 5. Intel 2004 Required (Baseline) Desktop Power Supply Consumption, Residential Application

	Off	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	Totals
Efficiency	-	57%	60%	63%	67%	70%	70%	70%	70%	70%	70%	
Proportion of Year	60%	10%	20%	6%	2%	1%	1%					100%
Operating Time (hr/yr)	5,260	877	1,753	526	175	88	88	-	-	-	-	8766
Output (Watts)	-	25	50	75	100	125	150	175	200	225	250	
Input (Watts)	2.00	44	83	118	150	179	214	250	286	321	357	87.8
Power Supply Consumption (kwh/yr)	11	17	58	23	9	5	6	-	-	-	-	128
Total Computer Consumption (kwh/yr)	11	39	146	62	26	16	19	-	-	-	-	318

Table 6. 80 Plus Power Supply Consumption Desktop, Residential Application

	Off	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	Totals
Efficiency	-	75%	82%	83%	85%	87%	87%	86%	86%	85%	85%	
Proportion of Year	60%	10%	20%	6%	2%	1%	1%					100%
Operating Time (hr/yr)	5,260	877	1,753	526	175	88	88	-	-	-	-	8766
Output (Watts)	-	25	50	75	100	125	150	175	200	225	250	
Input (Watts)	2.00	33	61	90	118	144	172	203	233	265	294	66.2
Power Supply Consumption (kwh/yr)	11	7	19	8	3	2	2	-	-	-	-	52
Total Computer Consumption (kwh/yr)	11	29	107	48	21	13	15	-	-	-	-	243

Table 7. Desktop-Derived Server Energy Consumption

		Proportion of Power Supply's Maximum Rated Output Current										
PS Results		**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**	**Totals**
	Efficiency	47%	61%	67%	69%	71%	72%	72%	72%	72%	**72%**	
Current	Proportion of Year		30%	50%	20%						-	**100%**
EPS12V	Operating Time (hr/yr)	-	2,630	4,383	1,753	-	-	-	-	-	-	8766
350	Output (Watts)	35	70	105	140	175	210	245	280	315	**350**	
Watts	Input (Watts)	74	115	157	203	245	292	339	388	438	489	154
Typical	PSU Consumption (kwh/yr)	-	119	229	110	-	-	-	-	-	-	458
	Total Consumption (kwh/yr)	-	304	689	355	-	-	-	-	-	-	1,348
	Efficiency	47%	61%	67%	69%	71%	72%	72%	72%	72%	**72%**	
Current	Proportion of Year		30%	50%	20%						-	**100%**
EPS1U	Operating Time (hr/yr)	-	2,630	4,383	1,753	-	-	-	-	-	-	8766
425	Output (Watts)	43	85	128	170	213	255	298	340	383	**425**	
Watts	Input (Watts)	90	140	191	246	297	355	411	472	532	593	187
Typical	PSU Consumption (kwh/yr)	-	145	278	133	-	-	-	-	-	-	556
	Total Consumption (kwh/yr)	-	369	837	431	-	-	-	-	-	-	1,637
80 Plus	Efficiency	70%	81%	83%	84%	85%	85%	84%	84%	83%	83%	
Proposed	Proportion of Year		30%	50%	20%						-	**100%**
EPS12V	Operating Time (hr/yr)	-	2,630	4,383	1,753	-	-	-	-	-	-	8766
350	Output (Watts)	35	70	105	140	175	210	245	280	315	**350**	
Watts	Input (Watts)	50	86	127	167	206	247	292	333	380	422	123
Typical	PSU Consumption (kwh/yr)	-	43	94	47	-	-	-	-	-	-	184
	Total Consumption (kwh/yr)	-	227	554	292	-	-	-	-	-	-	1,074
80 Plus	Efficiency	70%	81%	83%	84%	85%	85%	84%	84%	83%	83%	
Proposed	Proportion of Year		30%	50%	20%						-	**100%**
EPS12V	Operating Time (hr/yr)	-	2,630	4,383	1,753	-	-	-	-	-	-	8766
425	Output (Watts)	43	85	128	170	213	255	298	340	383	**425**	
Watts	Input (Watts)	61	105	154	202	250	300	354	405	461	512	149
Typical	PSU Consumption (kwh/yr)	-	52	114	57	-	-	-	-	-	-	224
	Total Consumption (kwh/yr)	-	276	673	355	-	-	-	-	-	-	1,304

Documentation for the data and calculations in the table, line by line, is as follows:

- Efficiency is based on bench tests conducted by EPRI PEAC. The efficiency is calculated based on the measured input and output wattages (lines 4 and 5 of the tables). The bench test results may be viewed at http://www.efficientpowersupplies.org/pages/pc_tests.html with the methodology at http://www.efficientpowersupplies.org/pages/Generalized_Internal_Power_Supply_Efficiency_Test_Protocol_R3.pdf.
- Proportion of year is "back fit" by knowing the power supply efficiency (based on the output and input wattages), the annual consumption, the split between stand by and on modes, and a general understanding of the load profile of desktop computers. Each of these variables is documented below.
- The approximate annual total consumption of a desktop computer is established by a number of data sources, including:
  - "Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings. Volume 1:Energy Consumption Baseline," Kurt W. Roth et. al, Prepared by Arthur D. Little, Inc. for the U.S. Department of Energy. January 2002.
  - Ecos estimates made in report prepared for the NRDC: "*Laptop Computers: How Much Do They Use and How Much Can We Save*?" September 2003.

- The percentage split between standby and operating time is based on field surveys. See the attached report: *"After-hours Power Status of Office Equipment and Energy Use of Miscellaneous Plug-Load Equipment."* Judy Roberson, et. al., LBNL-53729-Revised, May 2004. See LBNL-53729 at http://enduse.lbl.gov/Info/Pubs.html (also attached).
- The load curve of a desktop computer: NRDC and Ecos worked with Intel to develop duty cycles based on Intel's known loading curves of desktop computers (the machines operate the vast majority of the time when not in standby at very low levels, between10% and 20%). This process was used to help Intel develop its power supply specification structure and levels.

The kWh savings numbers do not take into account a few factors that will increase the savings. These factors include power factor, HVAC interactions and an increase in overall power consumption as a result of more complex components in newer computers. Power factor and power quality are addressed below. HVAC interactions can increase the savings from 10% to 25% for commercial applications depending on the climate and cooling load. The base case computer is based on current technology, whereas future computers are expected to have components (video and sound cards, etc.) that draw more power and would therefore increase the savings.

Per Unit Demand (kW) Savings

The demand savings are based on data in Tables 3 through 6. To calculate demand savings, first calculate the average active wattage for the baseline and 80 Plus computer. Calculate the average active wattage by adding the total computer consumption across each load state (except off) and divide that by the total number of hours that the computer operates during those load states. For example, the commercial application baseline unit consumes 356 kWh over 5,523 hours during the year when the computer is on (the 10% to 50% load states). Dividing the kWh by the hours of operation (and converting from kWh to Wh) yields average active wattage of 64 watts. The average active watts are highlighted in yellow on each table.

The calculated demand reduction at the customer level is the difference between the average active wattage of the Intel required (64 watts) and the best current design power supply (48 watts), or 16 watts. Utility level demand savings requires multiplying the number of units incented into that utility's service territory and multiplying by a coincidence factor. The coincidence factor will vary by utility and by equipment type (e.g., commercial chiller may be different than office equipment).

Power Quality

Conventional power supplies often operate at a low power factor and introduce substantial amounts of total harmonic distortion (THD) into the grid, raising costs for utilities and the large commercial and institutional customers they serve. For example, the average power factor of typical computer power supplies is 0.60 to 0.67, and the average THD is 101% to 130%. The most advanced new power supply designs achieve a power factor of 0.9 or greater. They typically have an average THD of less than 20%. These power quality benefits have significant value to utilities and the large commercial customers they serve, above and beyond the energy savings resulting from higher efficiency. Today's desktop-derived servers are very much like high-end desktops in performance. The difference is that they function 24 hours a day and have no sleep mode. Most desktop-derived servers already have PFC but have higher wattage ratings.

Market Penetration and Program Participation

The energy savings from the 80 Plus program may be considered in terms of the additive impact from each unit incented, or in terms of the impact on the overall market (the market transformation effect). While the overall goal of the program is to transform the market, the program is cost effective based on the resource acquired for each unit incented. The following outlines the assumptions and methodology to calculate overall program savings from a resource acquisition perspective.

This section applies the per unit energy savings numbers documented above to calculate program impact. The key variables to calculate program impact are the:

- Ratio of commercial versus residential units incented in the program
- Life of the measure
- Market penetration assumptions

The computer manufacturers' target market for models sold with an 80 Plus power supply is primarily commercial although some portion of these units will be purchased by the residential sector. For the purposes of this savings calculation, it is assumed that 75% of the units sold will be commercial and 25% of the units sold will be residential, for a melded savings of 85 kWh per year.

The measure life of an 80 Plus power supply is assumed to be four years. This is based on anecdotal interviews with business and IT managers that claim computer equipment has a life in the range of three to five years. The IRS assumes a five-year depreciation schedule for computer equipment. This measure life does not take into account the fact that many businesses will resell or donate the equipment to a secondary user such as an employee or non-profit organization.

It is anticipated that the program will have a market penetration of approximately 5% of the personal computers sold into any given utility service territory. This is based on the following market data and assumptions in Table 8.

Table 8 – Market Penetration Factors

Market Share of Participating Manufacturers	35%
% Commercial Sales	62%
% Desktop	71%
Applicability to Commercial Desktops	40%
% of Qualifying Product Ineligible for Incentive	15%
Resulting Market Share Applicable to 80 Plus Program	**5%**

With 52.7 million new personal computers (desktop and laptop) sold in the U.S. per year,[7] the maximum annual participation for the U.S. market is 2.6 million units. Program participation for any given service territory will depend on the size of the service territory market relative to the U.S. market. Population is used as a reasonable proxy for market size. Participation for any given service territory may be calculated by multiplying that service territory's fraction of the U.S. population (293 million) times 2.6 million potential units.

Program Costs

Program cost structure is standardized to ensure fairness for each participating utility or regional organization, large or small. The variable costs are $5.00 of incentive funding for desktop PCs and $10 for desktop-derived servers, $0.35 of admin costs, and $3.00 of marketing costs per computer.[8] The one-time fixed costs are a $5,000 setup fee plus $0.01 per residential and commercial meter for each participating utility or market transformation organization. Energy savings become progressively less expensive as more utility, computer and power supply partners join the program.

[7] Daoud, D., A. Promisel, L. Loverde, "Worldwide PC 3Q03 Forecast Update, 2003 – 2007," IDC, Doc # 30607, January 2004.

[8] Reductions in the marketing costs per unit may be possible over time as the program achieves its initial goals, further improving program cost effectiveness.

Verification and Evaluation

Ecos' research partner, the EPRI Power Electronics Applications Center (EPRI PEAC), will test sample power supplies and computers on a regular basis to verify compliance. Bench testing will be conducted to pre-qualify product eligibility for the program and post-verify units shipped during the program. The pre-qualification tests will be arranged through the manufacturers prior to their product being marketed as 80 Plus qualifying. Approximately 30-50 post verification bench tests will be conducted for the program depending on the number of power supply manufactures, computer retailers and product lines qualifying for the program. The post verification bench tests will be randomly selected from units shipped through the program. The efficiency tests will be reviewed on a regular basis (quarterly or semi-annually) and reported to participating utilities and manufacturers. Additionally, we will publish our testing data at www.80plus.org.

As the first funding organization, the Northwest Energy Efficiency Alliance has expressed interest in jointly sponsoring an independent third party evaluation of the program. The evaluation contract will be managed independent of Ecos and is not included in the program budget outlined previously.

Questions?

Please contact Mark Hamilton at Ecos with any technical questions. He can be reached at 503.525.2700 x120 or via email at mhamilton@ecosconsulting.com.

DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix J:
UNIES Geothermal Report

RESIDENTIAL GROUND SOURCE HEAT PUMPS ON URBAN LOTS

PERFORMANCE AND COST EFFECTIVENESS

Final Report

Prepared For

North End Housing Project, Inc.
Manitoba Housing and Renewal Corporation (MHRC)
Manitoba Conservation (Sustainable Development Innovations Fund)
Manitoba Hydro Manitoba R-2000 Home Program
Winnipeg Housing and Homelessness Initiative

Prepared By

Bert Phillips, P.Eng.

and

Devin Stanski, Engineer in Training

UNIES Ltd.

October 21, 2003

<u>DISCLAIMER</u>

While every effort has been made to ensure that the information, calculations, conclusions and recommendations in this report are accurate and complete, the authors and project sponsors do not warrant the accuracy or efficacy thereof. Under no circumstances shall the authors or project sponsors be held responsible for any loss, costs or damage whatsoever resulting from any use or interpretation of this information.

Executive Summary

The Winnipeg Housing and Homelessness Initiative (WHHI), the North End Housing Project Inc., Manitoba Conservation and its Sustainable Development Innovation Fund, Manitoba Housing and Renewal Corporation and Manitoba Hydro initiated and funded a study to monitor and evaluate ground source heat pump systems installed in four energy-efficient dwelling units built during winter 2001/2002 in the core area of Winnipeg. Heat pump operation was monitored from April 2002 through July 2003.

COP is the ratio of energy delivered by the heat pump divided by the energy it consumes (see Section 4.1 for a detailed definition). Heating season COPs in the study houses were in the range of 2.6 to 2.8, including fan and pump energy, indicating that the heat pumps can reduce the cost to heat these houses by 60 to 65%, when compared to conventional electric heating. In two of the study houses, heating season COPs were as low as 1.4 to 1.6 because air filters were not cleaned, greatly reducing airflows through the heat pumps. When properly operated, the heat pumps are estimated to reduce space heating energy use in each study house by 6,000 to 7,000 kWh per year, worth $300 to $360 at an electric cost of $0.0516/kWh.

In cooling mode, the heat pumps appear to have SEER values of 11.5 to 13.5 once recirculation fan energy is removed to make the heat pump data comparable to conventional central air-conditioning systems. Energy savings in cooling mode were estimated at $10 to $20 per year, compared to standard efficiency split residential air conditioners coupled with forced-air furnaces.

The heat pump systems installed in the study houses cost $7,100 to $8,100 more than electric or high-efficiency gas forced-air furnaces with air conditioners. It is expected that maintenance costs over the life of the heat pump will be similar to those for the more conventional systems. At current energy prices, the simple payback on the incremental cost of the heat pump compared to the conventional alternatives is about 20 years. Expressed another way, annual energy cost savings are estimated to be about 5% of the incremental cost of the heat pump system.

The heat pumps had desuperheaters to reduce DHW loads. They were found to be marginally effective at reducing DHW loads and in the cooling season may have actually increased whole house energy use. This is due in part to the length of piping between the DHW tank and heat pump and in part because of the DHW setpoint temperature was close to the temperature of water supplied by the desuperheater.

The study results clearly illustrate the impact of dirty filters on heat pump performance, and thus the need to properly brief tenants on heat pump system operation and maintenance requirements. Proper operation and maintenance is more critical to heat pump performance than it is for conventional heating systems.

1.0 Background

A heat pump is a mechanical apparatus that transfers heat from a low temperature environment (i.e., heat source) to a higher temperature environment (i.e., heat sink). The apparatus is similar to an air conditioner, except that the primary objective of an air conditioner is to cool the heat source while the primary objective of a heat pump is to heat the heat sink. The heat delivered by a heat pump includes the (free) heat extracted from the heat source plus the (purchased) energy consumed by the heat pump. Thus, the amount of heat energy delivered by a heat pump exceeds the amount of energy purchased to operate the heat pump, making it an energy-efficient heating system choice. Over the past decade, the number of residential ground source heat pumps (i.e., heat pumps that use the earth as their heat source) installed in Manitoba has increased. Currently, about 200 units per year are installed in Manitoba, but few, if any, of those installations have been in core area neighbourhoods where houses are very closely spaced. This raised questions as to whether there were financial or practical impediments in installing ground source heat pump systems in the urban context.

The Winnipeg Housing and Homelessness Initiative (WHHI) funds and coordinates community groups that provide affordable housing to low income families. WHHI and the Province of Manitoba wished to evaluate whether ground source heat pump space and water heating systems in an urban setting could improve housing affordability, since low income persons spend a disproportionate fraction of disposable income on energy. The Province is also interested in reducing greenhouse gas emissions. To this end, the Province initiated a study to monitor and evaluate ground source heat pump systems installed in four energy-efficient dwelling units built during the winter of 2001/2002 for the North End Housing Project Inc. Operation of the heat pump systems installed in each of four dwelling units on Flora Ave. was monitored from April 2002 through July 2003.

Study sponsors include Manitoba Conservation and its Sustainable Development Innovation Fund, Manitoba Housing and Renewal Corporation and Manitoba Hydro. These organizations have an interest in providing Manitobans with cost-effective and environmentally sustainable housing and encouraging homeowners to adopt energy-efficient technologies. They do this by making accurate information on energy efficiency and energy alternatives available and by developing appropriate and effective policies and advisory services on these options, including residential heat pumps.

Between 1998 and 2000, Manitoba Hydro's Business and Engineering Services, Customer Services & Marketing undertook a study to compare the cost of forced-air electric heating to the cost of heating with a ground source heat pump system retrofitted into a 1700 square foot residence on a Hutterite colony in rural Manitoba. In that application, space heating system energy consumption with the heat pump system was approximately 40% of what it would have been if the house were electrically heated (i.e., a 60% saving). The purpose of the current study was to compliment the Hydro study with information on inner city/urban lifestyle and heat pump performance in small, energy-efficient dwelling units and to evaluate the economic attractiveness of these installations.

2.0 Summary of Work Completed

UNIES Ltd. was retained to monitor heat pump systems in four test houses and evaluate their performance. The test houses were two identical two-storey side-by-side duplex units over full basements. Each side of each duplex unit (i.e., each dwelling unit) had an above-grade floor area of about 90 m^2 (1000 sq.ft.), three bedrooms and a bathroom on the second floor, kitchen, living room and dining room on the main floor and an undeveloped basement with laundry facilities, heat pump, domestic hot water (DHW) tank and heat recovery ventilator (HRV). Designed, constructed and certified to meet R-2000 program requirements, each dwelling unit had winter design heat losses of about 6 kW (20,000 Btuh). Based on casual observation during site visits, it is believed that space temperatures were uniform throughout the house in both summer and winter.

The same model of heat pump was installed in each of the four dwelling units. The heat pumps were rated at two tons in space heating mode (i.e., 24,000 Btuh or 7 kW) and slightly more cooling. Heat pump blowers had conventional multi-speed PSC blowers. In addition, each heat pump had an auxiliary electric heater rated at 7 kW. The thermostats operated the auxiliary heater whenever space temperatures fell 1°C below the thermostat setpoint. Each heat pump was connected to eight 50 feet deep vertical ground loop wells, for an effective ground loop length of 400 feet. The small lot size did not pose any exceptional challenges to the installation of the heat pump ground loops. As the heat pumps utilize closed loops, there were no special permitting or inspection requirements imposed by the authorities having jurisdiction.

The initial project task was to establish a monitoring protocol that would provide the data needed to evaluate heat pump system operation, then to design a data acquisition system to collect this data. A literature search did not unearth much meaningful data, but an unpublished Manitoba Hydro heat pump study was very informative and formed the basis for the monitoring protocol in this study.

Methods to calculate heat pump performance were selected and reviewed to identify the data that must be collected. Manitoba Hydro provided two ENERNET K20 multi-channel energy meter/recorders (i.e., data acquisition systems) and an assortment of sensors and related system hardware for use in this project. The number of parameters that the data acquisition systems could monitor was limited, so monitoring “everything” and deciding what was needed later was not an option. The capabilities of the data acquisition systems, the operating parameters of the heat pumps and their constituent components, and the layout of equipment in the house were reviewed to determine how to best utilize the data acquisition system capabilities and to identify additional equipment required to collect the needed data.

When the heating systems in the test houses were substantially complete in January 2002, automated data acquisition systems were installed to record various heat pump system operating parameters. As installed, each data acquisition system panel monitored two heat pump systems (i.e., the heat pumps serving both dwelling units in a duplex). Electric parameters monitored in each dwelling unit were voltage at the house, amps drawn on L1 and L2 (i.e., total power supply to the house), amps drawn by the heat pump and amps drawn by the domestic hot water tank. Temperatures monitored in each dwelling unit were ground loop supply and return temperatures and desuperheater loop supply and return temperatures. (The desuperheater loop supplies heat from the heat pump to the domestic hot water tank.)

Flow meters were permanently installed in each ground loop and fluid flow rates were determined by measuring flow over a fairly long run time (100 minutes or more). These were compared to pump curves for the ground loop to confirm correct pump operation. Flow rates in the desuperheater loop were estimated from loop head loss calculations and the manufacturer's pump performance curve. Measurements and calculations were performed to estimate heat loss from the desuperheater loop to the house.

After installation, the data acquisition system was checked to ensure it was operating properly and that all intended data was being collected and correctly recorded. The data acquisition systems allow data to be downloaded and the systems to be reprogrammed from a remote site via telephone connection and modem. Initially, getting the telephone/modem connections to work was extremely challenging because of software problems which were eventually resolved.

After the data acquisition systems became operational in early February 2002, data was routinely downloaded and reviewed to ensure that the data acquisition system was functioning correctly and to assess the operation of the heat pump system. In mid March 2002, a review of the data revealed abnormal energy use by the domestic hot water tank in House #3 and the heat pump in House #4. The contractor that installed the equipment found and corrected problems in these houses. At that time, "gating" relays were added to the data acquisition system. These marked data when the heat pump compressor was running, easing analysis of the field data. On April 18, 2003, the gating functions in House #1 and House #2 failed, so limited data was available for these houses after this date.

The domestic hot water tank element failure in House #3 would have become apparent when the house was occupied and the homeowner did not have an adequate supply of hot water. The electric heating elements in House #4 heat pump would meet all space heating requirements, so it is possible that the heat pump failure would have gone undetected until the occupant became aware that his or her electric utility bills were higher than they should be or that the heat pump did not provide air conditioning, as expected.

Ground source heat pumps modify earth temperatures over the course of the year, cooling the earth over the winter and heating it over the summer. Changes in ground temperatures impact heat pump performance. Thus, the systems must be monitored for at least one full cooling and heating season to acquire reliable performance data. Because of construction delays, the test house heating systems were not operational until mid winter 2001/2002. House #3 was occupied in March 2002. House #4 was occupied in May 2002. Neither House #1 nor House #2 was occupied until August 15, 2002. For these reasons, the planned monitoring period (fall 2001 to summer 2002) was extended for a year to include one full winter.

3.0 Description of Data Gathered

The data acquisition systems continuously monitored operation of all four heat pumps over the monitoring period. Monitored data was accumulated over specified time periods, then stored by the data acquisition system. In order to reduce the bulk of the data to be analyzed, the time period normally specified for accumulating data was four hours. Occasionally, fifteen minute or shorter time periods were specified to allow close examination of heat pump operating characteristics. Data was downloaded into a computer spreadsheet program in which various calculations and data manipulations were performed to help our understanding of heat pump operation in the test houses.

Electric parameters monitored in each dwelling unit were voltage at the house, amps drawn on L1 and L2 (i.e., total power supply to the house), amps drawn by the heat pump and amps drawn by the domestic hot water tank. From these data, energy consumption (kWh) was determined for the whole house, the heat pump and the domestic hot water tank.

Temperatures monitored in each dwelling unit were ground loop supply and return temperatures and desuperheater loop supply and return temperatures. Because energy transfer only occurs when loop pumps operate, these data were gated, that is to say loop temperature data was recorded separately when the loop pumps were operating. Coupling loop temperature to fluid flow rates allowed calculation of energy flow rates through the loops. (Ground loop fluid flow rates were measured, desuperheater loop fluid flow rates were estimated from engineering calculations and manufacturer's pump performance data.)

Prior to occupancy, various tests, measurements and observations were made on site, including power draws of various components of the heat pumps, ground loop flow rates, desuperheater loop temperature drops and physical measurements of piping runs. Some occupants were interviewed to gather data on how they operated their systems. These interviews were beneficial in explaining some unexpected variances in system operation.

On completion of monitoring, the installing contractor was retained to check the condition and operation of each of the heat pumps. At the same time, monitoring equipment was removed from the study houses, and exit interviews were done with two occupants. One occupant did not wish to participate in the interview, and there had been a recent change of occupants in one house, so an exit interview would not have been meaningful.

4.0 Data Analysis and Results

The data acquisition systems became operational in early February 2002 after which data was routinely downloaded and reviewed. In mid March 2002, it was observed from the field data that energy use by the domestic hot water tank in House #3 and the heat pump in House #4 was abnormal, compared with the energy use in the other three houses. The contractor that installed the equipment investigated and found the upper element in the domestic hot water tank in House #3 was burned out and a broken wire in the heat pump resulted in House #4 being heated by the auxiliary heaters, not the heat pump.

During winter of 2002/2003, the data gathered for Houses #1 and #2 was unusual in that it indicated the heat pump systems did not run for extended periods of time (sometimes in excess of 24 hours), then ran continuously for extended periods of time. Arrangements were made to interview the occupants and inspect the heat pumps and monitoring systems. In both cases, the occupants were recent immigrants to Canada with a lack of understanding of heating systems or how to operate the electronic thermostats. They switched their heating systems off for extended periods of time, then turned them on until the house warmed up. The occupants noted that the wide swings in indoor temperature affected comfort. During the interview, operation of the thermostat was explained to the occupants. During the exit interview, occupants observed that thermal comfort improved after the initial interview.

In April 2003, the gating functions in House #1 and House #2 failed. As this was near the end of the monitoring period, no effort was made to correct the gating problem.

The data gathered from the test houses has been evaluated in a variety of ways in an effort to analyze the various aspects and parameters of heat pump operation. A summary sheet of heat pump energy data is in Appendix A to this report. Parts of that summary sheet are reproduced in the discussion below.

4.1 Heat Pump Coefficient of Performance

The common measure for heat pump efficiency is coefficient of performance or COP. COP is the ratio of energy delivered by the heat pump divided by the energy consumed by the heat pump. A COP of 1.0 is equivalent to electric resistance heating. A higher COP indicates a more efficient heating system (i.e., more delivered energy per unit of purchased energy). COP is expressed mathematically as:

$$\text{COP} = \frac{\text{heating energy delivered by the heat pump}}{\text{energy consumed by the heat pump}}$$

or

$$\text{COP} = \frac{\text{energy extracted from the ground + electric energy consumed by the heat pump}}{\text{electric energy consumed by the heat pump}}$$

In heating mode, the heat pump system extracts energy from the ground. The heat extracted from the ground was calculated from heat pump run time, ground loop flow rate and the temperature difference between fluid flow to the ground loop and fluid flow from the ground loop, corrected for density and specific heat of the fluid in the ground loop. In heating mode, energy extracted from the ground loop is the “free” heat energy produced by the heat pump.

Purchased energy, which is the electric energy consumed by the heat pump, was measured and accumulated in each time period by the data acquisition system. COP will vary, depending on what energy consumptions are included in calculations. For example, circulation fan energy and/or ground loop energy may or may not be included in the COP calculations. Excluding specific purchased energy uses from COP calculations results in higher COP values.

Heating season COPs calculated using all energy used by the heat pumps ranged from 1.4 to 2.9. Close analysis of the data reveals reasons for this wide range. The heat pumps have back-up electric resistance heaters that operate whenever space temperature fell 1^{o}C below the thermostat set point. As a result of the way the heat pumps in Houses #1 and #2 were operated during winter 2002/2003, the electric resistance heaters operated most hours that the heat pumps operated. This significantly increased heat pump energy consumption, decreasing the calculated COP. Operation of heat pump circulation fans varied, sometimes occupants operated them continuously, sometimes on automatic (i.e., only on demand for space heating or cooling). Continuous fan operation increased electric energy consumption and decreased the COP calculated.

Table 1 presents monthly COP data for the four test houses during heating months. The column titled “Raw COP” includes all electric consumption by the heat pumps. In the column titled “COP w/o Fan”, COP is re-calculated with heat pump energy use adjusted to eliminate the impact of continuously operating furnace circulation fans. Fan power consumption while the heat pumps were operating are included in the COP calculations.

Table 1 - Heating Season COP

	House #1		House #2		House #3		House #4	
	Raw COP	COP w/o Fan	Raw COP	COP w/o Fan	Raw COP	COP w/o Fan	Raw COP	COP w/o Fan
2002								
March	2.8		2.5	2.7	2.4		1.7	
April	2.6		2.2	2.7	2.4	2.5	2.2	2.5
Oct	1.9	2.3	1.9	2.8	2.5	2.6	2.4	2.6
Nov	1.5	1.7	1.4	1.6	2.5		2.3	
Dec	1.5	1.6	1.4	1.6	2.6		2.7	
2003								
Jan	1.4	1.6	1.4	1.5	2.6		2.7	
Feb	1.5	1.6	1.4	1.5	2.6		2.7	
March	1.3	1.4	1.6	1.6	2.5		2.6	
April	1.0		1.4		2.3		2.4	

It was not possible to extract the energy used by the resistance heaters in the heat pumps in Houses #1 and #2 in order to get COPs which could be fairly compared to these for Houses #3 and #4; however, close examination of the data indicates that heating season COPs for all four heat pumps were in the range of 2.6 to 2.8, once energy from continuously running fans and resistance heating are subtracted from heat pump energy consumption. The data also indicate that COP declines slightly through the heating season. This may be explained by the fact that over the winter, ground temperatures decline, so the heat pumps must work harder to extract heat from the ground. The heat pump supplier indicated that he expected COPs to exceed 3.0.

Another factor causing the gradual decline in heating COP in House #1 and House #2 was that heat pump air filters were not routinely cleaned. The heat pumps were equipped with washable electrostatic air cleaners which have a fine mesh. As filters load up with dirt, airflow through the filter and across the heating coil declines. Reducing airflow adversely affects heat pump performance. The data indicate a slight improvement in COP in February for House #1 and March for House #2, which corresponds with the timing of the initial occupant interviews. After the initial occupant interviews, auxiliary heaters in the heat pumps in House #1 and House #2 continued to operate most of the time that the heat pump operated because at the reduced airflow, the heat pump heating coil was not able to heat the house, so auxiliary heat was still required to maintain space temperatures. The heat pump installer service rep suggested that the filters should be cleaned monthly. The occupants in Houses #1 and #2 did not clean filters at all over the study period. The occupants in Houses #3 and #4 indicated that they cleaned the filters monthly during the heating season.

When the heat pump in House #4 was not operating correctly from March 18 to March 21, the data indicate that the heat pump system extracted a modest amount of heat from the house and transferred it to the ground (i.e., it cooled the house) even though the house required heating.

4.2 Heat Pump Performance - Cooling Mode

In cooling mode, the heat pump transfers heat from the house to the ground. The data indicated that the heat pumps in Houses #3 and #4 were operated to provide air conditioning in the summer, but the heat pump cooling function was not utilized in Houses #1 and #2. The limited cooling mode data available for Houses #3 and #4 indicates that each of these heat pump systems provided about 60 hours of cooling in June, 100 hours in July and 75 hours in August. The cost to cool Houses #3 and #4 from June through August was about $50 each, $10 to $20 less than if the houses had standard efficiency, residential split air conditioners and forced-air furnaces.

SEER (seasonal energy-efficiency rating) is an energy-efficiency rating method for air-conditioning systems. SEER 10 is typical of good residential central air conditioners, SEER 13 is very good, while SEER 18 is state-of-the-art. These values are for the central air-conditioning unit alone, and do not include circulation fan energy. In cooling mode, the heat pumps in Houses #3 and #4 appear to have SEER values of 9.5 to 11.5 including circulation fan energy. When recirculation fan energy is removed to make the heat pump data more comparable to conventional central air-conditioning systems, SEER may be as high as 13.5.

4.3 Heat Pump Desuperheater Loop Performance

The heat pumps in the study houses had optional desuperheater loops. High temperature refrigerant from the heat pump heats domestic hot water (DHW) in the desuperheater. When the heat pump operates, water from the DHW tank is circulated between the DHW tank and the heat pump desuperheater through insulated water lines. A toggle switch allows the desuperheater pump to be disabled. The desuperheater loops were operated throughout the study period. The electric elements in the DHW tank operate as normal, maintaining DHW temperatures when contribution from the heat pump is not sufficient. The amount of energy transferred to the DHW tank was calculated as the product of estimated flow in the loop and the temperature difference between water being supplied to the desuperheater loop and water returning from the desuperheater loop. Electric energy used by the DHW tank elements was recorded by the data acquisition systems.

In houses without a hot water draw (e.g., unoccupied houses), all energy consumed by the DHW tanks meets tank standby heat losses. Provided that basement and DHW temperatures are relatively stable, DHW tank standby losses will be fairly stable over time. A review of DHW tank energy consumption for Houses #1 and #2, both of which were unoccupied in July and August, 2002, revealed standby heat losses of 111 watts in House #1 and 122 watts in House #2. During this time period, these heat pumps did not operate, so the heat pumps did not provide any heat to the DHW tank.

A comparison was made of electric energy supplied to the DHW tanks during heating season periods without a domestic hot water draw. Data for April 2002 indicate that the electric elements provided 70 watts of heat to the DHW tank in House #1 and 84 watts to House #2. This indicates that the energy delivered to the DHW tank from the desuperheater loop was much less than expected, given the amount of heat energy supplied to the desuperheater loop.

Analyzed another way, the data indicate that 160 kWh of energy was delivered into the desuperheater loop in April 2002 in House #1, but standby losses were only reduced by 33 kWh. The remaining 127 kWh was heat lost into the basement from the desuperheater loop. Similarly, of the 187 kWh delivered into the desuperheater loop of House #2 in April 2002, 157 kWh heated the basement and 30 kWh offset standby DHW tank heat losses.

Thus it appears that about 80% of the heat energy from the desuperheater loop was lost to the space and only 20% contributed to DHW heating during April. On-site measurements of temperature drop in the desuperheater loop lines and engineering calculations of heat loss from pipes both indicate that these estimates of heat loss are realistic. In the study houses, it is estimated that operation of the desuperheater loop during the heating season would reduce DHW tank electric energy use by 250 to 350 kWh per year per house.

Two factors lead to the high heat loss ratio. The electric elements in the DHW tank maintained the water in the tank at a temperature near the temperature of the water being supplied from the desuperheater, so the potential for the desuperheater to heat the water in the tank was small. The second factor was that the DHW tanks were located across the basement from the heat pump, so desuperheater pipe loops are quite long (about 15 meters or 50 feet long) and heat losses from the pipes were quite high. Had the DHW tank been located immediately adjacent to the heat pump, the desuperheater loop length would have been cut in half and half the heat losses could have been eliminated. Alternatively, doubling the thickness of pipe insulation would halve heat loss.

Losses from the desuperheater loop heat the basement. In the heating season, this is not a problem, but when the heat pump is being operated in cooling mode, heat losses from the desuperheater loop will add heat to the house, increasing the amount the heat pump must run to cool the house. Close analysis of the desuperheater heat loss data indicate that the electrical energy needed for the heat pumps to air condition desuperheater loop heat losses out of the house exceeds the electric energy reduction at the hot water tank. In other words, when the house is being air conditioned, operating the desuperheater increases whole house electrical energy consumption.

If the desuperheater loops were connected to a DHW preheat tank, is estimated that the energy needed to heat DHW would have been reduced by 30 to 50%. (Electric DHW tank standby losses would remain unchanged.) In Houses #3 and #4, which were occupied by families with young children for one full year during the monitoring period, this would amount to annual energy savings of 600 to 1100 kWh, worth $30 to $60. In houses with low DHW consumption, savings would be less, while savings would be greater in households with very high DHW consumption.

4.4 Free Energy and Purchased Energy

The energy that the heat pump extracts from the ground is "free" energy. This free energy and the energy purchased to operate the heat pumps are presented monthly for each house during the heating season months in Table 2. Total free energy and energy purchased to operate the heat pumps for winter 2002/2003 are also presented, along with an estimate of the value of purchased energy and avoided cost from the free energy.

Table 2 - Free Versus Purchased Heat Pump Energy

	House #1		House #2		House #3		House #4	
	Free kWh	Purchased kWh	Free kWh	Purchased kWh	Free kWh	Purchased kWh	Free kWh	Purchased kWh
2002								
March	604	341	674	458	441	305	333	461
April	596	364	684	570	544	399	598	492
Oct	219	251	336	376	760	513	609	424
Nov	325	662	231	560	987	653	785	589
Dec	400	878	346	814	1,121	713	957	550
2003								
Jan	244	638	513	1,226	1,325	828	1,290	763
Feb	392	778	467	1,086	1,258	791	1,218	733
March	201	666	459	825	1,004	666	887	549
April	8	330	102	236	432	324	427	303
Winter 02/03 Totals	1788	4202	2454	5123	6887	4489	6171	3909
	5990		7577		11376		10080	
Value of Energy**	$92	$217	$127	$264	$355	$232	$318	$202

** Value of energy calculated assuming electricity cost of $0.0516/kWh

Purchased energy to operate the heat pumps appears to be similar in all houses. However, occupant interviews conducted in winter of 2002/2003 indicated that mean indoor temperatures in Houses #1 and #2 were much lower than in Houses #3 and #4. During the site visit in House #1, interior temperature was in the range of 10^{o}C. The occupants in Houses #1 and #2 confirmed that they turned their heating systems on and off, and low average space temperatures were typical. As previously explained, this operating practice resulted in the electric resistance heaters in the heat pumps operating most hours that the heat pumps operated, which reduced heat pump hours of operation and thus the amount of "free" energy extracted from the ground. The net effect was that Houses #1 and #2 operated at significantly lower average indoor temperatures than Houses #3 and #4 over the winter, but did not have lower space heating costs.

The "free" energy is the energy savings that the heat pump provides. In Houses #3 and #4, this saving was in the range of 6,000 to 7,000 kWh for winter 2002/2003. At an average electric cost of $0.0516/kWh, these energy savings would be worth $300 to $360. Improper heat pump operation and dirty air filters, as was observed in Houses #1 and #2, significantly reduced the savings provided by the heat pumps.

4.5 Economic Costs and Benefits

The heating and ventilating systems installed in the study houses included a heat pump, an HRV, controls and related ductwork and cost $12,640 per house. The conventional alternate would have been electric or high-efficiency gas forced-air furnaces in lieu of the heat pumps, at an estimated per house cost of $4,500 to $5,500 respectively, including air conditioning. Thus the heat pump system had an incremental cost of $7,100 to $8,100 compared to a conventional heating system. A preheat tank could have been added into the DHW loops at an estimated cost of less than $400 per house. (Similar cost estimates for conventional heating systems were obtained from three sources: NEHP staff, a heating contractor working on similar houses and "2002 Baseline Survey of New Manitoba Houses" prepared for Manitoba Hydro by G. Proskiw, August 30, 2002.)

Energy utility costs to operate the heat pump heating system are lower than the electric forced-air furnace alternative by an estimated $300 to $360 per year in heating mode and $10 to $20 in cooling mode, assuming filters are routinely cleaned and the heat pumps are properly maintained. As installed, it appears that the impact of the heat pump desuperheater on DHW heating energy use was negligible. Had preheat tanks been installed in the DHW supply loop, it is estimated that operating the desuperheater loop would reduce DHW energy consumption by $30 to $60 per year at current electric rates.

Table 3 "Estimates of Service Lives of Various System Components" in Chapter 36 "Owning and Operating Costs" of the 2003 ASHRAE Applications Handbook places the median estimate of air-to-air residential and commercial heat pump life expectancy at 15 years. Estimated median life for commercial water-to-air heat pumps is 18 years, the same as gas-fired furnaces. The writer expects repair and maintenance costs over the life of the heat pump system to be comparable or more than they would be for an electric furnace and air conditioner, and comparable or better than for a gas-fired forced-air furnace and air conditioner.

Comparisons to gas-fired furnaces are complicated by the fact that gas rates were volatile over the course of the study. However, because of Manitoba's very low electric rates, the cost of heating with electricity or high-efficiency gas appliances was very close to equal over the time frame of the study and preparation of this report.

In summary, for an incremental cost of \$7,100 to \$8,100 (not including taxes), the heat pump systems in the study houses are estimated to yield annual energy savings of \$300 to \$360 (not including taxes) for space heating and \$10 to \$20 for space cooling. The incremental cost/incremental energy cost savings yield simple paybacks of about 20 years for the study house heat pumps, at current Manitoba energy rates.

The costs presented in this report do not include GST, PST or City of Winnipeg taxes or permit fees. In Manitoba, an effective rate of 4.5% GST is added to heating system costs (i.e., 7% GST less a 2.5% rebate on new construction). 7% PST is added to the hardware but not labour component of heating system installation. Energy costs are subject to 7% GST. The space heating component of energy bills in Manitoba is not subject to PST. A City Tax of 2.5% is added to energy bills. In Manitoba, the overall rate of taxes added to space heating energy costs are typically slightly higher than taxes added to the cost of the heating system in new construction. Excluding taxes from the calculations does impact total costs but it does not appreciably affect simple payback.

5.0 <u>Conclusions and Recommendations</u>

Calculations and crosschecks indicate that the data gathered is reasonable. In the heating season, the heat pumps appear to have operated at COPs in the range of 2.5 to 2.8, when blower fan and ground loop pump energy consumed during heat pump operation is included. As such, it may be expected that the heat pumps in the study houses would reduce space heating costs by 60% to 65%. At $0.0516/kWh, the heat pumps in these houses would be expected to provide annual energy savings on space heating, air conditioning and domestic hot water heating worth $300 to $400 per house, provided the heat pumps are operated correctly and air filters are routinely cleaned. Given that the heat pumps are estimated to have an incremental cost of $7,100 to $8,100, the simple payback based on energy savings were around 20 years in the study houses.

Space heating is only part of whole house energy load; the percent reduction in the whole electric utility bill would be less than the reduction in space heating load. For example, space heating accounted for about 80% of whole house energy use in mid winter and 40% to 60% in spring and fall and a negligible amount in summer. A 60% to 65% reduction in space heating costs would translate into about a 50% reduction in the mid winter electric utility bill, a 30% reduction in spring and fall bills and no savings in summer.

Field data and engineering calculations indicate that the desuperheater loop does more space heating than DHW heating, with about 80% of the heat in the loop being lost to the space. In cooling mode, heat lost from desuperheater loops will increase air-conditioning loads. To meet the increased air-conditioning loads, the heat pump will use more energy than was saved in heating DHW (i.e., operating the desuperheaters in the summer will increase the electric utility bills). As such, the homeowners should be instructed to turn off the desuperheater loop pumps during the summer. Heat losses from the desuperheater loop would be less if the DHW tanks were located nearer the heat pumps.

Part of the reason for the high heat losses from the desuperheater loop is that water being circulated in the loop is at the DHW tank setpoint temperature, which is quite hot. Reducing loop temperatures would reduce loop heat losses. One strategy that would reduce average desuperheater loop temperatures would be to utilize a DHW preheat tank that would not have heating elements. The desuperheater would heat water in the preheat tank, and this preheated water would be the feed water to the DHW tank. This approach is well suited for houses with high DHW consumption, but not effective for houses with low DHW use.

The poor performance of the heating systems in House #1 and House #2 is attributed to the occupants' lack of understanding of the electronic thermostats and the need to routinely clean air filters. During the exit interviews, some occupants indicated that they did not recall receiving any instruction on operation or maintenance of their heating systems. The installer indicated that he provided instruction to the first tenant and to a maintenance person, but not to the later tenants. It is recommended that all tenants of these units be instructed on operation and maintenance of the heat pumps. This would be best done several weeks after occupancy, when the occupants are familiar with the dwelling and are more likely to absorb the information provided because they are not preoccupied with the task of settling in.

The heat pump performance results reported in this study are specific to the four study houses. While general conclusions may be drawn from the data reported, the performance of different heat pumps in similar houses or of similar heat pumps in different applications may vary significantly from the heat pumps in these study houses. If changes in technology improve heat pump system efficiency or if energy prices increase, heat pump systems will become more economically attractive.

Heat pumps tend to be more economically attractive in houses with high heat losses because heat pump system costs increase at a slower rate than heat pump system capacity (i.e., doubling the capacity of a heat pump system does not double heat pump system cost). Thus one should expect the cost/benefit ratio of similar heat pumps installed in more typical Manitoba houses (i.e., larger houses with higher heat losses) to be more attractive than measured and reported for the study houses.

Any investment in energy conservation, including heat pump systems, should be evaluated against other investment options. The costs and benefits of heating system options should be compared to more efficient building envelope components (e.g., improved windows, higher levels of insulation, etc.), heat recovery, water conservation, energy-efficient lighting and appliances, energy-efficient furnace blower or any other applicable energy saving opportunity.

Appendix A

Field Data Summary Table

House #1	kWh from Ground	kWh to Ground	kWh to DHW	HP Cons. kWh	DHW Cons. kWh	Other kWh	Total kWh (house)	COP	Run-time (hrs)
Mar 13-31	604.3	0.0	176.7	340.9	7.0	23.4	371.3	2.8	158.2
April	596.2	0.0	160.0	364.3	49.8	19.5	433.6	2.6	154.4
May	365.4	0.0	84.9	264.0	78.3	24.0	366.3	2.4	93.3
June	19.4	0.0	3.5	183.1	96.2	63.4	342.7	1.1	4.9
July	0.0	0.0	0.0	226.0	83.2	83.1	392.3	1.0	0.0
August	0.0	0.0	0.0	221.2	89.3	76.6	387.1	1.0	0.0
September	114.2	0.0	24.6	201.2	102.8	63.3	367.3	1.6	22.9
October	218.6	0.0	42.1	250.8	1,013.3	403.2	1,667.3	1.9	44.9
November	324.9	0.0	77.6	661.8	970.7	465.3	2,097.8	1.5	71.5
December	399.8	0.0	107.7	877.7	635.1	402.0	1,914.9	1.5	92.6
January 03	243.9	0.0	63.6	638.2	569.5	742.7	1,950.4	1.4	57.4
February03	391.8	0.0	121.4	777.8	501.5	619.0	1,898.3	1.5	96.1
March 03	201.1	0.0	67.2	665.8	533.7	569.3	1,768.9	1.3	49.2
Apr 1-28 03	8.3	0.0	1.9	329.7	476.6	313.7	1,120.0	1.0	2.0
House #2	**kWh from Ground**	**kWh to Ground**	**kWh to DHW**	**HP Cons. kWh**	**DHW Cons. kWh**	**Other kWh**	**Total kWh (house)**	**COP**	**Run-time (hrs)**
Mar 13-31	674.1	0.0	205.1	458.0	6.1	62.5	526.6	2.5	187.2
April	683.6	0.0	186.6	569.9	50.2	87.3	707.4	2.2	193.7
May	370.1	0.0	86.8	427.9	83.3	87.2	598.4	1.9	105.9
June	17.7	0.0	3.3	230.4	101.2	72.2	403.7	1.1	5.3
July	0.0	0.0	0.0	226.7	89.5	97.9	414.1		0.0
August	0.0	0.0	0.2	231.8	95.5	81.5	408.7		0.2
September	121.9	0.0	35.1	227.0	81.2	89.6	397.7	1.5	29.5
October	335.5	0.0	114.0	376.3	220.3	299.9	896.5	1.9	82.1
November	231.3	0.0	122.1	559.6	239.9	340.7	1,140.2	1.4	57.4
December	346.1	0.0	201.8	814.0	249.8	428.4	1,492.2	1.4	89.9
January 03	513.2	0.0	314.6	1,226.2	204.9	475.1	1,906.2	1.4	137.7
February03	466.7	0.0	287.6	1,086.1	190.0	418.5	1,694.6	1.4	125.2
March 03	459.3	0.0	247.5	824.8	254.6	367.9	1,447.3	1.6	115.6
Apr 1-28 03	101.8	0.0	50.7	236.3	280.2	260.7	777.2	1.4	24.2

House #3	kWh from Ground	kWh to Ground	kWh to DHW	HP Cons. kWh	DHW Cons. kWh	Other kWh	Total kWh (house)	COP	Run-time (hrs)
Mar 18-31	441.3	0.0	184.3	305.3	271.9	177.6	754.8	2.4	122.0
April	544.2	0.0	229.6	398.6	625.5	319.2	1,343.4	2.4	151.9
May	308.9	98.5	128.6	292.0	598.0	317.9	1,207.9		98.5
June	11.9	575.5	46.5	234.5	549.3	284.6	1,068.4	2.7	73.7
July	0.0	912.7	70.1	387.3	470.0	351.3	1,208.7	2.5	104.9
August	0.0	456.9	31.4	297.5	403.4	313.9	1,014.8	1.6	51.4
September	199.1	201.3	101.5	258.5	377.3	258.3	894.1		70.1
October	759.8	0.0	329.4	513.3	362.3	299.2	1,174.8	2.5	188.6
November	986.7	0.0	456.0	653.4	333.8	309.4	1,296.6	2.5	261.1
December	1,121.4	0.0	494.7	712.7	312.9	295.8	1,321.5	2.6	301.3
January 03	1,325.3	0.0	603.4	828.2	342.8	309.8	1,480.8	2.6	364.5
February03	1,257.9	0.0	401.7	791.4	318.9	243.4	1,353.7	2.6	352.7
March 03	1,004.1	0.0	460.6	666.0	433.6	266.7	1,366.3	2.5	287.2
April 03	431.9	0.0	174.9	324.0	456.4	222.8	1,003.2	2.3	124.0
May 03	125.0	122.9	51.7	227.7	526.0	310.6	1,064.3		49.9
June 03	0.0	479.5	18.1	318.4	411.4	304.4	1,034.2	1.6	52.7
Jul 1-21 03	0.0	496.5	25.9	248.7	217.7	199.2	665.5	2.1	54.8

House #4	kWh from Ground	kWh to Ground	kWh to DHW	HP Cons. kWh	DHW Cons. kWh	Other kWh	Total kWh (house)	COP	Run-time (hrs)
Mar 18-31	332.7	21.0	92.0	460.9	29.5	95.4	585.8	1.7	165.5
April	598.2	0.0	124.9	491.7	74.9	125.2	691.8	2.2	154.9
May	291.7	60.4	70.5	292.6	200.1	204.2	696.8		83.6
June	14.0	447.8	25.1	181.4	215.2	223.2	619.8	2.6	56.1
July	0.0	977.7	64.3	391.2	194.8	300.5	886.5	2.7	113.5
August	0.0	630.9	49.7	238.5	202.5	284.5	725.5	2.9	75.2
September	122.2	255.7	59.1	183.9	201.0	282.3	667.2		57.5
October	608.7	0.0	357.8	423.7	119.7	288.2	831.5	2.4	159.1
November	784.6	0.0	515.3	589.0	83.6	346.2	1,018.9	2.3	224.9
December	956.7	0.0	494.7	549.7	143.7	464.3	1,157.7	2.7	240.2
January	1,290.2	0.0	563.6	763.0	101.2	412.2	1,276.4	2.7	343.6
February03	1,217.5	0.0	529.4	732.6	109.9	451.8	1,294.4	2.7	334.3
March 03	886.5	0.0	358.1	548.6	131.2	347.7	1,027.5	2.6	243.6
April 03	426.6	11.0	152.1	302.6	187.6	241.0	731.2	2.4	115.5
May 03	110.5	144.9	39.8	147.2	240.2	220.9	608.3		48.6
June 03	0.0	577.1	16.7	230.1	234.6	304.2	768.9	2.6	69.4
Jul 1-21 03	0.0	509.2	31.5	173.0	141.1	216.7	530.7	3.1	59.1

DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix K:
Kats et al. Report on Green Buildings

The Costs and Financial Benefits of Green Buildings

A Report to California's
Sustainable Building Task Force

October 2003

Principal Author: Greg Kats, Capital E

Contributing Authors: Leon Alevantis, Department of Health Services
Adam Berman, Capital E
Evan Mills, Lawrence Berkeley National Laboratory
Jeff Perlman, Capital E

This report was developed for the Sustainable Building Task Force, a group of over 40 California state government agencies. Funding for this study was provided by the Air Resources Board (ARB), California Integrated Waste Management Board CIWMB), Department of Finance (DOF), Department of General Services (DGS), Department of Transportation (Caltrans), Department of Water Resources (DWR), and Division of the State Architect (DSA). This collaborative effort was made possible through the contributions of Capital E, Future Resources Associates, Task Force members, and the United States Green Building Council.

October 3, 2003

Dear Colleagues,

This study, *The Costs and Financial Benefits of Green Building,* represents the most definitive cost benefit analysis of green building ever conducted. It demonstrates conclusively that sustainable building is a cost-effective investment, and its findings should encourage communities across the country to "build green."

In August 2000, Governor Davis issued Executive Order D-16-00, establishing sustainable building as a primary goal for state construction and tasking the State and Consumer Services Agency with its implementation. Our agency established the Sustainable Building Task Force, a unique partnership among more than 40 governmental agencies, whose combined building, environmental, and fiscal expertise has produced outstanding results, including funding for this report.

Since its inception, the Sustainable Building Task Force has worked diligently to incorporate green building principles into California's capital outlay process. Our many successes include:

- Building the first LEED Gold state owned office building in the country, the Education Headquarters Building, which is saving taxpayers $500,000 a year in energy costs alone;
- Including sustainable building performance standards, such as energy efficiency, in over $2 billion of state construction and renovation contracts;
- Constructing many high visibility state "leadership buildings," which are models of sustainability, including the Caltrans District 7 Office building in Los Angeles;
- Promoting on-site renewable energy, such as the installation of over an acre of photovoltaic panels on the roof of the Franchise Tax Board Building in Rancho Cordova – which is the largest array on any state office building in the country;
- Assisting the Chancellor of the new 10th University of California campus, UC Merced, in her goal to construct the greenest campus in the country with an initial target of LEED Silver for all construction;
- Impacting the sustainability of K-12 bond funded school construction throughout the state by providing funding and technical assistance to support the work of the Collaborative for High Performance Schools (CHPS), including the construction of 13 demonstration high performance schools; and
- Confirming through rigorous emissions testing that the careful selection of building materials in concert with environmentally responsive cleaning practices results in cleaner and healthier indoor environments.

While the environmental and human health benefits of green building have been widely recognized, this comprehensive report confirms that minimal increases in upfront costs of about 2% to support green design would, on average, result in life cycle savings of 20% of total construction costs -- more than ten times the initial investment. For example, an initial upfront investment of up to $100,000 to incorporate green building features into a $5 million project would result in a savings of $1 million in today's dollars over the life of the building. These findings clearly support the work of the Sustainable Building Task Force and reinforce our commitment to build the greenest state facilities possible.

This report was funded by several Sustainable Building Task Force member agencies, including the Air Resources Board, the Department of Finance, the Department of General Services, the Department of Transportation, the Department of Water Resources, the Division of the State Architect, and the Integrated Waste Management Board. Their resources and staff support have helped to increase our collective knowledge of the true costs and benefits of green building. In addition, I would like to recognize the contributions of Undersecretary Arnold Sowell and Senior Consultant Amanda Eichel of the State and Consumer Services Agency. Their leadership, as well as their commitment to this subject, made this project possible.

With the signing of Executive Order D-16-00 by Governor Davis, California embarked on a road to sustainability. Since that time many cities, counties, and school districts, as well as the Board of Regents for the University of California, have established similar sustainable building goals. It is extremely rewarding not only to note the major accomplishments of this Task Force, including this first of a kind study documenting the cost-effectiveness of green building, but also to witness the national impact of these extraordinary interagency efforts.

Best regards,

Aileen Adams
Secretary

TABLE OF CONTENTS

Executive Summary

Integrating "sustainable" or "green" building practices into the construction of state buildings is a solid financial investment. In the most comprehensive analysis of the financial costs and benefits of green building conducted to date, this report finds that a minimal upfront investment of about two percent of construction costs typically yields life cycle savings of over ten times the initial investment. For example, an initial upfront investment of up to $100,000 to incorporate green building features into a $5 million project would result in a savings of at least $1 million over the life of the building, assumed conservatively to be 20 years.[1]

The financial benefits of green buildings include lower energy, waste disposal, and water costs, lower environmental and emissions costs, lower operations and maintenance costs, and savings from increased productivity and health. These benefits range from being fairly predictable (energy, waste, and water savings) to relatively uncertain (productivity/health benefits). Energy and water savings can be predicted with reasonable precision, measured, and monitored over time. In contrast, productivity and health gains are much less precisely understood and far harder to predict with accuracy.

There is now a very large body of research, reviewed in this report, which demonstrates significant and causal correlation between improvements in building comfort and control measures, and worker health and productivity. However, these studies vary widely in specific measured correlations. Further, there has been relatively little work completed to evaluate specific, measurable benefits from green building design in California. Clearly, the benefits are significant and not zero, but the data supports a broad range of calculated benefits – in contrast to the more precisely measurable energy, water, and waste savings.

The financial benefits conclusions in this report should therefore be understood in this context. Energy, waste, and water savings as well as emissions reductions can be viewed as fairly precise, reasonably conservative estimates of direct benefits that alone significantly exceed the marginal cost of building green. Health and productivity benefits can be viewed as reasonably conservative estimates within a large range of uncertainty. Further research is necessary to better quantify and capture the precise savings associated with these benefits. Additional studies might include such measures as evaluating green building effects on insured and uninsured health effects, employee turnover, worker well being and, where relevant (e.g. in schools), test scores.

Background

"Green" or "sustainable" buildings use key resources like energy, water, materials, and land much more efficiently than buildings that are simply built to code. They also create healthier work, learning, and living environments, with more natural light and cleaner air, and contribute to improved employee and student health, comfort, and productivity. Sustainable buildings are cost-effective, saving taxpayer dollars by reducing operations and maintenance costs, as well as by lowering utility bills.

[1] Although this report was written with specific regard to California state buildings, data is national in scope and conclusions are broadly applicable to other types of buildings and for other public and private sector entities.

Over the last few years, the green building movement has gained tremendous momentum. The United States Green Building Council (USGBC), a national non-profit organization, has grown dramatically in membership. The USGBC's Leadership in Energy and Environmental Design (LEED) rating system has been widely embraced both nationally and internationally as the green building design standard. Public and private sector entities, including the cities of Santa Monica, San Diego, San Francisco, San Jose, Long Beach, Los Angeles, Seattle, and Portland; San Mateo County; the University of California; the Department of the Navy; the federal General Services Administration; and the states of Oregon, New York and Maryland have all adopted green building policies and clean energy standards. In addition, corporate entities, including Steelcase, Herman Miller, Johnson Controls, Interface, IBM, PNC Financial Services, Southern California Gas Company, Toyota, and Ford Motor Company, have constructed green buildings.

Recognizing the tremendous opportunity for California state government to provide leadership in the area of exemplary building design and construction methods, several years ago Governor Davis issued two Executive Orders that address the siting and building of state facilities:

- Executive Order D-16-00 establishes the Governor's sustainable building goal: "to site, design, deconstruct, construct, renovate, operate, and maintain state buildings that are models of energy, water, and materials efficiency; while providing healthy, productive and comfortable indoor environments and long-term benefits to Californians...The objectives are to implement the sustainable building goal in a cost effective manner…; use extended life cycle costing; and adopt an integrated systems approach.[2]"
- Executive Order D-46-01 provides guidance on the process the Department of General Services will use to locate and lease space, including such considerations as proximity to public transit and affordable housing, preserving structures of historic, cultural, and architectural significance, opportunities for economic renewal; and sensitivity to neighborhood and community concerns.[3]

The Issue of Cost

To implement the Executive Orders, the Secretary of the State and Consumer Services Agency, Aileen Adams, formally convened an interagency Sustainable Building Task Force (Task Force) comprised of over 40 state agencies, including representatives with energy, environmental, fiscal, construction, property management, and historic preservation expertise. As the Task Force set about its implementation work, the uncertainty about the "cost" of green buildings became an issue of growing importance and increased discussions.

While there seems to be consensus on the environmental and social benefits of green building, there is a consistent concern, both within and outside the green building community, over the lack of accurate and thorough financial and economic information. Recognizing that the cost issue was becoming more and more of a prohibitive factor in the mainstreaming of green building not only within California but across the country, several members of the Task Force funded an Economic Analysis Project to determine more definitively the costs and benefits of sustainable

[2] State of California, Governor's Executive Order D-16-00. August 2000. Available at: http://www.governor.ca.gov/state/govsite/gov_homepage.jsp.
[3] State of California, Governor's Executive Order D-46-01. October 2001. Available at: http://www.governor.ca.gov/state/govsite/gov_homepage.jsp.

building.[4] Sustainable buildings generally incur a "green premium" above the costs of standard construction. They also provide an array of financial and environmental benefits that conventional buildings do not. These benefits, such as energy savings, should be looked at through a life cycle cost methodology, not just evaluated in terms of upfront costs. From a life cycle savings standpoint, savings resulting from investment in sustainable design and construction dramatically exceed any additional upfront costs.

It is generally recognized that buildings consume a large portion of water, wood, energy, and other resources used in the economy. Green buildings provide a potentially promising way to help address a range of challenges facing California, such as:

- The high cost of electric power.
- Worsening electric grid constraints, with associated power quality and availability problems.
- Pending water shortage and waste disposal issues.
- Continued state and federal pressure to cut criteria pollutants.
- Growing concern over the cost of global warming.
- The rising incidence of allergies and asthma, especially in children.
- The health and productivity of workers.
- The effect of the physical school environment on children's abilities to learn.
- Increasing expenses of maintaining and operating state facilities over time.

Benefits include some elements that are relatively easy to quantify, such as energy and water savings, as well as those that are less easily quantified, such as the use of recycled content materials and improved indoor environmental quality. Prior to this report, no comprehensive analysis of the actual costs and financial benefits of green buildings had been completed, although there are a number of studies that do begin to address this very important issue.

- In October 2002, the David and Lucille Packard Foundation released their Sustainability Matrix and Sustainability Report, developed to consider environmental goals for a new 90,000 square foot office facility. The study found that with each increasing level of sustainability (including various levels of LEED), short-term costs increased, but long-term costs decreased dramatically.[5]

- A second, older study conducted by Xenergy for the City of Portland identified a 15% lifecycle savings associated with bringing three standard buildings up to USGBC LEED certification levels (with primary opportunities to save money associated with energy efficiency, water efficiency and use of salvaged materials).[6]

---

[4] Funding agencies include the Air Resources Board (ARB), California Integrated Waste Management Board (CIWMB), Department of Finance (DOF), Department of General Services (DGS), Department of Transportation (CalTrans) Department of Water Resources (DWR), and Division of the State Architect (DSA).

[5] "Building for Sustainability: Six Scenarios for the David and Lucille Packard Foundation Los Altos Project," prepared for the David and Lucille Packard Foundation, October 2002. Available on-line at: http://www.packard.org/pdf/2002Report.pdf.

[6] "Green City Buildings: Applying the LEED Rating System," prepared for the Portland Energy Office by Xenergy, Inc and SERA Architects, June 18, 2000. Available at: http://www.sustainableportland.org/CityLEED.pdf.

In addition, a number of other studies document measurable benefits for enhanced daylighting, natural ventilation, and improved indoor air quality in buildings. Benefits associated with these "green" features include enhanced worker and student productivity, as well as reduced absenteeism and illness.

For example:

- One study performed by the Heschong-Mahone group looked at students in three cities and found that students in classrooms with the greatest amount of daylighting performed up to 20% better than those in classrooms that had little daylight.[7]
- A study at Herman-Miller showed up to a 7% increase in worker productivity following a move to a green, daylit facility.[8]
- A Lawrence Berkeley National Laboratory study found that U.S. businesses could save as much as $58 billion in lost sick time and an additional $200 billion in worker performance if improvements were made to indoor air quality.[9]

Report Methodology and Format

This report is the first of its kind to fully aggregate the costs and benefits of green buildings. Specifically, the bulk of this report reviews and analyzes a large quantity of existing data about the costs and financial benefits of green buildings in California. Several dozen building representatives and architects were contacted to secure the cost of 33 green buildings compared to conventional designs for those buildings. The average premium for these green buildings is slightly less than 2% (or $3-5/ ft^2, see *Implications for California,* pg.18), substantially lower than is commonly perceived. The majority of this cost is due to the increased architectural and engineering (A&E) design time necessary to integrate sustainable building practices into projects. Generally, the earlier green building gets incorporated into the design process, the lower the cost.

A literature review conducted for this report revealed that there is sufficient data from which to construct reasonable estimates about the value of many green building attributes. Historically, both private firms and public agencies do not recognize the full financial value of green buildings. They usually acknowledge some benefits from lower energy and water use, but completely ignore or critically undervalue other, often significant, financial benefits of green buildings during the design and construction decision-making process.[10] For most of these benefits, such as emissions reductions and employee productivity, there are multiple methods that can be used to derive values of benefits, as well as a large range of values that can be assigned to them. In most cases, there is no single "right" answer. Nonetheless, the report underscores that based on the body of

[7] Heschong Mahone Group, "Daylighting in Schools: An Investigation into the Relationship Between Daylight and Human Performance," 1999. Available at: http://www.h-m-g.com; Follow up studies verified the rigor of analysis and subsequent research continues to show positive correlation between daylighting and student performance.

[8] Judith Heerwagen, "Do Green Buildings Enhance the Well Being of Workers?" *Environmental Design and Construction Magazine*. July/August 2000. Available at: http://www.edcmag.com/CDA/ArticleInformation/coverstory/BNPCoverStoryItem/0,4118,19794,00.html.

[9] William Fisk, "Health and Productivity Gains from Better Indoor Environments," summary of prior publications (see Appendix J), with figures inflation-adjusted for 2002 dollars and rounded.

[10] See, for example "CEC Environmental Performance Report." Available at: http://www.energy.ca.gov/reports/2001-11-20_700-01-001.PDF. 2003 EPR will be finalized and available in October 2003 as part of the *Integrated Energy Policy Report*.

existing data, it is possible to determine reasonable, conservative estimates of financial benefits for a range of green building attributes.

The report also reveals the need for further research and analysis. In all areas, consistently conservative assumptions were made in view of data limitations. Additional research will help to refine cost and benefit estimates and likely lead to increased financial benefit calculations for green building. Additionally, throughout the report, the reader is directed to online databases and publications for the most accurate and relevant information. In many instances, these referenced documents are available online, and URLs are provided in the footnotes.

Conclusion

The benefits of building green include cost savings from reduced energy, water, and waste; lower operations and maintenance costs; and enhanced occupant productivity and health. As Figure ES-1 shows, analysis of these areas indicates that total financial benefits of green buildings are over ten times the average initial investment required to design and construct a green building. Energy savings alone exceed the average increased cost associated with building green.

Additionally, the relatively large impact of productivity and health gains reflects the fact that the direct and indirect cost of employees is far larger than the cost of construction or energy. Consequently, even small changes in productivity and health translate into large financial benefits.

Figure ES-1. Financial Benefits of Green Buildings Summary of Findings (per ft^2)

Category	20-year NPV
Energy Value	$5.79
Emissions Value	$1.18
Water Value	$0.51
Waste Value (construction only) - 1 year	$0.03
Commissioning O&M Value	$8.47
Productivity and Health Value (Certified and Silver)	$36.89
Productivity and Health Value (Gold and Platinum)	$55.33
Less Green Cost Premium	($4.00)
Total 20-year NPV (Certified and Silver)	**$48.87**
Total 20-year NPV (Gold and Platinum)	**$67.31**

Source: Capital E Analysis

Despite data limitations and the need for additional research in various areas, the findings of this report point to a clear conclusion: building green is cost-effective and makes financial sense today.

Acknowledgements

Fifty members of the Sustainable Building Task Force provided guidance and significant staff and research time to shape this work. The leadership of Arnie Sowell, Undersecretary of the California State and Consumer Services Agency, made this report possible. Amanda Eichel, Senior consultant with the California State and Consumer Agency, provided invaluable research and organizational support.

The US Green Building Council served as a partner in this effort, providing critical data, insights and support throughout the project.

Principal author Greg Kats serves as Chair of the Energy and Atmosphere Technical Advisory Group for LEED and serves on LEED's steering committee.[11]

Other members of the Capital E team - Hank Habicht, Jim Rogers and Joe Romm - provided valuable insights, edits and support.

Vivian Loftness and the Carnegie Mellon University's Department of Architecture provided invaluable information and data on the productivity benefits from improved indoor air quality.

A group of California and national leaders served on the Green Building Valuation Advisory Group, and provided invaluable guidance and information throughout the project.

Green Building Valuation Advisory Group

Gregg Ander	Chief Architect, Southern California Edison
Bob Berkebile	Principal, BNIM Architects
Anthony Bernheim	Principal, SMWM
Steve Castellanos	California State Architect
Christine Ervin	President, US Green Building Council
Vivian Loftness	Head, Department of Architecture, Carnegie Mellon University
Roger Platt	VP and Counsel, Real Estate Roundtable
Bill Reed	VP Integrative Design, Natural Logic
Art Rosenfeld	Commissioner, California Energy Commission
Beth Shearer	Director, Federal Energy Management Program, US DOE

The authors were greatly helped by the kind assistance and advice from a large range of experts in state agencies, architectural firms and elsewhere, particularly:

Hashem Akbari, Lawrence Berkeley National Laboratory
Dan Burgoyne, California Department of General Services
Bill Browning, Rocky Mountain Institute
John Boecker, Robert Kimball & Associates
Charles Eley, Eley Associates & The Collaborative for High Performance Schools
Randy Ferguson, California Department of General Services
William Fisk, Lawrence Berkeley National Laboratory

[11] Lead author contact information: gkats@cap-e.com, www.cap-e.com, or 202 463-8469. For purposes of disclosure, Greg Kats co-founded and until 2001 served as Chair of the IPMVP, the national standard for monitoring and managing building energy and environmental performance. LEED and IPMVP are referred to frequently in this report.

Kathy Frevert, California Integrated Waste Management Board
David Gottfried, WorldBuild and the US Green Building Council
Nigel Howard, US Green Building Council
Wendy Illingworth, Economic Insights, Inc.
Pat McAuliffe, California Energy Commission
Daryl Mills, California Energy Commission
Gregg Morris, Future Resources Associates
Brendan Owens, US Green Building Council
Rubin Tavares, California Energy Commission
Jim Tilton, California Department of Finance
Robert Watson, Natural Resources Defense Council
Robert Wilkinson, University of California Santa Barbara, Department of Environmental Studies
John Wilson, California Energy Commission

In addition, valuable assistance and/or draft review comments were provided by:

Lucia Athens	City of Seattle Green Building Program
Sam Baldwin	US Department of Energy
Panama Bartholomy	California Department of General Services, Division of the State Architect
John Blue	California Integrated Waste Management Board
Bob Boughton	California Department of Toxic Substances Control
Marilyn Brown	Oak Ridge National Lab
Ty Carson	US Green Building Council
Tom Deitsche	US Green Building Council
Sean Dockery	California Department of General Services, Division of the State Architect
William Dougherty	Tellus Institute
Beverly Dyer	US Department of Energy, Federal Energy Management Program
Simon Esching	California Department of Water Resources
Gary Estrada	California Department of General Services, Office of Risk and Insurance Management
Karen Finn	California Department of Finance
Doug Grandy	California Department of General Services
Dave Hasson	City of Portland, Environmental Services
Tom Hicks	US Environmental Protection Agency, Energy Star Program
Ray Hoagland	California Department of Water Resources
Tom Hoff	National Renewable Energy Lab
Steve Kasower	US Bureau of Reclamation, Southern California
Matt Layton	California Energy Commission, Systems Assessment & Facilities Siting
Dale Lessick	Irvine Ranch Water District
Hal Levin	Lawrence Berkeley National Laboratory
Joe Loyer	State Energy Siting Division, Environmental Unit
Amory Lovins	Rocky Mountain Institute
Fred Luzzi	California Department of General Services, Real Estate Services Division, Buildings and Property Management Branch
Lisa Maddaus	California Urban Water Conservation Council
Nadav Malin	Environmental Building News
Gary Matteson	Mattesons and Associates
Lisa Matthiessen	Davis Langdon Adamson

Mike Meredith	California Department of General Services, Real Estate Services Division
Jeff Morris	Sound Resource Management
Peter Morris	Davis Langdon Adamson
Jim Ogden	3D/I
Aya Ogishi	UC Berkeley, Department of Agricultural and Resource Economics
Tom Phillips	California Air Resources Board
Steve Prey	California Department of Transportation
Jack Safely	Metropolitan Water District of Southern California
Chris Schmidle	California Integrated Waste Management Board
Jennifer Seal	Rocky Mountain Institute
Dave Sharky	California Department of General Services, Real Estate Services Division, Buildings and Property Management Branch
Lisa Skumatz	SERA, Inc.
Arnie Sowell	California State and Consumer Services Agency
Gail Sturm	Cushman & Wakefield
Scott Tomeshevski	California Energy Commission
James Toothaker	Formerly of the Governor's Green Government Council, Pennsylvania
Barbara Van Gee	California Integrated Waste Management Board
Jed Waldeman	California Department of Health Services
Clark Williams	California Integrated Waste Management Board
Alex Wilson	Environmental Building News
Gary Wolff	Pacific Institute
Hank Zaininger	Zaininger Engineering

I. Overview of Project

In September 2002, California's Sustainable Buildings Task Force (SBTF)[12] – composed of representatives from over 40 state agencies – with funding from seven of its constituent agencies,[13] hired a team, lead by Capital E, to undertake an economic analysis project to aid in the effort to evaluate the cost and benefits of sustainable building.

This report is intended to provide immediately useful analytic support for making informed and cost-effective building design decisions. Identification of gaps and recommendations for additional research are mentioned throughout the text and compiled in Section XII – Recommended Next Steps. These are intended to provide guidance to the SBTF in identifying opportunities to further improve understanding of the full costs and benefits of green buildings.

What is a Green Building?

"Green" or "sustainable" buildings are sensitive to:

- Environment.
- Resource & energy consumption.
- Impact on people (quality and healthiness of work environment).
- Financial impact (cost-effectiveness from a full financial cost-return perspective).
- The world at large (a broader set of issues, such as ground water recharge and global warming, that a government is typically concerned about).

California's Executive Order D-16-00 establishes a solid set of sustainable building objectives: "to site, design, deconstruct, construct, renovate, operate, and maintain state buildings that are models of energy, water and materials efficiency; while providing healthy, productive and comfortable indoor environments and long-term benefits to Californians." [14] This green building Executive Order requires consideration of externalities, economic and environmental performance measures, life cycle costing, and a whole building integrated systems approach when making sustainable building funding decisions. These objectives for sustainable building design include not only tangible savings associated with energy, water and waste efficiencies, but also "softer" benefits, such as human health and productivity, impact on the environment and incorporation of recycled content materials.

---

[12] See: http://www.ciwmb.ca.gov/GreenBuilding/TaskForce/, State of California Sustainable Building Task Force website.

[13] The seven CA state agencies that funded this study are the California Air Resources Board (ARB), California Integrated Waste Management Board (CIWMB), Department of Finance (DOF), Department of General Services (DGS), Department of Transportation (Caltrans), Department of Water Resources (DWR), and Division of the State Architect (DSA).

[14] State of California, Governor's Executive Order D-16-00. August 2000. Available at: http://www.governor.ca.gov/state/govsite/gov_homepage.jsp.
The goals of sustainable building practice in California, according to one recent article, are to: a) enhance indoor air quality; b) improve occupant health and productivity; c) increase the efficiency of material, energy, and water resource usage; and d) reduce the environmental impacts associated with the production of raw materials and the construction, deconstruction and long-term operation of buildings. Alevantis et al., "Sustainable Building Practices in California State Buildings," *Proceedings of Indoor Air 2002: The 9th International Conference on Indoor Air Quality and Climate*. Monterey, CA, June 30 – July 5, 2002. Vol. 3, pp. 666-671, Indoor Air 2002, Inc. Available at: http://www.indoorair2002.org.

In December 2001, the SBTF released the report, *Building Better Buildings: A Blueprint for Sustainable State Facilities*,[15] the first in a series of reports that will document the progress of California state government in implementing the Governor's sustainable building goals. The Blueprint notes that sustainable buildings are often called green or high performance buildings. The US Green Building Council (USGBC)[16] uses the term "green" to define a building with the same objectives as those described in the *Blueprint*. Other initiatives, such as New York's High Performance Building Design Guidelines,[17] use the term "high performance" to describe virtually the same set of building characteristics. The High Performance Guidelines draw particular attention to the use of advanced technology, or "smart infrastructure," and its impact on tenant ability to control key building comfort measures (such as temperature and light levels) to increase performance.[18]

This report will use the terms "sustainable" and "green" synonymously and interchangeably.

Sustainable design practices have been applied in American buildings for millennia, as evidenced in the exquisite structures of the Hopi Indians a thousand years ago. However, the term sustainable or green architecture as a modern, integrated design philosophy appears to be very recent. The first references to "green architecture" and "green building label" reportedly appeared in the British publication *The Independent* in London in early 1990, followed by the first American use of the term "green architecture" in mid-1990, on the editor's page of *Architecture* magazine.[19] The American Institute of Architect's Committee on the Environment started in 1989.[20] In 1991, the city of Austin established the first green building program in the United States[21] – there are now dozens of such programs nationally.[22] The Green Building committee of the American Society for Testing and Materials (ASTM) also formed in 1991.[23] Thus, the modern green building movement appears to be little over a decade old. It is therefore impressive that there is already an emerging national consensus on the definition of a green building and a rapidly increasing number of green projects in both the public and private sectors.

While there is no exactly "correct" weighting of green attributes, there is a broad consensus both with regard to the general attributes that constitute greenness, as well as the approximate

---

[15] California State and Consumer Services and Sustainable Building Task Force. "Building Better Buildings: A Blueprint for Sustainable State Facilities," December 2001. Available at: http://www.ciwmb.ca.gov/GreenBuilding/Blueprint/.

[16] See: http://www.usgbc.org, United States Green Building Council website.

[17] New York City Department of Design and Construction. "High Performance Building Guidelines*."* April 1999. Available at: http://home.nyc.gov/html/ddc/html/highperf.html.

[18] See, for example: Alan Traugott, "Green Building Design = High Performance Building Design," *Consulting-Specifying Engineer*, January 1999, pp. 68-74.

[19] Nathan Engstrom, "The Rise of Environmental Awareness in American Architecture: From the Bruntland Commission to LEED," *Platform* (A publication of the School of Architecture at the University of Texas at Austin), Fall 2002. Available at: http://www.ar.utexas.edu/csd/documents/stu-papers/engstrom-1.pdf.

[20] See: http://www.aia.org/cote, American Institute of Architect's Committee on the Environment (COTE) website.

[21] See: http://www.ci.austin.tx.us/greenbuilder/, The City of Austin Green Building Program.

[22] For a useful summary table (with URLs) of two dozen green building programs in the US, see: Peter Yost, "Green Building Programs – An Overview," *Building Standards*, March – April 2002, p. 13. Available at: http://www.buildingscience.com/resources/articles/default.htm.
The Table was adapted from a longer article in *Environmental Building News*.

[23] See: http://www.astm.org, ASTM "Sustainability" Subcommittee E06.71 of Committee E06 "Performance of Buildings."

weighting that these different attributes should receive.[24] However, the definition of a sustainable building is innately subjective. There is no universally accepted way to compare such diverse green attributes as, for example, improved human health, reduced water pollution and reduced forest cutting. Different green building programs balance various dimensions of "greenness" through a necessarily subjective weighting. For example, Green Globes, a US online assessment tool for benchmarking the greenness of building performance, attributes 34% of the weighting of building greenness to energy use, more than the USGBC's Leadership in Energy and Environmental Design (LEED) Rating System's 29%.[25] Because of the wide range of "green" attributes considered, no single scientific denominator exists, and weighting reflects consensus best judgment rather than scientific determination.

The range of definitions of what constitutes a green or sustainable building includes:

- The British Research Establishment Environmental Assessment Method (BREEAM) was launched in 1990 and is increasing in use.[26]
- Canada's Building Environmental Performance Assessment Criteria (BEPAC) began in 1994.[27] This system was never fully implemented due to its complexity.
- The Hong Kong Building Environmental Assessment Method (HK-BEAM) is currently in pilot form.[28]
- The US Green Building Council (established in 1993) began development of the Leadership in Environmental and Energy Design (LEED) Green Building Rating System™ in 1994. Version 2.0 of the LEED standard was formally released in May 2000; Version 2.1 was released in November 2002.[29]

US state or regional green building guidelines include:

- New York's High Performance Building Guidelines (1999).[30]
- Pennsylvania's Guidelines for Creating High Performance buildings (1999).[31]

---

[24] For an elegant review of green building design evolution, see:
"Building for Sustainability: Six Scenarios for the David and Lucille Packard Foundation Los Altos Project," October 2002. Available on-line at: http://www.packard.org/pdf/2002Report.pdf.
This comprehensive study evaluates the life cycle cost of six increasingly green designs, each built to a different standard of sustainability. Increases in initial capital costs are weighed against decreases in operating costs to determine net present value (NPV) for each building type over a 30, 60 and 100 year period. The study concludes, even without taking into account most externalities, that life cycle cost for a green building is considerably lower than for a conventional one.

[25] Green Globes – Environmental Assessment of Buildings. Energy Criteria. Available at: http://www2.energyefficiency.org/crit-energy.asp; US Green Building Council's LEED Rating System Energy Criteria. Slide 28, LEED™ Point Distribution, http://www.usgbc.org/Docs/About/usgbc_intro.ppt.

[26] British Research Establishment. BREEAM Environmental Assessment Tool. Information Available at: http://products.bre.co.uk/breeam/.

[27] See: http://www.bepac.dmu.ac.uk/, BEPAC website.

[28] HK-BEAM Society. Hong Kong Building Environmental Assessment Method, Version 4/03 Pilot. May 2003. Available at: http://www.bse.polyu.edu.hk/Research_Centre/BEP/hkbeam/main.html.

[29] US Green Building Council. LEED™ Version 2.1Rating System. November 2002. Available at: http://www.usgbc.org/Docs/LEEDdocs/LEED_RS_v2-1.pdf.

[30] New York City Department of Design and Construction High Performance Building Guidelines. April 1999. Available at: http://home.nyc.gov/html/ddc/html/highperf.html.

[31] State of Pennsylvania Guidelines for Creating High Performance Buildings, 1999. Available at: http://www.gggc.state.pa.us/publictn/gbguides.html.

In addition, there are a dozen or more local applications of LEED, generally adding more stringent requirements as part of state certification. Federal work on green buildings, coordinated by DOE's Federal Energy Management Program, has also developed important programs and resources on green building best practices. [32]

LEED as the US Green Building Standard

The United States Green Building Council (USGBC), a national non-profit entity, developed the Leadership in Energy and Environmental Design (LEED) Green Building Rating System™[33] to rate new and existing commercial, institutional, and high-rise residential buildings according to their environmental attributes and sustainable features. The LEED system utilizes a list of 34 potential performance based "credits" worth up to 69 points, as well as 7 prerequisite criteria, divided into six categories:

- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality
- Innovation & Design Process

LEED allows the project team to choose the most effective and appropriate sustainable building measures for a given location and/or project. These "points" are then tallied to determine the appropriate level of LEED certification. See Appendix A for a full list of LEED Version 2.1 prerequisites and credits.

Four levels of LEED certification are possible; depending on the number of criteria met, and indicate increasingly sustainable building practices:

LEED Certified	26-32	points
LEED Silver	33-38	points
LEED Gold	39-51	points
LEED Platinum	52+	points

There is a general perception that LEED is becoming the standard for US green building design. As the industry magazine *Health Facilities Management* described in October 2002, "LEED has become the common benchmark for sustainability."[34] Although imperfect and still evolving, LEED has rapidly become the largest and most widely recognized green building design and certification program in the US, and probably in the world.

LEED was first introduced through a Pilot Program, and twelve buildings received version 1.0 certification in March 2000. Version 2.0 was released shortly thereafter for use as a design and certification tool. At the end of 2000, about 8 million square feet of buildings were undergoing

---

[32] See for example: "Greening Federal Facilities", second edition, May 2001, produced by BuildingGreen, Inc. See: http://www.eere.energy.gov/femp/techassist/green_fed_facilities.html.
[33] US Green Building Council. LEED Rating System, Version 2.1. November 2002. Available at: http://www.usgbc.org/Docs/LEEDdocs/LEED_RS_v2-1.pdf.
[34] Craig Applegath and Jane Wigle, "Turning Green," *Health Facilities Management*, October 2002, pp. 22-27.

LEED certification. By early 2003, this number had jumped to over 100 million square feet. As of December 2002, of all new construction projects in the United States, an estimated 3% had applied for LEED certification, including 4% of schools, 16.5% of government buildings and 1.1% of commercial projects.[35] In addition, many buildings use LEED as a design tool without going through the certification process.[36] LEED's use and impact is therefore more pervasive than the figures suggest. All indications are that this explosive growth will continue. Despite its limitations, the strength and likely future durability of LEED and its definition of green buildings derives from several factors:

- LEED is broad and democratic in nature, currently with 3000 organizations representing all sectors of the building industry. Membership has roughly doubled annually over the last three years. [37]
- LEED continues to change through large, professional, voluntary committees, and a staff that is responsive to the evolving needs of its large and diverse membership. New products are being developed, including: LEED for Existing Buildings, LEED for Commercial Interiors, LEED for Core and Shell, LEED for Homes, LEED for Neighborhood Developments, and LEED for Multiple Buildings.[38]
- The USGBC spends millions of dollars each year to support LEED in a number of ways, including: an extensive training program; the LEED Accredited Professional exam; a Resource guide; LEED templates; an extensive LEED website for registered projects, technical data and scientific committees; and a growing staff of professionals dedicated to LEED.

States and municipalities can create local applications of LEED, generally adding more stringent regional requirements. This approach has been used in Portland, Oregon[39] and Seattle, Washington.[40] These programs require buildings to receive LEED certification, but are tailored to meet the specific resource concerns of the region.[41]

Many other jurisdictions are currently creating LEED-based guidelines and ordinances. Some have developed guidelines that closely follow LEED but are not viewed as LEED compatible,

---

[35] US Green Building Council, Urban Land Institute and The Real Estate Roundtable. "Making the Business Case for High Performance Green Buildings." 2002. Available at: https://www.usgbc.org/Docs/Member_Resource_Docs/makingthebusinesscase.pdf.
All percentages based on square footage not on number of buildings. For total LEED square footage see also: www.usgbc.org.

[36] See for example: Larry Flynn, Senior Editor, "Sustainability," *Building Design and Construction*, April 2001.

[37] US Green Building Council. USGBC Member Directory. 2003. Available at: https://www.usgbc.org/Members/members_directory.asp.

[38] LEED™ Green Building Rating System Committees, US Green Building Council. 2003. Available at: https://www.usgbc.org/Members/member_committees.asp.

[39] Portland Office of Sustainable Development, Green Building Division. "City of Portland Supplement to the LEED Rating System." 2002. Available at: http://www.sustainableportland.org/portland_leed.pdf.

[40] City of Seattle Green Building Team. "City of Seattle CIP Supplements to the LEED Green Building Rating System™." 2001. Available at: http://www.cityofseattle.net/sustainablebuilding/Leeds/docs/LEEDSupplements.PDF.

[41] Darren Bouton and Geof Syphers, "Creating Green Building Criteria for Local Governments: Recommendations for San Jose LEED," paper presented at the USGBC International Green Building Conference, October 2002.
Available at: http://www.usgbc.org/expo2002/schedule/documents/DS509_Bouton_P324.pdf.

such as the High Performance Guidelines of North Carolina's Triangle Region.[42] The USGBC's recent publication, *Making the Business Case for High Performance Green Buildings*, co-produced with the Urban Land Institute and The Real Estate Roundtable, provides a useful overview of green building benefits as well as a list of cities, states and other entities that have adopted LEED.[43]

LEED in California

There are more LEED registered projects within California – over 140 as of August 2003[44] – than in any other state. In 2001, in support of state greening efforts, California's Sustainable Building Task Force developed the LEED Supplement for California State Facilities.[45] This regionalized supplement to LEED V.2.0 is intended for guidance purposes and is not required for use in state projects. It provides information on California codes, policies and practices and is hosted on the CIWMB's website[46] for public use, though it has not been officially adopted.

On the local level, LEED has been adopted in a number of California municipalities. The city of San Jose,[47] San Francisco city and county,[48] the city of San Diego,[49] the city of Santa Monica,[50] San Mateo County,[51] and Los Angeles city and county[52] have all made commitments to LEED. The city of Oakland[53] and Alameda County[54] and have developed their own LEED-based green building guidelines. The city of Pleasanton recently passed an ordinance requiring both public and private buildings to meet the standards of LEED Certified level, subject to a few modifications.[55]
As an interim step towards the adoption of LEED at the state level, the California Sustainable Building Task Force, in collaboration with the Department of General Services, has developed

---

[42] Triangle J Council of Governments. "High Performance Guidelines: Triangle Region Public Facilities." September 2001. Available at: http://www.tjcog.dst.nc.us/hpgtrpf.htm.
[43] USGBC. 2002. Op. Cit.
[44] LEED Registered Project List, US Green Building Council, April 2, 2003. https://www.usgbc.org/LEED/Project/project_list_registered.asp.
[45] For California application of LEED, see: http://www.ciwmb.ca.gov/GreenBuilding/Design/LEEDforCA.doc.
[46] See: http://www.ciwmb.ca.gov/GreenBuilding/, California Integrated Waste Management Board Green Building Website.
[47] City of San Jose. "Green Building Policy." 2001. Available at: http://www.ci.san-jose.ca.us/esd/gb-policy.htm.
[48] City and County of San Francisco. "Resource Efficient City Buildings Ordinance." 1999. Available at: http://www.sfgov.org/sfenvironment/aboutus/policy/legislation/efficient.htm.
[49] City of San Diego. "Policy No. 900-14: Sustainable Building Practices." 2002. Available at: http://clerkdoc.sannet.gov/RightSite/getcontent/local.pdf?DMW_OBJECTID=09001451800850ad.
[50] City of Santa Monica. "Green Building Guidelines." 1997. Available at: http://greenbuildings.santa-monica.org/introduction/introduction.html.
[51] San Mateo County. Green Building. See: http://www.co.sanmateo.ca.us/smc/county/content/0,,1774_2126_13802237,00.html.
[52] City of Los Angeles. "Sustainable Building Initiative: An Action Plan for Advancing Sustainable Design Practices." 2001. Available at: http://www.lacity.org/SAN/lasp/sbi-draft-nov2001-300.pdf.
[53] City of Oakland. "Oakland Sustainable Design Guide." 2001. Available at: http://www.oaklandpw.com/greenbuilding/.
[54] Alameda County Waste Management Authority. "New Construction Green Buildings Guidelines." 2001. Available at: http://www.stopwaste.org/nhguide.html.
[55] City Council of the City of Pleasanton. "Ordinance No. 1873." Adopted December 2002. Available at: http://www.ci.pleasanton.ca.us/pdf/greenbldg.pdf.

two lists of technologies that are intended to guide development of new buildings.[56] The Tier 1 list includes many green technologies – such as "cool roofs" (described in Section IX) – that have been predetermined as cost-effective by the Department of Finance and are expected to be included in new construction. The Tier 2 list includes technologies that should be included in new designs as long as they are cost justified, and as the project budget allows.

In reality Tier 1 and Tier 2 technologies are inconsistently included in construction. Part of the reason is that the benefits of green design are best achieved when green technologies and practices are adopted as part of an integrated design rather than on a piecemeal basis. An integrated green building design approach – such as LEED – provides a way to incorporate green technologies and practices in a way that is more likely to be cost-effective. [57]

In addition to LEED, another rating system has been developed specific to K-12 schools in California. The Collaborative for High Performance Schools, or CHPS, is a diverse group of government, utility, and non-profit organizations with a unifying mission to improve the quality of education for California's children.[58] The goal of the CHPS is to create a new generation of high performance school facilities in California. The focus is on public schools and levels K-12, although many of the design principals apply to private schools and higher education facilities as well. High performance schools are healthy, comfortable, resource efficient, safe, secure, adaptable, and easy to operate and maintain. They promote higher test scores, help school districts retain quality teachers and staff, reduce operating costs, increase average daily attendance (ADA), reduce liability, and promote environmental stewardship and joint use opportunities.

CHPS has developed a three volume Best Practices Manual for High Performance Schools, including a set of design criteria to "rate" CHPS schools.[59] Different from LEED, CHPS is self-certifying, and CHPS schools must score 28 out of 81 possible points for eligibility.

---

[56] State of California, Real Estate Services Division,"Exhibit C – Tiers: Energy Efficiency and Sustainable Building Measures," July 1, 2002. Available at: http://www.ciwmb.ca.gov/GreenBuilding/Design/Tiers.pdf.
[57] The benefits and process of green design are extensively documented in RMIs "Green Development: Integrating Ecology and Real Estate." See www.rmi.org.
[58] See: http://www.chps.net, The Collaborative for High Performance Schools website.
[59]The Collaborative for High Performance Schools. "CHPS Best Practices Manual, Volumes I-III, 2002." Available at: http://www.chps.net/manual/index.htm#score.

II. Important Assumptions

Life Cycle Assessment (LCA)

This report uses a life cycle costing (LCC) approach to evaluate and integrate the benefits and costs associated with sustainable buildings. Life cycle costing, often confused with the more rigorous life cycle assessment (LCA) analysis, looks at costs and benefits over the life of a particular product, technology or system. LCA, in contrast, involves accounting for all upstream and downstream costs of a particular activity, and integrating them through a consistent application of financial discounting. The result – if data is available -- is a current "cradle to grave" inventory, impact assessment and interpretation (e.g., a net present value estimate). However, the art and science of calculating true life cycle impacts and costs of green buildings is still evolving and is generally not practiced. Currently, decisions on whether or not to invest in a green building are typically based only on first costs plus, in some cases, a discounted value of lowered energy and water bills. This report seeks an approach that draws on the discipline of LCC practices to identify and clearly document the benefits and costs of the most important green building attributes, including some that are generally not explicitly considered in building investment decisions.

There are a number of international green building assessment programs that provide tools for evaluating building performance across a large range of green performance criteria.[60] European LCA work is extensive and some of it ties into the internationally accepted ISO quality certification process.[61] A popular Canadian core and shell assessment tool – Athena [62] – was recently used in designing the Clearview Elementary School in Pennsylvania[63] and the Battery Park City residential construction project in New York City.[64] BEES, a building materials selection tool developed by the U.S. Government's National Institute of Standards and Technology (NIST), is useful for specifying materials and can be used with Athena to create a whole building life cycle analysis.[65] Some of the most rigorous science-based LCA tools are not available in English – these include LEGOE from Germany, an LCA program that runs in the background with CAD software,[66] and EcoQuantum from Holland.[67]

Altogether, there are a dozen or more life cycle tools each with various strengths and limitations – Athena, for example, despite its strengths, is currently based only on Canadian data.[68]

---

[60] For an extensive international listing of green building evaluation and life-cycle related tools and programs with related URLs, go to: http://buildlca.rmit.edu.au/links.html.
[61] For European life cycle work see: http://www.ecotec.com/sharedopet/password/rhrsum13.htm.
[62] Athena Version 2.0 Environmental Impact Estimator. 2003. Available at: See http://www.athenasmi.ca/.
[63] Clearview Elementary School Athena Model Output, 7Group. Available at: http://www.sevengroup.com/pdf/Athena.PDF.
[64] The Athena Sustainable Materials Institute Members Newsletter. Volume 3, Number 1. June 2002. See: "Updates Green Building Challenge 2002." Available At: http://www.athenasmi.ca/news/down/Ath_vol_3_1.pdf.
[65] BEES 3.0 Software Download available at: http://www.bfrl.nist.gov/oae/software/bees.html.
[66] Available only in German at: http://www.legoe.de.
[67] Available only in Dutch from the Environmental Institute at the University of Amsterdam (IVAM). A demo of an older version is available in English at: http://www.ivambv.uva.nl/uk/index.htm.
[68] For a valuable recent review of life cycle tools, see: Gregory Norris and Peter Yost, "A Transparent, Interactive Software Environment for Communicating Life-Cycle Assessment Results," *Journal of Industrial Ecology*, 2002, Volume 5, Number 4. For a good overview of international life cycle development, see: "Evolution and Development of the Conceptual Framework and Methodology of Life-

This report does not use any of these specific tools. Rather, it follows the general life cycle approach in evaluating a broad spectrum of costs and benefits using the limited data available. There are many substantial information gaps preventing a full life cycle cost assessment of green buildings. To cite just two examples: data on the full cost of water is incomplete, and available data on emissions from energy use should (but generally does not) reflect the life cycle emissions from energy extraction, transportation, use and disposal, as well as from energy generation. The objective of this report is to aggregate the available data about green buildings, and to develop a reasonable net present value estimate of their future associated costs and benefits.

Use of Present Value (PV) and Net Present Value (NPV)

The overarching purpose of this report is to answer the following question: Does it make financial and economic sense to build a green building? Green buildings may cost more to build than conventional buildings, especially when incorporating more advanced technologies and higher levels of LEED, or sustainability. However, they also offer significant cost savings over time.

This report will seek to calculate the current value of green buildings and components on a present value (PV) or net present value (NPV) basis. PV is the present value of a future stream of financial benefits. NPV reflects a stream of current and future benefits and costs, and results in a value in today's dollars that represents the present value of an investment's future financial benefits minus any initial investment. If positive, the investment should be made (unless an even better investment exists), otherwise it should not.[69] This report assumes a suitable discount rate over an appropriate term to derive an informed rationale for making sustainable building funding decisions. Typically, financial benefits for individual elements are calculated on a present value basis and then combined in the conclusion with net costs to arrive at a net present value estimate.

Net present value can be calculated using Microsoft's standard Excel formula:

$$NPV = \sum_{i=1}^{n} \frac{values_i}{(1+rate)^i}$$

The formula requires the following:

- **Rate**: Interest Rate per time period (5% real)
- **Nper (n)**: The number of time periods (20 years)
- **Pmt (values):** The constant sized payment made each time period (annual financial benefit)

This provides a calculation of the value in today's dollars for the stream of 20 years of financial benefits discounted by the 5% real interest rate. It is possible to calculate the net present value of the entire investment - both initial green cost premium and the stream of future discounted financial benefits - by subtracting the former from the latter.

Cycle Assessment," *SETAC Press*, January 1998. Available as an addendum to *Life-Cycle Impact Assessment: The State-of-the-Art*. See: http://www.setac.org. Environmental Building News, Dec 2002, p 14, by Nadav Malin (BEES review), and Environmental Building News, Nov 2002, p 15, by Nadav Malin (ATHENA review).

[69] See: http://www.investorwords.com/cgi-bin/getword.cgi?3257.

Discount Rate

To arrive at present value and net present value estimates, projected future costs and benefits must be discounted to give a fair value in today's dollars. The discount rate used in this report is 5% real. This rate is stipulated for use by the California Energy Commission[70] and is somewhat higher than the rate at which the state of California borrows money through bond issuance.[71] It is also representative of discount rates used by other public sector entities.[72]

Term

California's Executive Order D-16-00, committing California to provide energy efficiency and environmental leadership in its building design and operation, stipulates that "a building's energy, water, and waste disposal costs are computed over a twenty-five year period, or for the life of the building."[73] Buildings typically operate for over 25 years. A recent report for the Packard Foundation shows building life increasing with increasing levels of greenness. According to the Packard study, a conventional building is expected to last 40 years, a LEED Silver level building for 60 years and Gold or Platinum level buildings even longer.[74] In buildings, different energy systems and technologies last for different lengths of time – some energy equipment is upgraded every 8 to 15 years while some building energy systems may last the life of a building. This analysis conservatively assumes that the benefits of more efficient/sustainable energy, water, and waste components in green buildings will last 20 years, or roughly the average between envelope and equipment expected life.

Inflation

This report assumes an inflation rate of 2% per year, in line with most conventional inflation projections.[75] Unless otherwise indicated, this report makes a conventional assumption that costs (including energy and labor) as well as benefits rise at the rate of inflation – and so present value calculations are made on the basis of a conservative real 5% discount rate absent any inflation effects. In reality, this is quite an oversimplification and a more detailed analysis might attempt to make more accurate but complicated predictions of future costs. In particular, energy costs are relatively volatile, although electricity prices are less volatile than primary fuels, especially gas.

---

[70] California Energy Commission. "Life Cycle Cost Methodology: 2005 California Building Energy Efficiency Standards." March 2002. Available at: http://www.energy.ca.gov/2005_standards/documents/2002-04-02_workshop/2002-03-20_LIFE_CYCLE.PDF.

[71] See for example: "Analysis of GARVEE Bonding Capacity, Attachment D: Detailed Assumptions for Sensitivity Analysis." California State Treasurer's Office. Prepared for California Department of Transportation. 2003. Available at: http://www.treasurer.ca.gov/Bonds/garvee.pdf.

[72] The Wall Street Journal lists discount rates daily, dependent upon credit rating. See Market Data and Resources. Available at: http://online.wsj.com/public/site_map?page=Site+Map.

[73] California Executive Order D-16-00, August 2000. Op. Cit.

[74] A conventional building design for the Packard Foundation envisages a building life of 40 years. A silver building is expected to last 60 years, gold rated building is designed to last 80 years, while a platinum or "living building" – an extremely sustainable design – is projected to last for 100 years. See *"Building For Sustainability Report: Six Scenarios for The David and Lucile Packard Foundation,"* Los Altos Project, October 2002. Available at: http://hpsarch.com/TitlePageSpecial/2002-Report.pdf.

[75] See, for example: http://oregonstate.edu/Dept/pol_sci/fac/sahr/cf166503.pdf and http://www.jsc.nasa.gov/bu2/inflateGDP.html.

LEED as a Basis

Although this report will look at the lessons offered from a range of green design programs, LEED is used as the common basis for comparison because it has become the dominant definition of green buildings in the United States. For example, in seeking to quantify a building's "greenness," it will be described by its LEED level or equivalent (e.g., LEED Silver, representing 33 to 38 points).

A Note about Data Sources

The last few years have seen the emergence of meta-studies that screen, select, and provide up-to-date and well-linked compilations of important data sets related to green building benefits. For example, the Carnegie Mellon BIDS program has screened over one thousand studies to come up with approximately 90 of the most rigorous studies on the productivity impacts from green and high performance building designs.[76] Similarly, the US Green Building Council keeps a regularly updated list of all the cities and municipalities that use LEED or some version of LEED. Some areas, notably water and waste, lack comprehensive on-line databases. A brief annotated review of sources is included as an appendix for these two sections (Appendix L).

In many cases there is no recent reliable California data. For example, there appears to be no California-specific study on the environmental benefits of waste reduction. Similarly, in the last decade there have been no publicly available, comprehensive studies on California that calculate the full benefits (such as avoided transmission and distribution costs) of reduced energy demand, e.g., from measures such as on-site generation and energy efficiency. These gaps are noted in the text and are reflected in recommendations at the end of the report for additional research.

[76]Carnegie Mellon University Department of Architecture. Building Investment Decision Support Tool. 2002. Available at: http://www.arc.cmu.edu/cbpd/.

III. The Cost of Building Green

The Problems of Determining Cost

There has been a widespread perception in the real-estate industry that building green is significantly more expensive than traditional methods of development. A half dozen California developers interviewed in 2001 estimated that green buildings cost 10% to 15% more than conventional buildings.[77] The Sustainable Building Task Force *Blueprint*[78] identifies several obstacles to sustainable buildings, including:

- Incomplete integration within and between projects.
- Lack of life cycle costing.
- Insufficient technical information.

The *Blueprint* notes that because of these barriers, "many sustainable building applications are prematurely labeled as 'unproven' or 'too costly.'" [79] *Consulting – Specifying Engineer* echoed this view in its October 2002 issue, indicating that: "the perception that green design is more expensive is pervasive among developers and will take time to overcome" and "inhibiting green design is the perception that 'green' costs more and does not have an economically attractive payback." [80]

There is a growing body of performance documentation and online resources related to green building. For example, a new online source developed through a partnership of the US Department of Energy, Environmental Building News, the US Green Building Council, Rocky Mountain Institute, and the AIA Committee on the Environment includes 42 green building case studies, 13 of which are located in California.[81] Despite these advances, there is still little published data about actual cost premiums for green buildings. This information gap is compounded by the fact that the USGBC does not require that cost information be included with submissions for LEED certification.

Many developers keep cost information proprietary. In addition, even if developers are willing to share their cost data, determining a precise "green premium" for a given project is often very difficult for several reasons:

- Developers typically only issue specifications and costs for the designed building, not for other green options. Individual green items are sometimes priced out in comparison to non-green ones, but this is not the norm and does not provide a basis for cost comparison between green and conventional whole building design.

---

[77] Berman, Adam. "Green Buildings: Sustainable Profits from Sustainable Development," unpublished report, *Tilden Consulting*. July 30, 2001. Available from the author: adam@isabellafreedman.org.
[78] California State and Consumer Services Agency and Sustainable Building Task Force, December 2001. Op. Cit.
[79] *Ibid*, p. VI.
[80] Scott Siddens, Senior Editor, "Verdant Horizon," *Consulting –Specifying Engineer*, October 2002, pp. 30-34. Available at: http://www.syska.com/Sustainable/news/index.asp.
[81] US Department of Energy, Office of Energy Efficiency and Renewable Energy. High Performance Buildings Database. Available at: http://www.eere.energy.gov/buildings/highperformance/case_studies.

- Some green buildings being built today are showcase projects that may include additional and sometimes costly “finish” upgrades that are unrelated to greenness but that nonetheless are counted toward the green building cost increase.
- The design and construction process for the first green building of a client or design/architectural firm is often characterized by significant learning curve costs, and design schedule problems such as late and costly change orders.
- The relative newness of green technologies and systems can make designers, architects and clients conservative when using them. They may oversize green building systems and not fully integrate them into the building, thereby reducing cost savings and other benefits. Similarly, cost estimators may add uncertainty factors for new green technologies they are not familiar with, and these can compound, further inflating cost estimates.

National Green Building Leaders

Although more members and registered projects are located in California than in any other state, Pennsylvania, Massachusetts, Washington and Oregon have the most extensive, documented experience with green building and LEED.[82] Therefore, despite the general deficiency of published data on the cost of building green, there is substantial recent evidence from these and other entities to indicate that building green is less expensive than many developers think. In particular, this data comes in part from two municipalities with extensive experience building LEED projects: Pennsylvania and Seattle, WA.

Pennsylvania
Over the past several years, the state of Pennsylvania has constructed five LEED registered projects (three will be completed in 2003). Pennsylvania’s green building experience now enables it to build LEED Silver buildings that cost virtually the same as traditional buildings.[83] The state's first LEED Gold level green building, a 40,000 square foot office building in Cambria, PA, was built at $90 per square foot, just under comparable market rates for conventional buildings (See Appendix C).[84] Much of Pennsylvania's success comes from the state's ability to negotiate better prices from green manufacturers. Most green materials used in this project cost the same or less than the traditional alternative, reinforcing the fact that green design has matured and broadened into the mainstream and is no longer a cutting edge trend.[85]

Seattle, WA
Seattle was the first municipality in the nation to adopt a LEED Silver requirement for larger (over 5000 ft^2 occupied space) construction projects. The city currently has 11 LEED registered projects.

---

[82] Pennsylvania, Oregon and Washington have more projects per capita, per Gross State Product, and per Construction Gross State Product than California or other states across the country. See Appendix B for a Graphical Representation.
[83] Governor's Green Government Council, State of Pennsylvania. See: “Building Green in Pennsylvania,” CD-ROM available at http://www.gggc.state.pa.us.
[84] Commonwealth of Pennsylvania Department of Environmental Protection, Cambria Office Building. 2001. Available at: http://www.gggc.state.pa.us/building/Cambria/2300DEPCambriaDOBldg.pdf.
[85] Governor’s Green Government Council, State of Pennsylvania. “Building Green in Pennsylvania: Making the Case.” Video available at: http://www.greenworks.tv/green_building/archives.htm.

Detailed cost data from these projects has not yet been released, but according to a draft report, LEED Silver certification should not add cost to a project provided the following: [86]

- LEED Silver is made a requirement in the Request for Qualification for the Design Team and embedded within the construction documents, building construction, and commissioning.
- The selected Design Team has sustainable design embedded within the firm's design culture.
- Contractors, Property Managers, Real Estate Analysts, Budget Analysts, Crew Chiefs and Custodians are included on the Design Team.
- Selected sustainable design strategies are "whole system" in nature and integrated design solutions are pursued that cannot be peeled off from the base project as "add alternates."

A Cost Analysis of 33 LEED Projects

Cost data was gathered on 33 individual LEED registered projects (25 office buildings and 8 school buildings) with actual or projected dates of completion between 1995 and 2004. These 33 projects were chosen because relatively solid cost data for both actual green design and conventional design was available for the same building.

Virtually no data has been collected on conventional buildings to determine what the building would cost as a green building. And, surprisingly, most green buildings do not have data on what the building would have cost as a conventional building. To be useful for this analysis, cost data must include both green building and conventional design costs for the same building. Typically this data is based on modeling and detailed cost estimates. (As indicated elsewhere, LEED does not currently require that cost data for both conventional and green design be submitted. This report recommends that the USGBC consider making this a prerequisite or offer part of a credit for providing this data).

Attempts to compare the cost of a specific green building – such as a school – with other buildings of similar size and function in a different locality provide little help in understanding the cost of green design. The added cost impact of designing green may be very small compared with other building costs such as the cost of land and infrastructure. Therefore, a meaningful assessment of the cost of building green requires a comparison of conventional and green designs for the same building only.

Consequently, there is very little solid data on the additional costs associated with green design. Information for this report was collected primarily through a broad literature review; from several dozen interviews with architects and other senior building personnel; written and verbal communications with California's Sustainable Building Task Force members, USGBC staff, attendees at the Austin green building conference, and members of the Green Building Valuation Advisory Group; through a query posted in the Environmental Building News; and from others.

[86] Lucia Athens and Gale Fulton, "Developing a Public Portfolio of LEED™ Projects: The City of Seattle Experience." Electronic copy received from authors on December 20, 2002. Available at: http://www.usgbc.org/expo2002/schedule/documents/DS509_Athens_P126.pdf.

A resulting table containing each project name, location, building type, date of completion, green premium and certification level or equivalent can be found in Appendix C. Note that many of these buildings have not yet been certified by the USGBC. In these cases, the LEED level indicated is an assessment by the architect and/or client team reflecting very detailed analysis and modeling – this is viewed as a relatively accurate prediction of final LEED certification level.

While the size of the data set is not large, analysis provides meaningful insights into the cost premium for green buildings. Figures III-1 and III-2 show that, on average, the premium for green buildings is about 2%. The eight rated Bronze level buildings had an average cost premium of less than 1%. Eighteen Silver-level buildings averaged a 2.1% cost premium. The six Gold buildings had an average premium of 1.8%, and the one Platinum building was at 6.5%. The average reported cost premium for all 33 buildings is somewhat less than 2%.[87]

Figure III-1. Level of Green Standard and Average Green Cost Premium

Level of Green Standard	Average Green Cost Premium
Level 1 – Certified	0.66%
Level 2 – Silver	2.11%
Level 3 – Gold	1.82%
Level 4 – Platinum	6.50%
Average of 33 Buildings	1.84%

Source: USGBC, Capital E Analysis

[87] See Appendix C for a complete list of the 33 projects, their LEED levels, and green premiums.

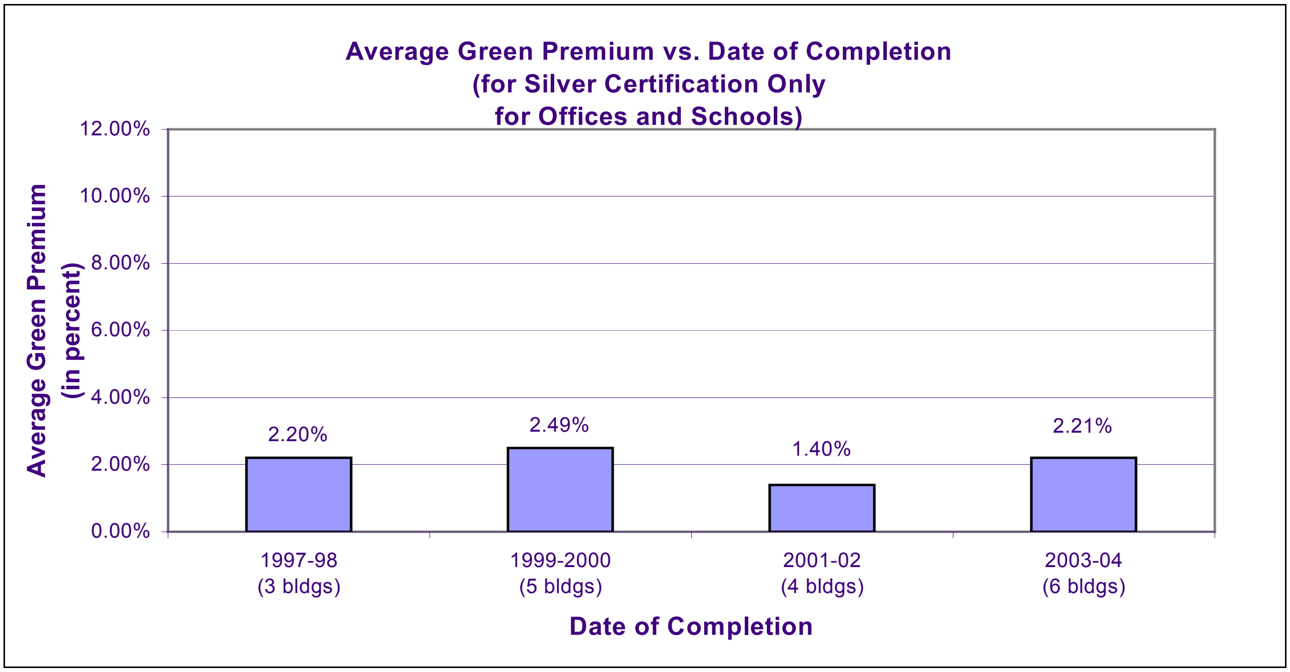
Figure III-2. Average Green Cost Premium vs. Level of Green Certification

Source: USGBC, Capital E Analysis

Figure III-3. Year of Completion and Average Green Cost Premiums for Buildings with Silver Certification

Year of Completion	Average Green Cost Premium
1997-1998	2.20%
1999-2000	2.49%
2001-2002	1.40%
2003-2004	2.21%
Avg. of 18 Silver buildings	2.11%

Figure III-4. Average Green Cost Premium vs. Date of Completion for Buildings with Silver Certification



Source: USGBC, Capital E Analysis

There is evidence that building green gets less expensive over time, with experience. However, an expected downward cost trend of the green cost premium is not clear in this data. The green premium is lowest for the most recently completed buildings (2001-02) and higher for buildings projected to be completed in 2003 and 2004. This data reflects two things. First, 2003-2004 buildings costs are projections and these tend to be slightly high (conservative). It can be expected that as these buildings are completed, the actual cost premium will, on average, be lower than projected in this data. Second and perhaps more importantly, the reported data includes both first time green buildings and buildings that may be the third or fourth green building by the same owner/designer builder team. Thus the data includes both relatively higher cost first timers and the efforts of experienced teams that generally achieve lower cost premiums.

The trend of declining costs associated with increased experience in green building construction has been experienced in Pennsylvania,[88] as well as in Portland and Seattle. Portland's three reported completed LEED Silver buildings (see Appendix C) were finished in 1995, 1997, and

[88] Data provided by John Boecker, L. Robert Kimball and Associates, A/E Firm for the Pennsylvania Department of the Environment Cambria Office Building, Ebensburg, PA, the PA Department of Environmental Protection Southeast Regional Office. Norristown, PA, and the Clearview Elementary School, York, PA.
See: http://www.lrkimball.com/Architecture%20and%20Engineering/ae_experience_green.htm.

2000. They incurred cost premiums of 2%, 1% and 0% respectively.[89] Seattle has seen the cost of LEED Silver buildings drop from 3-4% several years ago to 1-2% today.[90]

A second data anomaly is that reported cost levels for LEED Gold buildings are slightly lower than for Silver buildings, whereas the higher performance level requirements to achieve Gold would be expected to cost more than Silver levels. In part, this anomaly reflects the small data set – the Gold premium is an average across only six buildings. As additional green building data is assembled, costs are likely to more closely follow the rising cost levels associated with more rigorous levels of LEED. Nonetheless, the data indicates that it is possible to build Gold level buildings for little additional cost. The higher performance levels associated with Gold buildings (described below in Health and Productivity and other sections), combined with their potentially low cost premiums – as indicated in this small data set – suggest that, based on available data, LEED Gold may be the most cost effective design objective for green buildings.

Implications for California

The conclusions above indicate that while green buildings generally cost more than conventional buildings, the "green premium" is lower than is commonly perceived. As expected, the cost of green buildings generally rises as the level of greenness increases, while the premium to build green is coming down over time. Importantly, the cost of green buildings tends to decline with experience in design and development, as clients and their design and architecture teams move beyond their first green building. This trend suggests that California develop policies and procedures to favor the hiring of more experienced green building teams, and that this experience be embedded throughout the design team. Additionally, development of multiple green buildings within a particular California state agency or university can be expected to result in declining costs per building to that organization.

Assuming conservative, relatively high California commercial construction costs of $\$150/ft^2$ to $250/ft^2$,[91] a 2% green building premium is equivalent to $\$3\text{-}5/ft^2$. Use of lower construction costs in these calculations would tend to increase the reported cost effectiveness of green construction.

The rest of this report will attempt to quantify the size of financial benefits as compared with the costs of building green buildings.

---

[89] Data provided by Heinz Rudolf, BOORA Architects. See Portfolio/Schools at: http://www.boora.com/

[90] Lucia Athens, Seattle Green Building Program, Nov. 2002. See: http://www.cityofseattle.net/light/conserve/sustainability/.
The city is expected to soon release a review of over a dozen green Seattle buildings and specific costs premiums for these buildings.

[91] This is a reasonable, somewhat high (e.g. conservative) estimate as confirmed by Oppenheim Lewis Inc. and Anthony Bernheim, Principal, SMWM. Includes hard and soft costs (including design fees) associated with construction, but not land acquisition.

IV. Energy Use

Energy is a substantial and widely recognized cost of building operations that can be reduced through energy efficiency and related measures that are part of green building design. Therefore, the value of lower energy bills in green buildings can be significant. The average annual cost of energy in state buildings is approximately $1.47/ft^2.[92] On average, green buildings use 30% less energy than conventional buildings[93] – a reduction, for a 100,000 ft^2 state office building, worth $44,000 per year, with the 20-year present value of expected energy savings worth over half a million dollars.[94]

A detailed review of 60 LEED rated buildings, including 5 LEED rated buildings in California, clearly demonstrates that green buildings, when compared to conventional buildings, are:

- On average 25-30% more energy efficient (compared with ASHRAE 90.1-1999 and, for California buildings, Title 24 baselines);[95]
- Characterized by even lower electricity peak consumption;
- More likely to generate renewable energy on-site; and
- More likely to purchase grid power generated from renewable energy sources (green power and/or tradable renewable certificates.

Although the environmental and health costs associated with air pollution caused by non-renewable electric power generation and on-site fossil fuel use are generally externalized (not considered) when making investment decisions, the energy reductions realized through the design and construction of green buildings reduce pollution and lower the environmental impact of conventional power generation.[96] This report seeks to quantify some of the benefits, including the value of peak power reduction (in this section) and the value of emissions reductions (in Section V) associated with the energy strategies integrated into green building design.

---

[92] Over 95% of primary energy use in California state buildings is electricity, with the balance natural gas. Data provided by California Department of General Services, Real Estate Services Division, Building Property Management Brach. "Energy Cost Estimates," December 2002. See also *Appendix I*. 2002 energy costs were estimated at $1.60/ft^2/yr, but average California electricity rates are conservatively projected to drop from $0.12/kWh to $0.11/kWh. Energy use and cost data come directly from utility bills.

[93] Note: As a result of the energy crisis in California and various Flex-Your-Power energy efficiency campaigns, the State has already reduced electricity use in most buildings by close to 20%. Absolute energy savings typical of green buildings will be lower for energy efficient state buildings, which have already realized much of the benefit associated with energy efficiency. However the percentage reduction in energy use in these buildings is comparable to less efficient buildings – see subsequent data and discussion.

[94] Using 5% real discount rate over 20 year term, as discussed above. While both improved energy efficiency and on site generation result in lower energy bills, the reduced energy costs only capture a portion of the benefits accrued to the state. See for example: CEC Environmental Performance Report, http://www.energy.ca.gov/reports/2001-11-20_700-01-001.PDF.

[95] Based on analysis of Energy and Atmosphere Credit 1 – Energy Optimization points awarded to all LEED-NC v2 Certified projects.

[96] See: Lovins et al., "Small is Profitable," RMI, 2002. Available at: http://www.rmi.org.

Data on green buildings is somewhat limited because of the relative youth of a quantifiable definition of 'green' (this report uses the U.S. Green Building Council's LEED Green Building Rating System), a limited data set (60 LEED rated Buildings), incomplete reporting and/or insufficient reporting requirements (of the 60 LEED rated buildings, 19 were Certified under the LEED v1.0 Pilot which had different reporting requirements), and client preference for non-disclosure of data. All these limitations are evident in the small data set of five LEED rated buildings in California, including:

- Toyota Motor Sales South Campus Office Development, Torrance – LEED v2.0 Gold, 630,000 ft^2, completed in 2002.
- Ford Motor Company Premier Automotive Group North American HQ, Irvine – LEED v2.0 Certified, 253,000 ft^2, completed in 2001.
- William and Flora Hewlett Foundation Headquarters, Menlo Park - LEED v2.0 Gold, 48,000 ft^2, completed in 2002.
- Capital Area East End Complex 225, Sacramento – LEED v2.0 Gold, 479,000 ft^2, completed in 2003.
- UCSB Donald Bren School of Environmental Science and Management, Santa Barbara – LEED v1.0 Platinum, 90,000 ft^2, completed in 2000.

Data on energy use in these buildings was obtained directly from the USGBC,[97] and included a detailed review of the Energy Cost Budget documents required for award of LEED energy performance. Because some project teams have requested that their project data be kept confidential the data is presented in a format that ensures that the performance characteristics of specific buildings are masked. These California LEED rated buildings on average demonstrate energy efficiency commensurate with the 25-30% national average reduction for green buildings.[98] Energy efficiency (relative to a California Title 24 baseline) improvements for the five buildings (in order of lowest to highest) are 22%, 30%, 30%, 35%, 40%.

The Price of Energy

Calculating the current financial value of lower future energy consumption requires estimating future energy costs, and this is complicated by the rapidly changing tariff structures of California's utilities. California electricity rates have climbed steeply over the past several years, in large part due to surcharges mandated by the CPUC in response to the recent electricity crisis. As indicated in Figure IV-1, peak electricity prices are as high as $0.34 per kWh for buildings (including most state buildings) that are on time-of-use rates. At this time, it is not clear what future electricity prices will be.[99]

---

[97] Data provided by the US Green Building Council, December 2002 (Brendan Owens, LEED Engineer).

[98] Because the energy performance baseline in California is Title 24, which is more rigorous than the prevailing national ASHRAE standard, it might be expected that energy reduction in California green buildings would be less than for LEED buildings nationally. This does not appear to be the case. Several reasons for this may include relatively high California energy prices (and recent price increases) that would tend to increase incentives for aggressive energy reduction measures, and the existence of California standards in areas other than energy – such as recycling and indoor environmental quality - that provide a higher baseline for non-energy performance for California sustainable buildings, and that may make energy improvements below the Title 24 baseline not more costly *relative* to other dimensions of green design.

[99] McAuliffe, Pat. California Energy Commission, Office of Commissioner Art Rosenfeld, December 2002.

The majority of California state buildings are on tariffs with time-of-use rates. These include relatively high electricity prices during periods of peak grid-wide electricity use, in an attempt to reduce peak consumption. The Pacific Gas & Electric (PG&E) commercial tariff, in Figure IV-1 below, is typical of these time-of-use commercial rates.

Figure IV-1. PG&E A-6 Time of Use Rate Schedule (simplified)

Customer Charge	**Season**	**Time-of-Use Period**	**Energy Charge** (per kWh)	**1/4/01 Energy Surcharge** (per kWh)	**6/1/01 Energy Surcharge** (per kWh)	**Total Energy Charge** (per kWh)	**"Average" Total Rate** (per kWh)
Single phase service per meter/day =$0.26612; Polyphase service per meter/day =$0.39425. Plus Meter charge =$0.22341 per day for A6 or A6X; =$0.06571 per day for A6W	**Summer**	On peak	$0.23258	$0.01000	$0.10064	**$0.34322**	$0.14487
		Part Peak	$0.10288	$0.01000	$0.04551	**$0.15839**	
		Off Peak	$0.05618	$0.01000	$0.03551	**$0.10169**	
	Winter	Part Peak	$0.11562	$0.01000	$0.04551	**$0.17113**	
		Off Peak	$0.07169	$0.01000	$0.03551	**$0.11720**	

Source: http://www.pge.com/tariffs/CommercialCurrent.xls

PG&E's average commercial rate is currently about $0.15 per kWh.[100] San Diego Gas & Electric (SDG&E)[101] and Southern California Edison (SCE)[102] have similar rates. Other utilities, such as Sacramento Municipal Utility District (SMUD) have slightly lower average commercial rates. The current average cost of electricity for state buildings is about $0.12/kWh, reflecting a concentration of state buildings in lower tariff utility districts, such as SMUD.[103] This rate is likely to drop by the end of 2003 as a substantial temporary surcharge (intended to help California utilities regain solvency) is dropped. However, there may be an additional bond surcharge of about $0.005/kWh imposed in 2003. In addition, the CPUC may implement a $0.50+/kWh "super peak" surcharge on the peak hours of 15 of the hottest (and highest peak electricity use) days in the year.[104] The CEC believes that at end of 2003 rates may drop to about $0.11/kWh,

[100] For PG&E rates, see: http://www.pge.com/tariffs/CommercialCurrent.xls and http://www.pge.com/tariffs/GNR2_Current.xls.
[101] For SDG&E rates see: http://www.sdge.com/tariff/elec_commercial.shtml, and http://www.sdge.com/tm2/pdf/GN-3.pdf.
[102] For SCE Rates, see: http://www.sce.com/NR/sc3/tm2/pdf/ce87-12.pdf and http://www.sce.com/sc3/005_regul_info/005a_tariff_book/005a3_rates/005a3b_biz_rates.htm.
[103] Data provided by the California Energy Commission, Office of the Supervisor of Rates, December 2002. See also: Electricity in California. California Energy Commission. Available at: http://www.energy.ca.gov/electricity/index.html#rates.
[104] California Energy Commission. Office of Energy Commissioner Art Rosenfeld. November 2002.

and that this is a good, conservative estimate for future average commercial electricity prices (Note: Higher electricity rates would increase the benefits of green buildings).[105]

This report therefore assumes a real average commercial electricity price for 2003 and beyond of $0.11/kWh. This rate is used for calculations involving schools as well, even though schools are more evenly distributed through higher tariff utility districts (benefits accruing to green schools may therefore be understated in this analysis). Projected future electricity savings are discounted at the 5% (real) rate. However, calculating the full benefits of lower energy costs from green buildings is more complex than this because green buildings tend to use disproportionately less energy during peak times, when electricity is more valuable and expensive.

Cutting Peak Power

The unique integrated design and construction process that green buildings typically follow considers the building holistically. Interactions between competing building systems (lighting vs. cooling, fresh air vs. humidity control, etc.) are therefore analyzed simultaneously, allowing the building designers to reduce peak power demand by downsizing building systems, particularly air conditioning and lighting loads, while providing a comfortable indoor environment. For most of California (except the generally foggy northern coast) and much of the US (especially in the South and Midwest) air conditioning is the dominant energy user during peak load. The largest and third largest electricity demands, respectively, in California during a typical 50,000 MW peak load period are commercial air conditioning – representing 15% of peak load, and commercial lighting – representing 11% of peak load.[106] By encouraging integrated design and awarding credit for optimization of building energy systems, LEED provides strong incentives to cut both of these peak demand uses.

LEED encourages:

- *Integrated design*: Project teams consider building systems in total to optimize competing demands.
- *High Performance Lighting*: Incorporation of more efficient lights, task lighting, use of sensors to cut unnecessary lighting, use of daylight harvesting and other advanced lighting techniques and technologies. These measures can significantly reduce power demand from electric lights. In hot weather, this reduction has the added advantage of reducing cooling loads in a building, which in-turn reduces required air conditioning.
- *Increased Ventilation Effectiveness*: Helps cut air conditioning load during peak through improved system optimization.
- *Underfloor Air Distribution Systems*: Use of a plenum below a raised floor to deliver space conditioning. Typically cuts fan and cooling loads, substantially lowering air conditioning load (see "Underfloor Air" in Section IX).

---

[105] Data provided by the California Energy Commission, Office of the Supervisor of Rates, December 2002. See also: California Energy Commission. "2002-2012 Electricity Outlook Report." February 2002. Available at: http://www.energy.ca.gov/reports/2002-02-14_700-01-004F.PDF.

[106] John Wilson, Art Rosenfeld and Mike Jaske, "Using Demand Responsive Loads to Meet California's Reliability Needs," paper presented at 2002 ACEEE summer conference. Available from: jwilson@energy.state.ca.us. Note: the number two user of electricity in California is residential air conditioning.

- *Commissioning*: A systematic process to ensure that building systems are designed, installed and operating as planned. Incorporation of commissioning tends to increase building system performance and cut energy use, helping to ensure that design objectives and performance targets are met and that energy savings persist (see "Commissioning" in Section IX).
- *Heat Island Reduction Measures*: By increasing the reflectivity of roofs and other typically dark surfaces, it is possible to lower building and urban temperatures, in turn reducing air conditioning loads and peak demand (see "Cool Roofs" in Section IX).
- *On-site Generation*: Two of the eight LEED Gold level buildings reviewed use photovoltaics (PV) to generate 20% of their power on site. PV is coincident with peak power usage, and so contributes to peak demand reduction.

Although peak demand reduction data is not provided or is incomplete for some buildings (LEED certification requirements do not currently require peak reduction information), California LEED rated buildings, like non-California buildings, generally show larger reductions in peak demand than in overall energy use. For the three California LEED rated buildings for which peak reduction data was submitted, electricity for space cooling and lighting (of conditioned space) varied widely but indicated an average electricity peak demand reduction of 17%. This average includes a shift from electricity to natural gas for most space cooling in one of the buildings. The fuel switch from electricity to natural gas artificially inflates the electricity peak demand reduction in this building. A fourth California LEED building, for which incomplete data was submitted, indicates a 13% reduction in total building energy use by implementing natural ventilation strategies rather than relying solely on mechanical HVAC.

The very limited California data set indicates that peak demand reduction in California green buildings is significant and consistent with a preliminary estimate of 10% peak demand reduction below average energy reduction in green buildings. The correlation between peak demand reduction in green buildings evident in the limited data set warrants further research. Preliminary discussions, between report authors and the USGBC, are underway to modify LEED credit requirements to require peak demand reduction data in LEED documentation.

It is important to emphasize that there is not yet sufficient data to exactly predict peak demand reduction from green buildings. Uncertainties result from a limited data set, inconsistencies in documentation, incomplete documentation, technical issues such as fuel switching, and the large variability between building designs. Nonetheless the available green building data is significant and collectively indicates that green buildings - including green buildings in California - on average provide peak demand reduction that is significantly larger than average energy reduction.

LEED places a high priority on building energy performance. Energy efficiency (including building commissioning, renewable energy and green power) is the single largest LEED credit category and represents 27% of the total points available in the LEED Green Building Rating System. LEED rated buildings, on average, use 30% less energy than those that meet the standard energy requirements of Title 24 (for California buildings) or ASHRAE 90.1 (in the rest of the country). Additional confirmation comes from analysis of USGBC data for 21 LEED rated buildings (including 6 buildings in California) - 8 Certified buildings, 5 Silver buildings and 8 Gold buildings. Both analyses (looking at a partially overlapping set of buildings) indicate that Gold buildings are generally the most energy efficient and Certified buildings the least efficient.[107] On a weighted average basis, green buildings are 28% more efficient than conventional buildings and generate 2% of their power on-site from photovoltaics (the large

[107] This building data is from USGBC from buildings that have completed the LEED certification process.

majority of green buildings do not have on-site generation and the 2% on site generation average reflects significant on-site generation from a few green buildings).

Figure IV-2. Reduced Energy Use in Green Buildings as Compared with Conventional Buildings

	Certified	Silver	Gold	Average
Energy Efficiency (above standard code)	18%	30%	37%	28%
On-Site Renewable Energy	0%	0%	4%	2%
Green Power	10%	0%	7%	6%
Total	**28%**	**30%**	**48%**	**36%**

S*ource: USGBC, Capital E Analysis*

As discussed above, green buildings use an average of 30% less purchased energy than conventional buildings. In addition, green buildings are more likely to purchase "green power" for electricity generated from renewable energy sources. Green power purchases can take two forms:

- Customers can purchase green power directly from their utility or from a local green power provider. In this case customers are paying for electricity generated from renewable energy sources, typically by a local provider in the state or utility jurisdiction. About 40% of US electricity customers have this option.
- Customers can purchase green certificates, or green tags. In purchasing green certificates, a customer is buying ownership of the reduced emissions (and by implication the environmental and health benefits) associated with renewable power, even though the green generating facility is frequently not in the customer's vicinity. All electricity consumers have this option.

For 21 green buildings on which USGBC has collected data, 6% of the electricity purchased was green.[108] Two factors need to be considered in determining the net impact that green power purchases by green buildings have on emissions (discussed in Section V). First, a small and growing portion – slightly less than 1/2% of the general population – already buys green power.[109] This suggests that adoption of LEED provides a 5.5% net increase in green power purchases compared with conventional buildings. Secondly, LEED recently modified its green power purchase requirement to allow purchase of green certificates. With this change, 100% of LEED buildings now have the ability to get LEED credit for buying green power, providing virtually universal availability. This is in contrast to direct green power purchases, which are currently available in areas containing only 40% of the population. This broadening of the green power credit will therefore significantly increase the portion of LEED buildings that buy green power (an issue that should be explored in more detail).

[108] Data provided by the USGBC. Capital E analysis with USGBC, November and December 2002.
[109] Jan Hamrin. Center for Resource Solutions, communication January 12, 2003. This number includes business as well as residential consumers.

Because all buildings are now able to buy green power, in the form of certificates, this report assumes that the portion of green power purchased by LEED green buildings will rise from 6% to 9% - an increase proportionally less than the doubling in buildings that can buy green power and receive LEED credit for it. A conservative estimate is that the future difference between average green building green power purchase and total average building green power purchase will rise from 5.5% (cited above) to 8.5%. Note that this is equal to 6% of total electricity use in an average non-green building.

This report therefore assumes that an average green building in the near future will purchase 9% of its electricity from green sources, or about 8.5% more than an average conventional building. Since a green building uses only 70% of the electricity that a conventional building does, the emissions reduction value of green power purchases by a green building is effectively reduced to about 6%.

As indicated in figure IV-2, above, average green building use of conventional energy (and the resulting associated emissions) is therefore on average about 36% lower than conventional buildings.

Evaluation of LEED certification documentation for over a dozen buildings,[110] including four California buildings, indicates an approximate average reduction in energy use of 30%, but an average peak reduction of about 40%.[111] While the data set is limited, it nonetheless indicates that green buildings reduce peak demand to a greater degree than total energy consumption: green buildings have proportionately larger reductions in peak demand.

Energy Star, administered by the US EPA and DOE, is the best known national energy performance rating program. It recognizes buildings for superior energy performance – defined as the 25% most energy efficient portion of the market – based on actual energy usage. Unfortunately, like LEED, the Energy Star program does not evaluate peak demand reduction.[112] Both USGBC/LEED and EPA/Energy Star should gather and publish data on the peak demand reduction of, respectively, green and energy efficient buildings.

Value of Peak Power

Utility transmission and distribution (T&D) systems generally run at less than 50% capacity.[113] However, during periods of peak electricity use, the generation and T&D systems may be close to overloaded. The benefits of reduced consumption are largest during periods of peak power consumption – avoided congestion costs, reduced power quality and reliability problems, reduced pollution, and additional capital investment to expand generation and T&D infrastructure. The value of peak reduction is not just in avoided purchase of electricity, but also in avoided capacity

[110] Data provided by the USGBC, analysis by Capital E with USGBC. November and December, 2002
[111] Because USGBC does not require that peak load reduction data be submitted, the data quality is mixed and includes some buildings that specify peak load demand reduction and some building data that indicates this indirectly (e.g., through large reductions in air conditioning load). Additional building information reviewed provided no useful data on peak demand reductions.
[112] US EPA. Energy Star Technical Description for the Office Model. 2001.
Available at: http://www.energystar.gov/ia/business/evaluate_performance/technicaldescription.pdf.
[113] Electricity generation and distribution assets are less than half utilized most of the time. See: Amory Lovins et al, "Small is Profitable," RMI, 2002. http://www.smallisprofitable.org/.

and T&D costs.[114] Thus, energy benefits of green buildings need to be quantified not solely based on reduced energy use but also on reduced peak electricity demand.

Approaches for determining the value of peak demand reduction include: 1) marginal cost as imposed in time-of-use rates, and 2) the actual marginal cost of peak power – the cost of building peaking power plants, T&D required to deliver additional power, and related costs such as congestion costs.

An alternative, more elegant approach to calculating the full value of energy reduction in green buildings (including reduced peak demand reduction) would be to match energy reduction by time of use to the value of incentives being developed to reduce marginal load through demand reduction for three periods – baseload, shoulder periods and peak periods (up to 1000 hours per year). The California Energy Commission report, "Discussion of Proposed Energy Savings Goals for the Energy Efficiency Programs in California" evaluates the potential to achieve substantial energy efficiency savings by providing per kWh financial incentives for these three periods of $0.058/kWh, $0.10/kWh, and $0.167/kWh, respectively. [115] This spread between peak and average prices is used to estimate peak value below. Green building documentation does not provide energy use modeling data that would be required to precisely match green building energy use profiles to these marginal efficiency cost targets.

It appears that there is no recent, comprehensive, and publicly available analysis of the value of peak reduction in decreasing T&D, congestion, and related costs.[116] The most recent robust data, consisting of eleven utility studies, including four in California, is eight to ten years old. Summarized in Appendix D, these studies calculate the value to the grid of reduced peak demand due to on-site electricity generation.[117] On-site generation and on-site energy efficiency are functionally equivalent since both avoid the cost of additional central power generation, distribution facility capacity, and T&D.

These utility studies indicate an average T&D-related peak reduction value of $600 per kW (see Appendix D for calculations). To be very conservative, this report will reduce this value by 50%, providing an estimated value of T&D related benefits of $300/kW. This is almost certainly quite low and warrants further research. Gas peaking plants in California now have a capital cost of

---

[114] McAuliffe, Pat. California Energy Commission. October 2002. See also: Amory Lovins et al, "Small is Profitable," RMI, 2002. http://www.smallisprofitable.org/.

[115] Mike Messenger, "Discussion of Proposed Energy Savings Goals for Energy Efficiency Programs in California," *CEC Staff Paper*, September 2003. See: http://www.energy.ca.gov/reports/2003-09-24_400-03-022D.PDF

[116] Based on research and a range of interviews with experts at the CEC, PUC, utilities and elsewhere.

[117] As indicated, this data has limitations, which may both exaggerate and undervalue estimates. For example:

1) Only 4 out of 11 studies are from California, and these indicate an average T&D benefit of $510 per kW, lower than the average of $605.
2) The data is 8 to 10 years old. Benefits and costs are likely to have changed somewhat – for example, NIMBY (Not In My Back Yard) concerns and the resulting need to run a larger portion of additional transmission capacity underground have generally increased grid congestion and line expansion costs, indicating that current numbers would probably be higher than those calculated here.
3) Other benefits – described in great detail in the new publication, "Small is Profitable, the Hidden Cost Economic Benefits of Making Resources the Right Size" (RMI, 2002) – were not included in these studies and would tend to increase the value of T&D and related benefits.

On balance these issues would tend to make a comprehensive valuation of T&D and related benefits higher today than these studies indicate.

approximately \$600/kW.[118] Combining the current cost of new marginal generating facilities with \$300 T&D costs results in an estimated total value of \$900/kW for reduced peak demand.

Because of increasing congestion and more cumbersome construction restrictions, T&D and related costs are probably more expensive today than when these studies were done. For example, San Diego Gas & Electric has been planning to build a 31 mile, 500,000 volt transmission line in south Riverside County at an expected cost of \$300 million, or nearly \$10 million per mile –higher than historical costs for large transmission line extensions. However, a PUC administrative law judge recently ruled that the line is not cost-justified over the next five years based on projected electricity demand growth.[119] The explicit recognition of the link between projected electricity demand growth and approval of costly new power lines highlights the potential value of green buildings in reducing or even eliminating the large capital costs of line expansion.

Calculation

As discussed above, green buildings provide an average 30% reduction in energy use, as compared with minimum energy code requirements. For energy costs of \$1.47/ft^2/yr, this indicates savings of about \$0.44/ft^2/yr,[120] with a 20-year present value of \$5.48/ft^2. Energy savings alone exceed the average additional cost of green over conventional construction.

In addition, green buildings provide reduction in peak demand. An important area of research is to develop data needed to better calculate average peak demand reduction. Similarly, USGBC should consider requiring or encouraging that this data be provided in LEED certification documentation. USGBC does not currently require peak capacity analysis to be provided in LEED certification submissions, but output data from several commercially available energy models does provide this information. This report does not calculate savings based on peak capacity reduction. Instead, this report develops a peak reduction value based on data provided on peak energy demand reduction. As discussed above, the limited available data set of green building peak demand reduction for both California and non-California LEED rated buildings indicates a peak demand reduction of 10%.

The value of peak demand reduction can be approximated in several ways, including:

1) Based on California state building experience, a 10% reduction in peak demand for one million square feet of state prisons, hospitals or office buildings amounts to 200 kW, or about \$24,000 per year. On a per ft^2 basis this rule of thumb[121] works out to about \$0.024/ ft^2 per year.[122]

---

[118] California Energy Commission. "Comparative Cost of California Central Station Electricity Generation Technologies." *Final Staff Report*. June 2003. Available at: http://www.energy.ca.gov/reports/2003-06-06_100-03-001F.PDF, esp. Appendix C.

[119] "SDG&E's Plan for Power Line Dealt Blow," *Energy Info Source, California Energy Report* 10/21/02-11/03/02. Available at: http://www.energyinfosource.com/.

[120] 30% of \$1.47/ft^2/yr total energy costs at 5% discount rate over 20 year term – see Appendix I.

[121] Data provided by the California Department of General Services, November 2002.

[122] Data provided by the California Department of General Services, December 2002.

2) On the basis of an average energy use of 10 kWh/ft^2 per year in state buildings and an average spread in cost between average and peak demand price indicated in recent California Energy Commission estimates for incentives required to reduce marginal load (described above) of \$0.067/kWh, it is possible to estimate annual savings from lowered peak power consumption. Assuming peak demand is 8% of all hours, it is estimated, conservatively, that an 0.8 kWh shift from peak power, is worth \$0.04 per ft^2 per year.

The two estimates – \$0.024/ft^2/yr and \$0.04/ft^2/yr – represent a substantial spread, and indicate the need for better data gathering and more detailed modeling.[123] Adopting a conservative estimated annual savings of \$0.025/ft^2 results in the 20-year present value of the peak demand reduction attribute of green buildings at \$0.31/ft^2 (\$0.025/year, at 5% real discount rate over 20 years). It is important to emphasize that these are preliminary approximations based on limited data and that more rigorous and thorough modeling should be conducted as a larger data set develops. Despite these limitations, the conclusion indicates that green building energy reduction values include both lowered energy costs and some value of peak demand reduction. The value of peak demand and peak capacity reduction may be higher than estimated here.

Conclusion

Green building energy savings primarily come from reduced electricity purchases, and secondarily from reduced peak energy demand. The financial benefits of 30% reduced consumption at an electricity price of \$0.11/kWh are about \$0.44/ft^2/yr, with a 20-year present value of \$5.48/ft^2. The additional value of peak demand reduction from green buildings is estimated at \$0.025/ft^2/yr, with 20-year present value of \$0.31/ft^2. Together, the total 20-year present value of financial energy benefits from a typical green building is \$5.79/ft^2. Thus, on the basis of energy savings alone, investing in green buildings appears to be cost-effective.

Comment on Green Buildings and Demand Responsive Pricing

California's shift to dynamic electricity pricing and demand responsive buildings indicates an important future role for green buildings in helping to reduce energy and environmental costs. Several utilities across the country, including Georgia Power Company and Gulf Power have successfully provided financial incentives to customers to cut power consumption as a way to reduce and flatten load and avoid or delay the cost of building and/or operating additional generating capacity. However, California has become the national leader, and is developing dynamic pricing policies and programs to cut costs, increase system efficiency, and create a more intelligent and efficiently used electricity grid.[124]

California is helping residents and businesses install metering and control systems to support increased response to price signals to cut power usage through such measures as load shifting, moving air conditioning to before peak periods, and demand reduction measures such as lowering lighting levels. These measures, now proven ways to cut energy costs by rewarding price

[123] Modeling by Gregg Morris of Future Resources Associates based on A-6 Schedule (Figure IV-1) indicates a range of \$0.026 -\$0.039/ft2/year, indicating that the \$0.025/ft/year estimate is conservative (this analysis is available upon request, gmorris@emf.net).
[124] See: Arthur Rosenfeld, Michael Jaske and Severin Borenstein, "Dynamic Pricing, Advanced Metering and Demand Response in Electricity Markets", Hewlett Foundation Energy Series, October 2002. See: http://ef.org/energyseries_dynamic.cfm

responsive customer load management, are being expanded to increase customer, utility, and state benefits. Green buildings are ideal candidates for demand responsive load management because they already typically include relatively advanced metering and energy management systems. If, as seems likely, green building continues to grow very rapidly, these buildings should comprise an important part of California's strategy to expand demand responsive load management. In addition, the USGBC should consider adopting policies that encourage green buildings to include metering and energy management systems. These systems allow buildings to more readily participate in and secure the financial benefits of demand responsive power pricing and grid management.

V. Emissions from Energy

Energy use in California state buildings is over 95% electricity (See Appendix I). The generation of electricity, particularly from fossil fuels, creates a number of harmful emissions. As indicated in Figure IV-2 (Section IV, above), average green building use of conventional energy (and the resulting associated emissions) is on average about 36% lower than conventional buildings. Adding emissions reductions from green power purchases to overall electricity consumption reduction provides a total emissions reduction of 36% compared to conventional buildings.

Value of Pollution Associated with Energy

Energy use in California state buildings and schools is predominantly electricity. Reduction in electricity use means lower emissions of pollutants (due to avoided burning of fossil fuels to generate electricity) that are damaging to human health, to the environment and to property.[125]

Air pollutants that result from the burning of fossil fuels include:

- Oxides of Nitrogen (NOx) – a principal cause of smog.
- Particulates (including PM10) – a principal cause of respiratory illness (with associated health costs) and an important contributor to smog.
- Sulfur Dioxide (SO2 or SOx) – a principal cause of acid rain. (SOx and SO2 are functionally the same for the purposes of this report.)
- Carbon Dioxide (CO2) – the principal greenhouse gas and the principal product of combustion.

Additional fossil fuel related pollutants include reactive organic compounds (ROC) and carbon monoxide (CO). These pollutants are not evaluated here because California power plant emissions represent 0.24% and 0.33%, respectively, of the statewide emissions totals and their values in other building aspects are small.[126] Volatile Organic Compounds (VOCs) may have significant value but are not calculated in this report. A more comprehensive analysis should evaluate the costs of a fuller set of these additional pollutants, including mercury.

There are at least three ways of valuing the costs of air pollution associated with burning fossil fuels:

1) The direct costs of pollution effects on property, health and environment can be calculated and then allocated on a weighted or a site-specific basis.
2) The cost of avoiding or reducing these pollutants can be used as a way to determine market value of pollutants.
3) The market value of pollutants can be used if there is an established trading market.

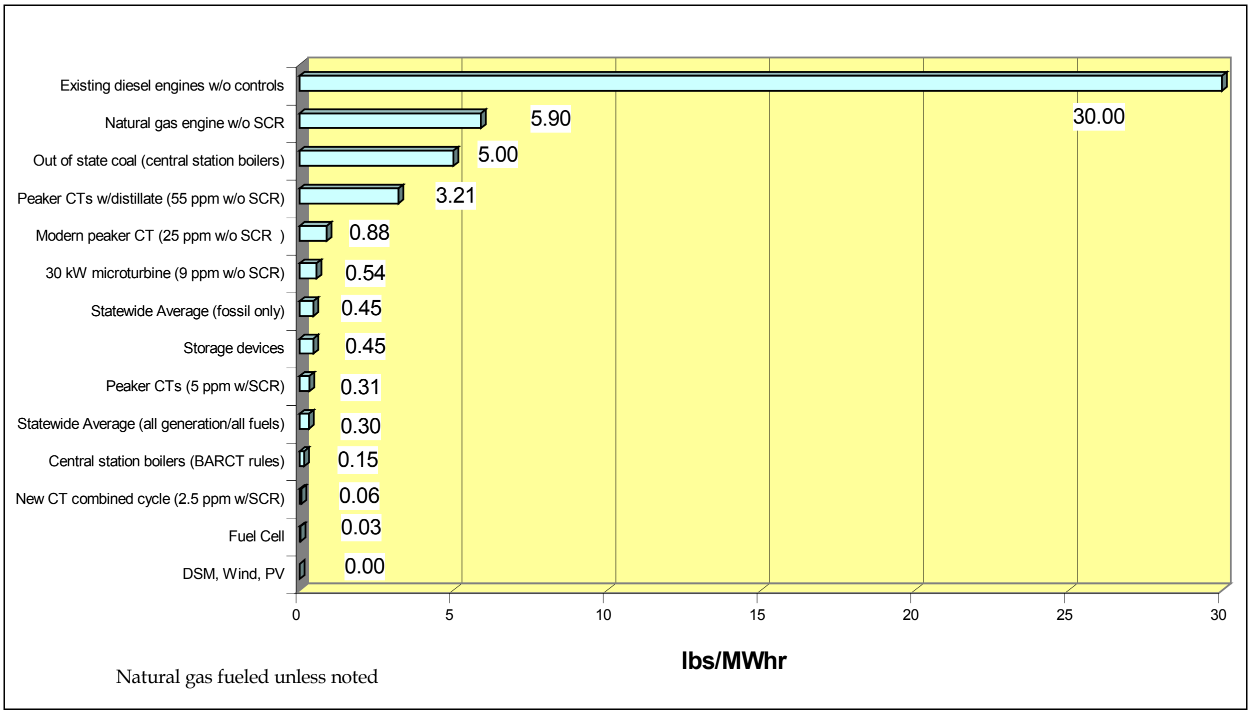
[125] Other forms of power, such as nuclear and hydro, also have environmental costs, though it is not within the scope of this report to evaluate these issues. Note that emissions intensity can vary by time of day, by season and other factors such as peak vs. baseload power (an issue that is addressed elsewhere in this report), although emissions impact is roughly proportional to energy use.
[126] California Energy Commission, "Environmental Performance Report of California's Electric Generation Facilities," July 2001. Available at: http://www.energy.ca.gov/reports/2001-06-28_700-01-001.html.

Each of these approaches has limitations and no one is universally "correct."

Emissions from Energy Use

The emissions reduction from decreased energy use depends on when reduction occurs and what energy source is displaced. Some of the most harmful emissions include NOx, SOx, particulates, and CO2. As indicated in Figure V-1 below, emissions vary vastly from back-up dirty diesel generators (of which the state has 3500 MW[127]) that produce 30 lb of NOx/MWhr,[128] down to zero emissions from renewable energy.[129]

Figure V-1. Generation Technologies Comparative NOx Emissions (lb/MWhr)



Source: "Performance Report of California's Electric Generation Facilities," CEC, July 2001.

Figure V-1 demonstrates that different sources of power are responsible for very different levels of pollution, and consequently different levels of associated health, environmental and property related costs. Benefits derived from the reduction in emissions from green buildings depend in part upon when reductions occur and what type of power (clean or dirty) is displaced. Emissions can vary substantially between California utilities, by season, and by time of use. This report uses an average California emissions factor for electricity to determine the financial value of emissions reductions associated with green buildings. Green buildings also tend to reduce peak

[127] *Ibid.*
[128] *Ibid.*
[129] It should be noted that zero emissions for renewable energy – PV, wind, fuel cells, hydro, etc – refers only to the operation of these generating devices and not to their manufacture.

consumption even more than they reduce overall demand. A more precise estimate would factor in the energy use profile of green buildings and match this to time-of-day power generation and associated pollution. However, this is beyond the scope of this analysis. It should be noted that green buildings can contribute to reducing grid congestion and power reliability and availability problems and can help reduce use of dirty backup/standby generating units. This could be examined in a more detailed analysis.

For a number of reasons – new technology, a shift to renewable energy, improvements in power plant efficiency, emissions control technologies and plant retrofits – emissions of NOx and SOx have dropped sharply and are expected to continue dropping. The CEC Environmental Performance Report notes that, "between 1975 and 2000, NOx and PM10 emissions from power generation declined by 79% and 83% respectively." [130] This decline is summarized in Figure V-2 below.

Figure V-2. Comparison of California Statewide Emissions with Emissions from Power Generation (tons/day)

Pollutant	Source of Emissions	1975	1980	1985	1990	1995	2000	2005 (est.)	2010 (est.)
NO_x	From All Sources	4,761	4,947	4,950	4,929	4,207	3,570	3,008	2,573
	From Power Generation	385	341	161	141	107	79.0	66.5	65.1
	% Power Generation	8.1%	6.9%	3.3%	2.9%	2.5%	2.2%	2.2%	2.5%
PM_{10}	From All Sources	1,864	2,018	2,004	2,240	2,177	2,313	2,467	2,612
	From Power Generation	49.6	29.1	5.7	11.8	8.1	8.62	9.63	9.8
	% Power Generation	2.7%	1.4%	0.28%	0.53%	0.37%	0.37%	0.39%	0.38%

Source: California EPA, Air Resources Board, Emission Reduction Offset Transaction Cost Summary Report for 2001

The state of California accounts for CO2 inconsistently – the California Inventory of Greenhouse Gas Emissions does not require inclusion of out-of-state generation, whereas the California Emissions Inventory Improvement Program does.[131] Typically, California emissions factors calculated by the Energy Information Administration and others reflect only in-state generation. California imports about 20% of its power from out-of-state, and this power has much higher pollution levels. Total coal generation in 2002 for California was 6220 MW, although 3065 MW or slightly less than 50% was imported.[132] In Los Angeles Department of Water and Power territory, coal imports are even more significant: total coal generation owned by LADWP, for

[130] State of California, California Environmental Protection Agency, Air Resources Board, "Emission Reduction Offset Transaction Cost Summary Report for 2001," April 2002, Table 1. Available at: http://www.arb.ca.gov/erco/erc01web.pdf.
[131] Lynn Price et al., "The California Climate Action Registry: Development of Methodologies for Calculating Greenhouse Gas Emissions From Electricity Generation," presented at *Green Building International Conference,* November 2002. Available at: http://eetd.lbl.gov/ea/EMS/reports/50250.pdf.
[132] California Energy Commission. "California Gross System Power for 2002 In Gigawatt-Hours (GWh)." 2002. Available at: http://www.energy.ca.gov/electricity/gross_system_power.html.

example, is 2,235 MW – although almost all of it located out-of-state but sold in the California market.[133]

Figure V-3. California Power Emissions Factors from the Tellus Institute (CO2 Modified)

	Emission Factors (short tons per GWh)		
Pollutant	**1999**	**2010**	**2020**
Carbon Dioxide	308	308	308
Sulfur Dioxide	0.32	0.281	0.244
Nitrogen Oxides	0.404	0.448	0.399
PM-10	0.235	0.2	0.186

Source: Tellus Institute, 2002, modified by Capital E.

Tellus Institute has undertaken analysis of California power emissions, including out-of-state generation. Modified Tellus estimates are used here, principally because they include all power used in California, not just power generated in-state.[134]

These emissions factors developed by Tellus reflect the likely future average mix of electricity generating technologies and fuels used by the California market. They also reflect likely future trends in emission factors under the EIA's projected business as usual scenario through 2020. The Tellus Institute emissions estimates change over time, including a significant increase in CO2 intensity in 2010 and 2020, to 452 and 490 tons per GWh, respectively. Given California's continuing concerns about pollution, including global warming, and the state's recent commitment to expanded use of renewable energy, it appears that CO2 intensity is more likely to remain flat than rise, so this report uses the 1999 CO2 emissions factor throughout the period of calculation. Use of the higher Tellus numbers would indicate larger financial benefits of green buildings.

Estimated Costs Associated with Pollution from Power Generation

Air pollution from burning fossil fuels to generate electricity imposes very large health, environmental and property damage costs. Demonstrated health costs include increased mortality and increased respiratory ailments.[135] The health, environmental and property damages

[133] Information provided by the California Energy Commission, Systems Assessment and Facilities Siting Division. January 2003. (Matt Layton) See also: LADWP. Power Content Label. Available at: http://www.ladwp.com/power/pwrcontentlbl.pdf; US DOE. Energy Efficiency and Renewable Energy. GreenPower Network. 1999. "LA's New 'Green Power' Program Will Save Customer's Money." Available at: http://www.eere.energy.gov/greenpower/ladwp_599_pr.html.

[134] William W. Dougherty, Senior Scientist, "Characterization of Criteria Air Pollutant and Greenhouse Gas Emission Factors Associated with Energy use in the USA: Sources, Assumptions, Methodology," based on Reference Case of the EIA's AEO200, Tellus Institute, 2002. See also: US Department of Energy, "Carbon Dioxide Emissions from the Generation of Electric Power in the United States," July 2000. Available at: http://www.eia.doe.gov/cneaf/electricity/page/co2_report/co2emiss.pdf; U.S. Department of Energy, Energy Information Administration, "Updated State-level Greenhouse Gas Emission Factors for Electricity Generation," Washington, D.C. See DOE EIA site: http://www.eia.doe.gov/env/utility.html.

[135] See, for example: "The Benefits and Costs of Clean Air Act 1990 to 2010," 1991. Available at: http://www.epa.gov/air/sect812/1990-2010/fullrept.pdf and Jonathan Samet et al., "The National

associated with pollution from burning fossil fuels – commonly referred to as externalities – are only partially reflected in the price of energy. Estimating the costs of externalities is technically difficult, politically problematic, and overall an inexact science. There have been dozens of attempts to estimate the external costs of power generation, but these efforts have not produced consensus. [136]

The California Board of Energy Efficiency (CBEE) developed estimates for environmental adders of $0.0072/kWh, or about 3/4 of one cent per kWh.[137] The CEC sought to determine the damage functions (for health, property and environmental impacts) in their Electricity Reports of 1992 and 1994.[138] In the reports, the CEC expressed reservations about use of this data. Given the lack of consensus on the value of externalities, and changing generation profiles (including steep reductions in some pollutants since the CEC analysis), this report will not rely on these damage functions to calculate the value of emissions reductions.

Instead, this report will rely on market values for traded emissions as the least imperfect of the options available for determining emissions values. These prices reflect actual marginal cost of emissions reductions in relatively liquid and well-established trading markets covering the majority of California's population. For some pollutants, including NOx and SOx, there is a well-established, liquid market and these market prices serve as our best measure of both the marginal cost of emissions reductions and the value society places on them. It is important to note that because the current market for emissions is driven by caps set by regulations, and not the morbidity effects of emissions, it does not directly reflect the externalities of health impacts, and therefore the value of reductions may be significantly understated. Some pollutants, including NOx and PM10, have substantial vehicular sources, and it is possible that the true value of reduced emissions for stationary sources is the same as for mobile ones (although this discrepancy is not recognized in the emissions market). In addition, important pollutants, such as mercury and smaller particulates (e.g. PM2.5) have large adverse health effects that are not addressed in this report. A more comprehensive evaluation of a fuller set of pollutants would end to increase the estimated financial benefits associated with lower conventional energy used in green buildings.

The California Air Resources Board (ARB) compiles and publishes annual data on emissions offset transactions[139] from 35 districts. Figure V-4 contains the reported prices for these offsets.[140] The average value of offsets was used in calculations.

Morbidity, Mortality, and Air Pollution Study – Part II: Morbidity and Mortality From Air Pollution In the United States," Health Effects Institute, 2000. Available at: http://www.healtheffects.org/Pubs/Samet2.pdf.

[136] For a valuable introduction and overview of past California and national studies on externality cost and costs of emissions reductions, see Jonathan Koomey and Florentin Krause, "Introduction to Externality Costs," LBNL, 1997. Available at: http://enduse.lbl.gov/Info/Externalities.pdf .

[137] Nick Hall and Jeff Riggert, "Beyond Energy Savings: A Reviews of the Non-Energy Benefits Estimated for Three Low-Income Programs," *ACEEE Conference Proceedings, Program Measurement and Evaluation* – 10.111.

[138] California Energy Commission. "1994 Electricity Report." Available at: http://www.energy.ca.gov/reports/ER94.html.

[139] Prior annual compilations of the offset transactions in California that occurred from 1993 through 2000 can be found at http://www.arb.ca.gov/erco/erco.htm.

[140] California Environmental Protection Agency, Air Resources Board, "Emission Reduction Offset Transaction Cost Summary Report for 2001,"April 2002, Table 1. Available at: http://www.arb.ca.gov/erco/erc01web.pdf. See also: http://www.arb.ca.gov/cgi-bin/swish/search.pl.

Figure V-4. 2001 Prices Paid in Dollars Per Ton for California-based Offsets

	NOx	PM10	SOx
Average (mean)	$ 27,074	$ 46,148	$12,809
Median	$ 22,000	$ 25,000	$ 7,500
High	$104,000	$126,027	$82,192
Low	$ 774	$ 400	$ 15

Source: California EPA Air Resources Board

Because there is no cap on CO2 emissions and no California CO2 market, CO2 price-indexes are not compiled and included. To determine CO2 value it is necessary to look at alternative sources.

The Cost of Carbon: Putting a Price on CO2 Emissions

The vast majority of the world's climate change scientists have concluded that anthropogenic emissions – principally from burning fossil fuels – are the root cause of global warming.[141] The United States is responsible for about 22% of global greenhouse gas (GHG) emissions. Of this 22%, the US building sector is responsible for about 35% of US CO2 emissions. CO2 is the dominant global warming gas, equal to about 9% of global anthropogenic emissions. As a recent study notes, US buildings alone are responsible for more CO2 emissions than those of any other country in the world except China.[142]

A report published in July 2002 for the United Nations Environmental Program's Finance Initiatives Climate Change Working Group, *Climate Change and the Financial Services Industry*, warns of the large risks posed by global warming. The report concludes that the "increasing frequency of severe climatic events, coupled with social trends, has the potential to stress insurers, reinsurers and banks to the point of impaired viability or even insolvency." [143] John Fitzpatrick, CFO and Member of the Executive Board of Swiss Re, maintains, "climate change and substantial emissions reductions – like any other strategic global business challenge – ultimately become a financial issue." [144] The United Nations estimates the potential cost of global warming at over $300 billion per year, and insurance firms are becoming concerned about the possibility of lawsuits due to damage from human-induced global warming.[145]

Global warming is recognized as a potentially very costly issue for California, implying a significant value for CO2 reductions in this state. Projected changes in rainfall patterns and snowmelt will likely reduce both available freshwater supplies and the effectiveness of the state's hydropower infrastructure. If California experiences below average rainfall, it could cut the

---

[141] Intergovernmental Panel on Climate Change. World Meterological Association and United Nations Environmental Program. "IPCC Third Assessment Report – Climate Change 2001." Available at: http://www.ipcc.ch/.

[142] Kinzey et al., "The Federal Buildings Research and Development Program: A Sharp Tool for Climate Policy," *2002 ACEEE proceedings*, Section 9.21.

[143] Innovest, for the United Nations Environmental Program. Finance Initiatives Climate Change Working Group. "Climate Change and the Financial Services Industry," 2002. Available at: http://www.unepfi.net/.

[144] "Climate Change Related Perils Could Bankrupt Insurers," *Environmental News Service*, October 7, 2002. Available at: http://www.campaignexxonmobil.org/news/News.OneWorld100802.html.

[145] Katharine Q. Seeley, "Global Warming May Bring New Variety of Class Action", *New York Times*, September 6, 2001. Available at: http://www.commondreams.org/headlines01/0906-03.htm.

amount of power that the state gets from hydroelectricity, currently 20% of total power, by up to half.[146]

California's new climate change legislation, passed in October 2002[147] establishes global warming as an issue of legitimate state concern. In addition, previous legislation requires that the value of emissions reductions be considered in developing a present value assessment of solar energy systems for California state buildings.[148] California's building investment and construction programs should reflect this, probably by assigning a dollar value to avoided GHG emissions achieved through better building design. Even if this value is not based on a single, determinative methodology and even if it is low, recognizing the cost of global warming by assigning a dollar value of some amount is preferable to the current practice of assigning no value – effectively $0 – to CO2 reductions. It is also economically efficient for the state to explicitly recognize a value for CO2 in order to ensure a more cost-effective decision making process about building design choices.

It is important to note that because California is a relatively energy efficient state with relatively clean electricity generation, the emissions associated with energy use in California buildings are relatively low. Balancing this, the value of emissions traded in California markets is high relative to the rest of the US.

Market trading rules for CO2 are not yet established and there is no accepted cap on emissions to drive the creation of a California market. Therefore a range of approaches for determining a fair value for CO2 reductions is discussed below.

Assigning a Cost to Carbon

The large energy use of buildings (more than one third of energy used in the economy) has led to extensive analysis of strategies to cut CO2 emissions from this sector. Countries such as Holland are developing specific programs to reduce energy use and associated greenhouse gas emissions from their buildings sector.[149] Innovative legislation passed in 1997[150] in Oregon mandates that new power plants in the state offset a significant portion (roughly 17%) of their CO2 emissions either by avoiding, sequestering or displacing emissions or by funding projects that do the same.[151] To date, this program has funded projects (including those currently under negotiation)

---

[146] William Keese, "Electricity Supply/ Reliability 2000 to 2002," Report for the joint hearing to the California Senate, August 10, 2000. Available at: http://www.energy.ca.gov/papers/2000-08-10_KEESE_TESTIMONY.PDF.

[147] State of California Assembly Bill 1493. Chapter 200, Statutes of 2002. Available at: http://www.leginfo.ca.gov/pub/01-02/bill/asm/ab_1451-1500/ab_1493_bill_20020722_chaptered.pdf. For more on CO2 issues in California, see: http://www.arb.ca.gov/gcc/gcc.htm.

[148] State of California Senate Bill 82, Chapter 10, Statutes of 2001-2002, 2nd Extraordinary Session. Available at: http://www.leginfo.ca.gov/pub/01-02/bill/sen/sb_0051-0100/sbx2_82_bill_20011007_chaptered.pdf.

[149] Kool et al., "Development of Policy to Reduce CO2 emissions from the Dutch Building Sector," *ACEEE conference proceedings*, 2002, Section 9.23.

[150] State of Oregon House Bill 3283. Oregon Revised Statutes of 1997. Oregon Administrative Rules, Chapter 345, Division 24. Available at: http://www.climatetrust.org/housebill.html.

[151] The Climate Trust. "Funding Innovative Projects to Counter Rapid Climate Change." October 2002. Available at: http://www.climatetrust.org/CTBrochureOct2002.pdf; "2001 Annual Report," Available at: http://www.climatetrust.org/2001AnnualReport.pdf.

that will result in approximately 3.5 million metric tons of CO2 offsets.[152] Within California, legislation has established the California Climate Action Registry, a voluntary registry for businesses and organizations within California to record annual greenhouse gas emissions and track reductions over time.[153] However, there is currently no mandate for state agencies to participate in the Registry. For California, models indicate that achieving a slowdown in growth of CO2 emissions resulting from building energy use would require state taxes on CO2 of $5 per ton in 2005, rising to $14 per ton in 2020.[154]

Determining a value for CO2 reduction is a difficult proposition. For example, a recent Intergovernmental Panel on Climate Change (IPCC) report cites a range of values between $5 and $125 per ton of CO2.[155] CO2 trading programs in the US are emerging,[156] with the value of trades typically ranging from under $1 up to $16 per ton, with most trades at under $5 per ton, but with a general trend of prices rising. The World Bank has participated in 26 emissions reduction projects, with CO2 trading at $3 to $4 per ton.[157] BP has used a price of $10 per ton for internal trading of CO2.

Despite the wide range of current prices for CO2, there is a widespread perception that CO2 prices will rise as the market demand continues to grow, as more private firms and public entities participate, and as the least expensive tons get bought up first. Many macro models project that to meet significant CO2 reduction targets, CO2 prices must be in the $25-$50 per ton range. The exact clearing price depends to a large extent on the size of emissions reductions sought – a political issue that has yet to be resolved. The EU estimates that to achieve the Kyoto Protocol CO2 targets, CO2 cost will need to be about $30 per ton.[158]

A 2002 A.D. Little (ADL) study for the CEC and the ARB includes a detailed analysis of the value of CO2. This study summarizes CO2 values from four emissions trading firms active in the US and two emissions trading institutions, with prices ranging from $0.10 up to $70 per ton. The individual averages of the six institutions are between $2 and $35, with the average of these averages at $13 per ton of CO2 (note that most trades were at lower prices).

---

[152] The Climate Trust. "The Climate Trust Fact Sheet." 2003. Available at: http://www.climatetrust.org/aboutus.html.
[153] State of California Senate Bill 527, Chapter 769, Statutes of 2001. Available at: http://www.leginfo.ca.gov/pub/01-02/bill/sen/sb_0501-0550/sb_527_bill_20011012_chaptered.pdf.
[154] Kool et al. (all in 1999 dollars) Op. Cit.
[155] IPCC Working Group III, "Summary for Policymakers: The Economic and social Dimensions of Climate Change," 2001. Available at: http://www.ipcc.ch/pub/sarsum3.htm.
[156] Carbon Trade Watch. "Briefing No. 1: The Sky is Not the Limit: The Emerging Market in Greenhouse Gases." January 2003. Available at: http://www.tni.org/reports/ctw/sky.pdf. For a list of existing registry and emissions reductions programs, see also: http://www.nescaum.org/Greenhouse/Registry/state_matrix.html.
[157] "World Carbon Credit Trading Could Triple," *CNN*, October 22, 2002. Available at: http://www.evworld.com/databases/shownews.cfm?pageid=news221002-02.
[158] P. Capros and L. Mantzos, "The Economic Effects of EU-Wide Industry-Level Emission Trading to Reduce Greenhouse Gases," May 2000. Available at: http://europa.eu.int/comm/environment/enveco/climate_change/primes.pdf.

The ADL report concludes by recommending that California adopt a value of $25 per ton of CO2. The CEC estimated that $11 (2002 dollars) must be spent on reforestation to grow enough trees to absorb one ton of carbon dioxide each year.[159] A more recent report, completed by TIAX, LLC for the ARB and CEC completes a similar analysis, but recommends a value of $15 per ton of CO2 emissions.[160]

Given the large range of prices assigned to CO2 by emissions trading markets, policy makers, analysts and others, there is no exactly "right" price per ton of CO2. This analysis recommends that California state agencies adopt a value of $5 or $10 per ton when valuing CO2 emissions. Both of these prices are reasonable figures. These prices are above most current CO2 trades, but well below most medium term estimates for CO2 reduction costs, and below specific price estimates and projections for California. Additional analysis is recommended to arrive at a more thorough valuation of CO2, and this might, for example, include a range of values with probability assigned to each different value. Despite the uncertainties and large credible range of possible prices, some value per ton should be assigned to CO2 for the purposes of calculating the benefits of green buildings, and the relatively conservative prices estimates of $5 and $10 are modeled below.

Conclusion

The average California state building uses electricity at a rate of about 10 kWh/ft^2/yr.[161] Converting this to GWh, multiplying by the emissions factors for 2010 from Figure V-3, and then multiplying again by the average prices-per-ton from Figure V-4, yields yearly emissions costs per square foot (Figure V-5). Figure V-6 shows the 20-year PV of a 36% reduction in emissions of the four pollutants discussed above.

Figure V-5. Estimated Annual Cost of Emissions (/ft^2)

Pollutant	Emission Factors (short tons per GWh)	Dollars/ton		Annual Cost of Emissions for 10 kWh	
Carbon Dioxide	308	$5	$10	$0.015	$0.031
Sulfur Dioxide	0.281	$12,809		$0.036	
Nitrogen Oxides	0.448	$27,074		$0.121	
PM-10	0.2	$46,148		$0.092	

Source: Tellus Institute, California ARB, Capital E Analysis

[159] California Energy Commission, Committee Order for Final Policy Analysis, Docket No. 88-ER-8, March 27, 1990, as reported in the Tellus *Packaging Stud,* Report #4, "Impacts of Production and Disposal of Packaging Materials – Methods and Case Studies," p. 1-5. CPI adjusted from $8 in 1990 dollars.

[160] TIAX, LLC, "Benefits of Reducing Demand for Gasoline and Diesel," Report to the CARB and CEC, May 2003. Available at: http://www.energy.ca.gov/fuels/petroleum_dependence/documents/2003-05-07_600-03-005A1.PDF.

[161] Data provided by the California Department of General Services, Real Estate Services Division, Building Property Management Brach. See Appendix I. Energy use and cost numbers come directly from utility bills.

Figure V-6. 20-Year PV of 36% Pollution Reduction for California Buildings (/ft^2)

Pollutant	CO2 PRICE $5/ton	$10/ton
NOx	$0.54	$0.54
PM10	$0.41	$0.41
SOx	$0.16	$0.16
CO2	$0.07	$0.14
Total	**$1.18**	**$1.25**

Source: Capital E Analysis

This report will assume the lower $5 per ton value of carbon, indicating a 20-year PV of $1.18/ft^2 for emissions reductions from green buildings.

VI. Water Conservation

California is facing substantial water shortages that are expected to worsen. Drought years can be particularly difficult on Californians. Urban water users have experienced mandatory rationing, small rural communities have seen wells go dry, agricultural lands have been fallowed, and environmental water supplies have been reduced. Without additional facilities, all of these conditions will only deteriorate with California's projected population increase.[162] Thus, water conservation not only saves money for the end user through reduced utility expenditures, but also saves state water districts the costs of facilities construction and expansion and prevents potential environmental damage.

Green building water conservation strategies typically fall into four categories:

- Efficiency of potable water use through better design/technology.
- Capture of gray water – non-fecal waste water from bathroom sinks, bathtubs, showers, washing machines, etc. – and use for irrigation.
- On-site storm water capture for use or groundwater recharge.
- Recycled/reclaimed water use.

Taken together, these strategies can reduce water use below code/common practice by over 30% indoors and over 50% for landscaping.[163] Of 21 reviewed green buildings submitted to the USGBC for LEED certification (including 6 California buildings) all but one used water efficient landscaping, cutting outdoor water use by at least 50%. Seventeen buildings, or 81%, used no potable water for landscaping. Over half cut water use inside buildings by at least 30%.[164]

Current Practice in California State Commercial and Institutional Buildings[165]

The state's current strategy for water conservation in new or renovated buildings generally does not include measures that exceed federal codes. However, the SBTF has developed a 2-tiered list of sustainable building measures, which includes a number of water efficiency elements.[166] While in theory, new projects should include all feasible water efficiency technologies and strategies, in practice this is not done in most projects.[167] Additionally, state projects are not

[162] California Department of Water Resources, "California Water Plan Update BULLETIN 160-98," 1998, Volume 2, Chapter 6, p. 6-2. Available at: http://rubicon.water.ca.gov/. A more current update is expected from DWR in 2003.
[163] US Green Building Council LEED Reference Package, Version 2.0, June 2001, p. 65, and analysis of green buildings submitted to USGBC. Available for purchase at: http://www.usgbc.org/LEED/publications.asp.
[164] Data provided by USGBC.
[165] "Commercial" refers to water use at state office buildings and other commercial facilities. "Institutional" refers to water use at schools, colleges, universities and other non-office government facilities.
[166] California Department of General Services. Real Estate Services Division. "Tier 1 and Tier 2 Energy Efficiency and Sustainable Building Measures Checklists." July 1, 2002. Available at: http://www.ciwmb.ca.gov/GreenBuilding/Design/Tiers.pdf.
[167] California Department of General Services. Real Estate Services Division, Project Management Branch. "Energy Efficiency and Sustainable Building Measures Capital Projects Summary." August 8, 2002.

mandated to follow California's Model Water Efficient Landscape Ordinance of 1993, even when a project is located in an area where the local utility has adopted it. It is therefore assumed that most state buildings are no more water efficient than other private sector commercial projects in California, and that typical strategies employed to reduce water consumption in private sector projects have a similar impact on California state buildings.

The Cost-Effectiveness of Water Conservation and Demand Reduction Strategies[168]

The potential cost savings of water conservation has been documented in the commercial and institutional sectors. Two 1997 studies – one by the Metropolitan Water District (MWD) and one by the US EPA and the California Department of Water Resources (DWR) attempted to estimate this potential specifically in California.[169] The MWD study found that commercial water use volume could be cost-effectively reduced (average payback – 1.7 years) by approximately 23%. The DWR study came to similar conclusions, finding that a 22% reduction in water use could be cost-effectively generated through conservation strategies. Projected savings by building type include: office buildings - 40%, schools - 21%, and hospitals - 22%.[170] In both studies, the authors note that estimates are conservative, and only include relatively simple technologies and/or implementation strategies and short term paybacks.

Water conservation can take several forms. In an urban commercial or institutional setting, significant savings can be achieved through reductions in outdoor water use – with efficient landscape and irrigation design, automatic rain sensors, and landscape water audit programs to ensure that reductions are met – as well as indoors – with better leak detection, more efficient appliances, and aggressive audits (simply ensuring compliance with existing standards and regulations could result in a 3% demand reduction across the commercial, industrial and institutional sectors).[171]

The cost of urban water conservation programs is typically $500-$750/af of conserved water (1 af = 1 acre-foot = 325,851 gallons).[172] Water can also be conserved by increasing the efficiency of the distribution system. Reducing distribution system losses to 5% through full metering, annual water audits, and systematic leak detection and repair programs would cost an estimated $300/af.[173]

---

[168] Cost-effectiveness is described earlier in the assumptions section, and is consistent with the definition in "BMP Costs and Savings Study: A Guide to Data and Methods for Cost-Effectiveness Analysis of Urban Water Conservation Best Management Practices," prepared for the California Urban Water Conservation Council by A & N Technical Services, Inc, March 31, 1999. It states, "Cost-effectiveness analysis (CEA) is the comparison of costs of a conservation device or activity with its benefits expressed in physical units (for example, $Costs per AF of savings). Cost-benefit analysis (CBA) is the comparison of costs of a conservation device or activity with its benefits, also expressed in dollar terms (for example, $Net Benefits = $Benefits - $Costs)."

[169] Charles Pike*, "*Study of Potential Water Efficiency Improvement in Commercial Business," US EPA/DWR, April 1997.

[170] Jon Sweeten and Ben Chaput, "Identifying the Conservation Opportunities in the Commercial, Industrial, and Institutional Sector*,"* paper delivered to the AWWA, 1997, p.8.

[171] BULLETIN 160-98, p. 6-10. Op. Cit.

[172] A&N Technical Services. "BMP Costs and Savings Study: A Guide to Data and Methods for Cost-Effectiveness Analysis of Urban Water Conservation Best Management Practices*."* July 2000. Available for purchase at: http://www.cuwcc.org/publications.

[173] BULLETIN 160-98, p. 6-10, 6-11. Op. Cit.

Estimated Actual Cost of Water from the State Perspective

A recent empirical study in Canada estimated that the price charged for fresh water was only one-third to one-half the long-run marginal supply cost, and that prices charged for sewage were approximately one-fifth the long-run cost of sewage treatment.[174] Commonly uncounted components of the long-run marginal supply cost include: new marginal water supply expansion and treatment, new marginal wastewater capacity and treatment, and the economic costs caused by environmental damage. Given anticipated population growth and concomitant escalating water demand, these costs are likely to be significant. (For a brief description of California's current water situation including demand, forecasted growth rates, and supply constraints, please see Appendix F). These factors make conservation and demand reduction, as encouraged in green building, all the more attractive – water saved does not need to be treated or disposed.

The California Urban Water Conservation Council (CUWCC) has designed a model to account for all of these factors in determining the total savings of water conservation. Called the Total Society Cost Model,[175] it requires inclusion of all avoided future economic, environmental, and social costs in order to determine a true avoided cost of urban water conservation. It has yet to be implemented by a single agency, perhaps reflecting the fact that determining the true marginal cost of water is difficult.

The following factors contribute to the complexity of determining the true marginal cost of water:

- *Regional Differences*. The current and projected future cost of supplying, treating, delivering and disposing of water vary drastically between and within regions.
- *Future Cost of Water.* To value a water conservation measure today, it is necessary to predict future marginal water costs over the lifetime of the measure. The marginal cost of water in 2012 depends on multiple factors including: demographic changes, weather patterns and public policy choices.
- *Perspective.* Marginal cost depends on perspective. A private building owner, a local utility, a regional utility and a state will all have different marginal cost assumptions.
- *Hard-to-Quantify Environmental Costs*. Although attempts have been made to value some environmental costs (e.g., complying with anticipated regulations), the economic impacts of damages (e.g., habitat destruction, fish losses, local air pollution, greenhouse gas emissions, increased delta salinity, etc.) are generally more difficult to quantify.
- *Unpredictable Political Landscape*. For more than 20 years, California has been taking as much as one million acre-feet per year (1 maf/yr) from the Colorado River above an existing legal limit of 4.4 maf/yr. In January 2003, the Bush administration announced that California would no longer be entitled to this extra water. In 2003, this could mean California will lose as much as 650,000 af of anticipated water supply.[176] This decision will likely increase southern California's marginal cost of water.

[174] Steven Renzetti, "Municipal Water Supply and Sewage Treatment: Costs, Prices, and Distortions," *Canadian Journal of Economics*, v32, i3, May 1999, p. 688.
[175] This approach is described in "Guidelines for Preparing Cost-Effectiveness of Urban Water Conservation Best Management Practices," a publication of the CUWCC, Sept. 1996, pp.1-7.
[176] Dean Murphy, "The Politics of Water: California Water War Takes New Turn," *San Francisco Chronicle*, 2003. Available at: http://www.sfgate.com/cgi-bin/article.cgi?file=/chronicle/archive/2003/01/05/MN169799.DTL.

- *Climate Change Impacts*. Recent studies suggest that global warming will have a significant impact on California's water resources. It appears there is no available study that projects the impact of climate change on the cost of future water supplies.

Notwithstanding these challenges, two comprehensive studies have been released over the past several years that attempt to determine appropriate marginal water costs for the state. The more recent, *Urban Water Conservation Potential*, was produced by Gary Fiske and Associates for the California Urban Water Agencies (CUWA) in August 2001.[177] It assigns marginal cost numbers to every region of the state for each year from 2000 – 2040.[178]

Figure VI-1 below shows the present value of avoided marginal water costs over a 20 year period based on the CUWA study. *Supply* is the present value of the marginal price the utility would pay to obtain or develop an acre-foot of water each year. *Wastewater* is the present value of the average cost savings - $73.50/af - from the delay of new wastewater facilities construction over the same time period. *Wastewater O&M* is the present value of the average avoided cost to treat new supplies - $13.50/af - over the specified time period. The *Weighted Average Value* is based on anticipated population growth for each region of the state (see Appendix G for calculations).

Figure VI-1. 20-Year Net Present Value of Avoided Marginal Water Supply and Wastewater Treatment Costs to Local Water Agencies in 2003

	Supply (/af)	Wastewater (/af)	Wastewater O&M	Total (/af)
Bay Area	$8,392	$953	$201	$9,546
Central Coast	$4,423	$953	$201	$5,576
Sacramento	$629	$953	$201	$1,783
San Joaquin	$1,944	$953	$201	$3,098
South Coast	$7,920	$953	$201	$9,074
S. Lahontan	$3,683	$953	$201	$4,837
Tulare	$2,046	$953	$201	$3,200
Average	$5,075	$953	$201	
			Weighted Average Value:	**$6,299**

Source: Gary Fisk and Associates for CUWA, Capital E Analysis

The CUWA study highlights the large differences in marginal water costs between regions (Sacramento's current low cost reflects historical access to low cost water sources) and provides a potential baseline for regional marginal water cost analysis.

A second study, *Economic Evaluation of Water Management Alternatives*, was developed by CALFED in October 1999.[179] It makes predictions of marginal water costs in certain regions of California only for the year 2020, and is thus less useful for determining 20-year PV and yearly

[177] Gary Fiske and Associates, "California Urban Water Agencies Urban Water Conservation Potential*."* *Final Report*, August 2001.

[178] It is assumed that wastewater capacity expansion costs would not begin to accrue until 2005 as projects currently being developed should be counted as fixed, sunk costs.

[179] "Economic Evaluation of Water Management Alternatives," prepared for the CALFED Bay-Delta program, October 1999. Available at: http://calwater.ca.gov/Archives/WaterManagement/adobe_pdf/EconomicEvaluationofWaterManagementAlternatives_Oct99.pdf.

marginal water costs than the CUWA study. The "Unconstrained" scenario, CALFED's preferred/expected option of the seven analyzed, is presented in Figure VI-2 below:[180]

Figure VI-2. Marginal Cost Expectations for One Acre-foot of Water in 2020[181]

	CALFED	CUWA
South Coast	$1,045	$628
San Francisco Bay	$1,123	$867
San Joaquin River	$130	$138
Tulare Lake	$211	$143

Source: CALFED, CUWA

While the CALFED numbers are higher than those from CUWA, a more comprehensive assessment of California's water situation would probably reflect marginal cost numbers higher than both for most regions of the state. The California Water Plan Update from 1998[182] cites a number of water development projects and their costs.[183] According to this report, dam construction alone can cost $2.3 billion to deliver an average of 620,000 af/yr from the San Joaquin River. This excludes property, utility relocation and mitigation costs, as well as maintenance and other water delivery costs. Seawater desalinization, often viewed as the upper bound of economically feasible water, costs $1000-2000/af.[184] The following important factors should be included in order to accurately estimate marginal water cost.

Perspective. The marginal cost numbers from the CUWA study are equal to the price the agency pays for water. From the state's perspective, however, there are additional costs of developing new supplies and delivering water to the end user. These costs can be significant. For example, MWD has now begun accepting proposals from its member agencies to develop desalinization facilities. MWD will pay up to $250/af to subsidize the local construction of desalinization plants.[185] From the perspective of the MWD, the marginal cost of this water is $250/af. However, the actual development cost to the local agencies can be up to $2000/af.[186] Assuming an average annual cost of $1150/af suggests a 20-year PV of $14,332/af of new water capacity construction avoided, or more than 2 times higher than the weighted average cost for California indicated Figure VI-1.

[180] *Ibid.* Table 8.1.
[181] San Joaquin and Tulare Lake Region numbers are much lower than the Bay Area and South Coast for two primary reasons. First, their marginal need is for agriculture, and agricultural water is much less expensive to develop, treat, and dispose of than urban water. Second, both of these regions are closer to the water sources than the Bay Area and South Coast, sharply reducing pumping costs. Costs include amortized capital and O&M costs for supply measures, plus estimated retail cost components for treatment, distribution and administrative overhead.
[182] BULLETIN 160-98, Volume 2. Op. Cit.
[183] "California Water Plan Update BULLETIN 160-98," Volume 2, Chapter 6.
Download at: http://rubicon.water.ca.gov/pdfs/v2/v2ch6.pdf.
[184] *Ibid*, p.6-34.
[185] CUWA study. Op. Cit.
[186] CUWA study. Op. Cit.

Wastewater Treatment Costs. The authors of the CUWA study acknowledge that their wastewater treatment numbers could be refined.[187] The CUWA study assumes that the marginal cost of wastewater treatment will grow at the rate of inflation, as it has, on average, over the past ten years. However, a recent study released by the EPA suggests that future costs will likely rise much more rapidly than in the past.[188] The city of Portland, Oregon, for example, expects wastewater rates to rise by about 7% annually over the next decade, significantly higher than the 2-3% annual increase experienced over the past several years.[189]

Proposition 50 Supply Projects. This initiative, from the November 2002 ballot, requires California to issue $3.4 billion worth of bonds to fund a variety of water projects over the next several years. A portion of the funds is intended for new supply and advanced treatment projects including desalination and reclaimed water.[190] These relatively expensive projects were not included in the marginal cost assumptions in the CUWA study.

Projections of Environmental Costs. Environmental costs beyond those attributed to anticipated regulatory requirements are difficult to quantify. Not surprisingly, the authors of the CUWA study made no attempt to estimate them. Nevertheless, both water supply expansion and marginal consumption have significant potential environmental impacts. These include: wildlife habitat destruction, fish losses, local air pollution and climate change impacts, among others.[191]

In addition, multiple studies suggest that global warming will likely alter precipitation patterns in the state. A recent report by the Pacific Institute summarized the results of nearly 1,000 peer-reviewed studies on climate change. The report states "with very high confidence":

> *It is likely that reductions in snowfall and earlier snowmelt [caused by global warming] and runoff would increase the probability of flooding early in the year and reduce the runoff of water during late spring and summer. Basins in the western United States are particularly vulnerable to such shifts*.[192]

---

[187] Illingworth, Wendy. Economic Insights, Inc., Oct 15, 2002.

[188] The EPA reports that the expected gap between future revenues (based on historical price increase) and infrastructure needs will be approximately $148 billion over the next twenty years. See: US Environmental Protection Agency. "The Clean Water and Drinking Water Infrastructure Gap Analysis," August 2002. Available at: http://www.epa.gov/owm/gapfact.pdf.

[189] Data provided by the city of Portland, Environmental Services Department. October 2002.

[190] Proposition 50 allocates up to $200 million for desalination, treatment capacity expansion, and recycled water projects. "The Official Voter Information Guide to the November 2002 California Elections*.*" http://www.ss.ca.gov.

[191] See, for example, "Proceedings of a Workshop on Economic Non-Market Evaluation of Losses to Fish, Wildlife and Other Environmental Resources," Bay Institute of San Francisco, May 1987.

[192] Peter Gleick, "Water: The Potential Consequences of Climate Variability and Change for the Water Resources of the United States," September 2000, p. 4.
Available at: http://www.gcrio.org/NationalAssessment/water/water.pdf. A similar UCS study finds that more precipitation will fall as rain, rather than snow, causing massive flooding in the spring and droughts by late summer. Reduced summer runoff of fresh water would also increase summer salinity in San Francisco Bay, requiring less diversion in order to meet ecosystem and bay water quality needs. Christopher Field, "Confronting Climate Change in California: Ecological Impacts on the Golden State*,"* *Union of Concerned Scientist*, 1999.
Available at: http://www.ucsusa.org/publication.cfm?publicationID=7.

According to the California Climate Change Registry, climate change in California will also likely cause the following: a sea level rise of 4-35 inches by 2100, severe salt-water intrusion into coastal aquifers, and greater air pollution.[193]

Exclusion of Reclaimed Water Projects. Reclaimed water projects provide an increasingly large share of "new" water supply. In the Bay Area, for example, reclaimed water is expected to account for 50% of new supply over the next twenty years.[194] Reclaimed water projects typically cost $600-$1100/af – higher than the marginal costs numbers presented in the CUWA study in *every* region of the state. At an average cost of $850/af, the 20-year PV for avoiding new reclaimed water projects is about $10,593/af, or almost 2 times larger than CUWA estimates for the Bay Area.

This report will assume that actual costs are two times higher than indicated by CUWA data, for a state average 20-year PV of $12,598/af. For the reasons described above, even this adjusted cost estimate is likely to be low. Additional work needs to be conducted to obtain more accurate full cost numbers.

Conclusion

Green buildings are designed to conserve water. Taking the avoided cost of water to be only the average retail price paid by state agencies to local utilities, the literature suggests that there is considerable potential for cost-effective water conservation strategies in new and renovated building projects in many regions of the state. However, the actual value of water conservation to the state is not the avoided cost of retail water rates. Rather, it is the region-specific added cost of new marginal water supplies.

The CUWA study cited above advances knowledge of the marginal costs of new water supplies. But it is clear that additional work needs to be done to determine more realistic numbers. More comprehensive assumptions will likely yield higher marginal costs, and thus higher potential savings. Nevertheless, the CUWA study is a good basis for determining average statewide costs, and can be adjusted upward to reflect actual recent water costs.

The modified CUWA findings were applied to a hypothetical new state building project to determine potential savings and include this and a cost doubling to reflect the higher actual costs discussed above. This provides a 20-year PV of $0.51/ft^2 for water savings from green buildings. These costs are very likely conservative (low) for reasons discussed above. Please see Appendix G for the detailed calculations.

This investigation provides a conservative estimate for the value of water savings from green building, but also indicates that more research and analysis needs to be done.

[193] See: http://www.climateregistry.org/.
[194] "Water Conservation Master Plan Annual Report," FY02, East Bay Municipal Utility District. 2002. p.4.

VII. Waste Reduction

Nearly 60% (over 21 million tons in 1998) of waste in the state of California comes from commercial (i.e. non-residential) buildings.[195] Additionally, 57% of the construction and demolition (C&D) debris nationally comes from the non-residential sector.[196] California state buildings generally fall within this category.

Waste reduction strategies such as reuse and recycling, as promoted in green buildings, help to divert some waste from being disposed of in landfills. Diversion strategies result in savings associated with avoided disposal costs as well as in reduced societal costs of landfill creation and maintenance. In addition to diverting waste from landfills, recycling and reuse can catalyze further economic growth in industries that reprocess diverted waste and use recycled raw materials.

Green building waste reduction strategies can occur at time of construction and throughout the life of the building.

Construction waste reduction options include:

- Reuse and minimization of construction and demolition (C&D) debris and diversion of C&D waste from landfills to recycling facilities.
- Source reduction, e.g., (1) use of building materials that are more durable and easier to repair and maintain, (2) design to generate less scrap material through dimensional planning, (3) increased recycled content, (4) use of reclaimed building materials, and (5) use of structural materials in a dual role as finish material (e.g. stained concrete flooring, unfinished ceilings, etc.).
- Reuse of existing building structure and shell in renovation projects.

Building lifetime waste reduction includes:

- Development of indoor recycling program and space.
- Design for deconstruction.
- Design for flexibility through the use of moveable walls, raised floors, modular furniture, moveable task lighting and other reusable building components.

Together, these strategies can have a dramatic impact on reducing landfill disposal. C&D diversion rates have reached as high as 97% on individual state of California projects, and are typically at least 50-75% in green buildings.[197] C&D waste impacts vary greatly depending on the type of building project and whether it is new construction, renovation, or construction on already developed land.

---

[195] California Integrated Waste Management Board. "Statewide Waste Characterization Study: Results and Final Report." December 1999. p. ES-2: commercial and self-haul commercial values combined

[196] US Environmental Protection Agency Municipal and Industrial Solid Waste Division, Office of Solid Waste. "Characterization of Building-related Construction and Demolition Debris in the United States." June 1998. p. 2-11, Table 8.

[197] California State and Consumer Services Agency and Sustainable Building Task Force. "Building Better Buildings: A Blueprint for Sustainable State Facilities." December 2001. P.16.

Of 21 green buildings submitted to USGBC for certification, seventeen, or 81%, reduced construction waste by at least 50%, while 38% reduced construction waste by 75% or more.[198] Renovated projects can often utilize 75-100% of a building envelope and shell (excluding windows) and up to 50% of non-shell elements (walls, floor systems, etc.).[199]

Designing indoor recycling systems encourages recycling as part of a building's operational practices. Moveable walls, raised floors, modular furniture, and moveable task lighting can reduce the costs and wastes associated with reconfiguring office spaces (similar to saved churn costs of "Underfloor Air" – see Section IX).

It is clear that green buildings recycle and divert substantially higher levels of waste, and incorporate greater amounts of recycled or "re-used" materials than conventional buildings. However estimating the relative increases in waste recycling, diversion and use of green buildings compared with conventional buildings is difficult and tenuous.

Current Practice in California State Commercial and Institutional Buildings

Currently, there is no standard practice for incorporating all the waste reduction elements into state construction projects, although efforts are underway in each individual category.

C&D diversion requirements are incorporated into state contracts through the use of building performance standards and the Tier sustainable building measures checklists, which specify technologies that should be or can be used in new buildings. Tier 1 requires that all projects develop a recycling plan that results in the diversion of 50% or more of C&D materials, and Tier 2 encourages project teams to consider diverting 75% or more (if economically feasible). Although required, there is little evidence to date that indicates either is regularly done for state projects.[200]

The Tier 1 list also requires projects to "provide for dedicated space in and outside the building for the collection, storage, and loading of recyclable materials." Unfortunately, information is not readily available to indicate how often dedicated recycling space is actually included in space designs. AB 75 does require state agencies and large state facilities (college campuses and prisons) to divert 25% of generated solid waste from landfills by January 1, 2002 and to achieve a 50% diversion rate by January 1, 2004.[201] Regardless of whether or not dedicated space is included in design, state agencies are required to implement recycling programs and many recycling programs are in place and being enhanced to reach this goal.

With respect to the purchase of recycled content products, there is a state mandate through the State Agency Buy Recycled Campaign[202] (SABRC) that requires state agencies to meet recycled content requirements for products in each of 12 categories.[203] Contractors for state agencies must also supply recycled content products that meet the SABRC requirements. Although SABRC has

[198] Data provided by USGBC.
[199] LEED Reference Package. Version 2.0. US Green Building Council. June 2001. pages 170 - 180.
[200] Information provided by the California Integrated Waste Management Board, Green Building Section. November 2002. (Kathy Frevert).
[201] California Assembly Bill 75 (Strom-Martin) Statues of 1999, Chapter 764. Available at: http://www.leginfo.ca.gov/pub/99-00/bill/asm/ab_0051-0100/ab_75_bill_19991010_chaptered.html.
[202] See: http://www.ciwmb.ca.gov/BuyRecycled/StateAgency.
[203] See: http://www.ciwmb.ca.gov/BuyRecycled/StateAgency/Buying.htm.

been in place for approximately 14 years, Block 225 of the Capitol Area East End Project was the first construction project to attempt to implement the mandate. While not all materials used in Block 225 were SABRC compliant, this project was invaluable in helping the state to develop specification language, reporting procedures, and forms that will assist future state projects in their efforts to increase the use of recycled content products.[204] The Tier 1 list does include requirements for the use of recycled content products, promoting the incorporation of these materials into projects when appropriate. Because the checklists were developed considering only material first costs, those products deemed cost-effective are fairly limited.

Since the enactment of the 1989 California Integrated Waste Management Act (AB 939),[205] waste diversion in California has been steadily increasing – from 17% in 1990, to 25% in 1995, to 48% in 2002.[206]

The Retail Cost of Disposal and Diversion

Retail collection and removal fees in California currently range from $90 – $150/ton for disposal (including an average tipping fee of $34/ton)[207] and from $120 – $200/ton for recycling.[208] These are the fees paid by customers to waste management companies for waste collection and removal, and are associated with curbside recycling, not generally applicable to many commercial businesses. Higher fees for recycling collection probably result from the necessity to sort and collect separately different types of recycled waste. The range reflects many factors including: tipping fees, type of recycled material, recycled product markets and infrastructure, labor costs, and subsidies. Additionally, hauling costs may be higher for diversion/recycling because the waste must be transported farther in order to be processed.

Because of the relative high quality of many recovered building materials, well established markets, and lower collection costs, C&D recycling is generally less expensive per ton than curbside residential or commercial service. For example, C&D recyclers in the Sacramento region will accept concrete and asphalt for free and clean wood waste for less than $10 per ton,[209] while the Sacramento County Landfill charges $26 per ton[210] (hauling costs are not included in these figures). In this instance where the first cost of recycling is less than the first cost of disposal there is a direct financial incentive to divert materials for recycling and reuse.

---

[204] Information provided by CIWMB, Recycling Technologies Branch. September 2003 (Clark Williams, JoAnne Jaschke)

[205] California Assembly Bill 939, Sher, Chapter 1095, Statutes of 1989. Public Resources Code (PRC) sections 42920–42928 Available at: http://www.leginfo.ca.gov/cgi-bin/displaycode?section=prc&group=42001-43000&file=42920-42928.

[206] CIWMB, "Solid Waste Generation and Diversion, 1989-2002." Available at: http://www.ciwmb.ca.gov/lgcentral/Rates/Diversion/RateTable.htm

[207] CIWMB, "Active Landfill Profiles," 2003. Available at: http://www.ciwmb.ca.gov/Profiles/Facility/Landfill/Default.asp.

[208] Conversation with Aya Ogishi, Department of Agricultural and Resource Economics, UCB, November 6, 2002. (John Blue, CIWMB).

[209] Telephone inquiry: *California Concrete Crushing and Recycling* (916) 387-5050 and *Allied Waste-Elder Creek Transfer & Recovery Facility* (916) 387-8425)

[210] CIWMB. "2000 Solid Waste Tipping Fee Survey." Available at: http://www.ciwmb.ca.gov/landfills/TipFees/2000/

Estimated Actual Cost and Benefits of Landfill Diversion

From the perspective of the state, the value of diverting materials from landfills should include all quantifiable benefits that accrue to the state. These include direct economic benefits as well as avoided environmental costs.

Direct Economic Value

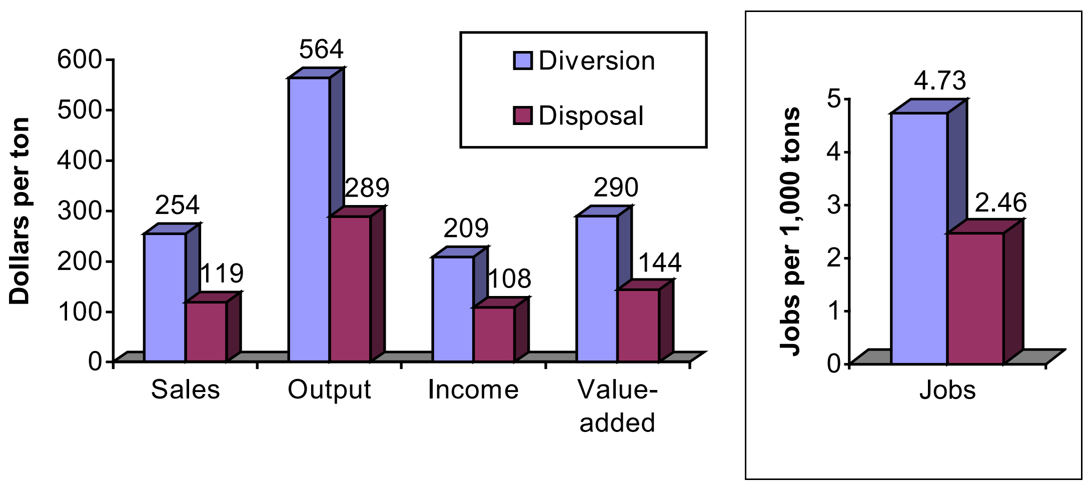
Two recently published studies have quantified the economic costs and benefits of landfill disposal and diversion in California. The Department of Agriculture and Resource Economics at UC Berkeley (UCB), in conjunction with the California Integrated Waste Management Board (CIWMB), published the first study in April 2001.[211] The second, conducted by the National Recycling Coalition (NRC), was released in July 2001.[212] It is important to note that these studies deal with the economic impacts of waste diversion in general and are not specific to C&D diversion. These studies have been included to show the positive economic impact of diversion as compared to disposal.

The UCB study used 1999 data to compare the economic impacts of waste disposal to diversion in six California regions. For both disposal and diversion, the study calculated Total Sales generated from waste and four multiplier effects:

- *Total Output* – a measure of how the disposal/diversion sector influences total economic activity including direct (e.g., collection of wastes), indirect (e.g., collection/recycling equipment manufacturers, other support businesses) and induced impacts (e.g., engineers/consultants) – not including environmental costs.[213]
- *Total Income* – a measure of the total income earned by all persons in the economy attributed to disposal/diversion.
- *Total Value Added* – a measure of the increase in the value of goods sold by all sectors of the economy, minus the costs of inputs.[214]
- *Number of Jobs* – the number of jobs created by disposal/diversion activities.

[211] *Ibid.*
[212] "California Recycling Economic Information Study (REI)," prepared for CIWMB by the National Recycling Coalition in association with R.W. Beck, Inc, July 2001. Available at: http://www.ciwmb.ca.gov/agendas/mtgdocs/2002/01/00007124.pdf.
[213] Total Output includes both Total Income and Value Added.
[214] Value Added also includes tax revenues.

Figure VII-1. Value of Diversion vs. Disposal in UCB Study



Source: Goldman and Ogishi, April 2001

In general, the UCB study found that total economic impacts from diversion are nearly twice as large as the impacts from disposal. One additional ton of waste disposed in a landfill in California generates $289 of total output in the state economy. One additional ton of waste diverted as recyclables generates an average of $564. Figure VII-1 above shows that only 2.46 jobs are created for every 1,000 tons of waste disposed, while 4.73 jobs are created for waste diverted as recyclables. The study also found that regional variation is significant. The Central Valley's total output impacts are nearly $350 per ton greater when waste is diverted, while the Eastern region is the only place in the state where, due to currently limited infrastructure to support recycling businesses, the average economic impacts for diversion are less than the impacts for disposal.[215]

The NRC study has a broader scope than the UCB study. It compares diversion to other sectors of the economy and shows how the economic impacts from diversion in California fit within the nationwide economy. It also uses different assumptions, input data and methodologies. Despite the differences, the resulting economic impacts per diverted ton are quite similar.

Averaging the results of the two diversion studies show that when material is diverted rather than disposed in a landfill, the marginal impacts are worth:[216]

- $325 per ton in Output Impact
- $70 per ton in Income Impact
- $111 per ton in Value Added Impact
- 2.15 jobs per 1,000 tons

[215] George Goldman and Aya Ogishi, "The Economic Impact of Solid Waste Disposal and Diversion in California." Paper presented at the *Western Agricultural Economic Association Meeting*, Logan Utah, July 20, 2001, p. 14. Available at: http://are.berkeley.edu/extension/EconImpWaste.pdf.
[216] These numbers are based on data from "Two Studies on the Economic Impacts for Diversion: A Brief Review by Board Staff" (unpublished document from the CIWMB).

The figures are intended to quantify the economic impacts for the period of one year – the year in which the waste is either disposed of or diverted. They are not 20-year PV numbers. Both studies may under-estimate the full marginal value of diversion. In the Berkeley study, for example, only data from manufacturers that use recycled materials extensively (as identified by the 1997 Census of Manufacturers) were included. In addition, the Census data set does not include all industries. The value of source reduction and reuse were also not included in the study, nor was the value of some common materials such as tires. Consideration of these factors would likely increase the value of diversion.

Avoided Environmental Costs

While no study completed to date has examined and quantified the environmental benefits of recycling in California, several have investigated the subject in other states. The most comprehensive study was conducted in Massachusetts in 2000. The study found average total net environmental benefit of recycling at $63 per ton. According to the study, diversion has two primary benefits compared to disposal:[217]

1) Fewer hazardous substances and greenhouse gases are emitted when products are manufactured with recycled materials instead of virgin wood, metal and petroleum resources.[218]
2) Fewer hazardous substances and other pollutants are released when materials are collected for recycling instead of landfill disposal or incineration.

Just as the economic impact described in the UCB and NRC studies must be further refined to create a more meaningful number, this environmental estimate should be adjusted to reflect California-specific conditions. In addition, projected costs for long-term maintenance of environmental hazards associated with landfill degradation should also be considered.

Conclusion

As discussed above, estimating financial benefits of waste reduction, diversion and recycling from green buildings relative to existing buildings is difficult. At present, the AB75 baseline for waste diversion for California state agencies is 25%, set to increase to 50% in 2004. Although this does not apply directly to specific building construction projects, construction and demolition debris diversion do factor into the overall state agency calculation. Currently, no data exist to indicate whether or not these goals are being met relative to construction projects. However, diversion rates in excess of 75% are commonly met on projects where project managers enforce the Tier 1 & 2 requirements for waste diversion. Improved reporting of diversion and disposal data for state projects would significantly improve the ability to estimate the waste reduction benefits of green buildings.

---

[217] Lisa Skumatz and Jeffrey Morris, "Massachusetts Recycle 2000: Baseline Report," prepared for the Commonwealth of Massachusetts Executive Office of Environmental Affairs (EOEA) Recycle 2000 Task Force, December 1998.

[218] Estimates of net benefits of GHG reductions are based on US EPA, "Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste, Final Report," September 1998, Exhibit ES-4. Available at: http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BVP7P/$File/r99fina.pdf.

It is possible, with a set of tentative assumptions, to estimate waste benefits associated with green buildings. This report uses the numbers from the UCB and NRC/REI studies, combined with the environmental benefit from the Massachusetts study, to calculate rough conservative values for C&D diversion in for new construction as well as demolition of pre-existing structure before construction:

- $0.03/ft^2 or $3,000 per 100,000 ft^2 building for construction only.
- $0.14/ft^2 or $14,000 per 100,000 ft^2 building for construction preceded by demolition.

Since green buildings attempt to use some of the pre-existing building envelope, it is probable that diversion percentages for the second case will be higher than estimated in this analysis. The details of these calculations are included in Appendix H.

In the absence of good data on present rates of waste diversion in green and conventional buildings during both their construction and operation, it is impossible to quantify the relative advantages of either one. However, it appears probable that the green building waste reduction advantage would not exceed about $0.50/ft^2, because of California's already aggressive waste reduction targets (as set forth in AB 75 and AB 989) – the effectiveness of which is evidenced by the increase in waste diversion from 17% in 1990 to 48% in 2002. [219]

A more thorough study is needed to obtain more realistic financial cost estimates of diversion versus disposal and to generate a California-specific value for the environmental benefits of construction and demolition waste diversion and recycling.

[219] CIWMB, "Solid Waste Generation and Diversion, 1989-2002." Available at: http://www.ciwmb.ca.gov/lgcentral/Rates/Diversion/RateTable.htm

VIII. Productivity and Health

California's Executive Order D-16-00, which established the Governor's sustainable building goals, includes the statement that sustainable building practices should "enhance indoor air quality; and improve employee health, comfort and productivity,"[220] indicating that health and productivity benefits should be explicitly recognized in the state's building design and funding decisions.

This section contains a brief overview of what is known about health, human comfort and productivity in relation to green building design and operation. The conclusion contains a reasonable and conservative estimate for the monetary value of productivity gains in green buildings. Health and productivity issues, often addressed separately, are combined here because both relate directly to worker well-being and comfort and both can be measured by their impacts on productivity.

The relationship between worker comfort/productivity and building design/operation is complicated.[221] There are thousands of studies, reports and articles on the subject. This report relies in large part on recent meta-studies that have screened tens or hundreds of other studies and have evaluated and synthesized their findings.

Potential Savings

The cost to the state of California for state employees is ten times larger than the cost of property. The following chart (Figure VIII-1) and supporting data (see Appendix I) represent state costs for 27,428 state employees in 38 state-owned buildings. Note that operations and maintenance (O&M) costs are allocated 44% for labor and 56% for property related expenses.[222] Average annual employee costs ($66,478 in salary and benefits - $65,141 - plus allocated operations and maintenance costs - $1,337), are 10.25 times larger than the cost of space per employee ($6,477).[223] Thus, measures that increase employee costs by 1% are equivalent, from a state cost perspective, to an increase in property related costs of about 10%. *In other words, if green design measures can increase productivity by 1%, this would, over time, have a fiscal impact roughly equal to reducing property costs by 10%.*

---

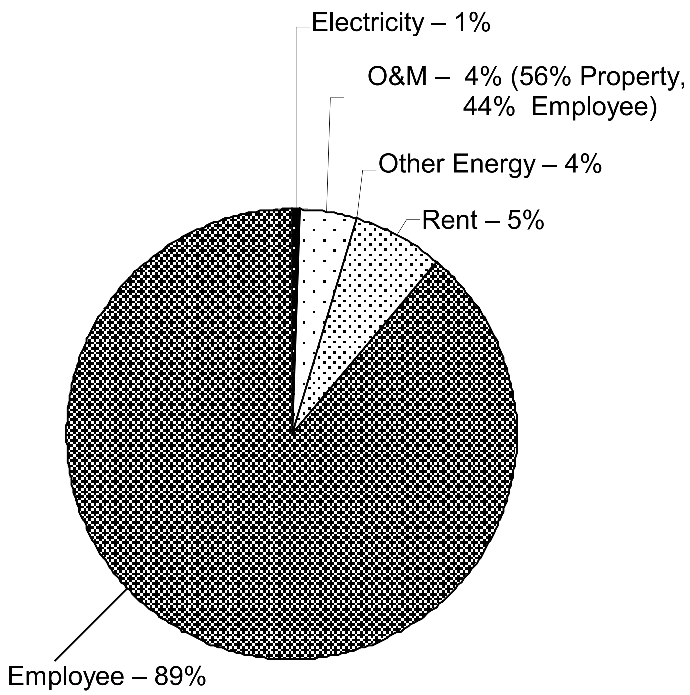
220 State of California. Governor's Executive Order D-16-00, August 2000. Available at: http://www.governor.ca.gov/state/govsite/gov_homepage.jsp.

221 One approach to address this complexity is offered by comprehensive building performance scoring tools for evaluating building design and operation benefits. One example of this type of scoring methodology is called the Balanced Scorecard. This approach evaluates four categories of building performance: Financial Results (cost of absenteeism, turnover, etc), Business Processes (innovation, product quality, etc), Customer Satisfaction (stakeholder relations - including public image and local economic impact), and Learning and Growth (human capital development - including work satisfaction and productivity). These kinds of broad systems approaches are valuable for explicitly demonstrating how green buildings support health, productivity and other benefits and meeting larger corporate objectives. However, these types of approaches are less helpful for quantifying the benefits of green building design. See for example: http://www.balancedscorecard.org/bscand/bsckm.html.

222 Operations and Maintenance cost ($3,039) are allocated 44% for labor and 56% for property related expenses. Data provided by the California Department of General Services, Real Estate Services Division. December 2002.

223 See Appendix I.

Figure VIII-1. Costs in California State Employee-Occupied Office Buildings
(December 2001 - September 2002 with projections for November-December 2002)



Source: Real Estate Services Division of Department of General Services.[224]

Increased productivity is closely linked to improved worker health. Companies with a demonstrably healthier work environment can also experience reduced insurance premiums – a topic covered in Section X.

The Building-Productivity Link

There is growing recognition of the large health and productivity costs imposed by poor indoor environmental quality (IEQ) in commercial buildings – estimated variously at up to hundreds of billions of dollars per year. This is not surprising as people spend 90% of their time indoors, and

[224] Data provided by the California Department of General Services. November 2002. Note that these include state owned buildings leased to state agencies and that on average these rental rates are slightly below market average – perhaps by about 10%. The data were not adjusted to account for this (by about 3%) because doing so has no significant effect on calculations or conclusions. Conditioned area per employee is assumed to be 225ft^2 – the number indicated by the California Department of General Services, Real Estate Services Division. This is significantly below the aggregate data summarized in Appendix I, provided by DGS, reflecting the fact that a substantial portion of building space is not conditioned occupied. Annual average energy cost is about \$1.60, conservatively projected to decline to \$1.47/ft^2. (Also see discussion of this data in Energy Use section.)

the concentration of pollutants indoors is typically higher than outdoors, sometimes by as much as 10 or even 100 times.[225]

Measuring the exact financial impact of healthier, more comfortable and greener buildings is difficult. The costs of poor indoor environmental and air quality – including higher absenteeism and increased respiratory ailments, allergies and asthma – are hard to measure and have generally been "hidden" in sick days, lower productivity, unemployment insurance and medical costs.

The discussion of IEQ and productivity issues in industry publications has expanded rapidly in the last decade to become a common theme, and has spilled over into popular media. Business Week's cover for its June 5, 2000 issue features a picture of a large menacing office building to accompany the feature story: "Is Your Office Killing You? The Dangers of Sick Buildings." [226] The article cites potential benefits of up to $250 billion per year from improved indoor air quality in US office buildings.

There are now hundreds of published testimonials about the health and productivity benefits that result from adopting green design strategies. For example:

- William Pape, the cofounder of VeriFone, reports that eighteen months after VeriFone employees began working in a building retrofitted to cut indoor pollutants and improve indoor environmental quality, absenteeism rates were down 40% and productivity was up by more than 5%. Pape notes that healthy workplaces have "done more to boost productivity than all the bandwidth in the world." [227]
- Gary Jay Saulson, the Senior VP and Director of Corporate Real Estate for PNC Realty Services, describes the benefits of the LEED Silver PNC Firstside Center building in Pittsburgh as follows: "people want to work here, even to the point of seeking employment just to work in our building. Absenteeism has decreased, productivity has increased, recruitment is better and turnover less." Two business units experienced 83% and 57% reductions in voluntary terminations after moving into the new Firstside facility.[228]

The relationship between green building strategies and productivity has been studied and documented extensively. There are number of substantial databases that aggregate and screen studies on the relationship between specific building performance attributes and productivity and worker well-being.[229]

---

[225] US Environmental Protection Agency, "Indoor Air Quality," January 6, 2003. Available at: http://www.epa.gov/iaq/.

[226] Michelle Conlin, "Is Your Office Killing You?" *Business Week*, June 5, 2000, http://www.businessweek.com/2000/00_23/b3684001.htm.

[227] William Pape, "Healthy, Wealthy, and Wise," *Inc*, 1998, No. 2, pp. 25-26. Available at: http://www.inc.com/articles/ops/office_management/office_design/1075-print.html. See also William Browning, "Boosting Productivity with IEQ Improvements," *Buildings Design & Construction*, April 1997.

[228] Compared with a control group that experiences an 11% reduction. "Shades of Green: 2002 Report of the Pittsburgh Green Building Alliance," http://www.gbapgh.org. This report provides a clear overview of green building benefits and valuable references and quotes on productivity and related green building benefits. See also: William Browning, "Successful Strategies for Planning a Green Building" *Planning for Higher Education*, Society of College and University Planners, March-May 2003, pp. 78-86.

[229] The Rocky Mountain Institute has been a pioneer in developing and publishing studies on green buildings and productivity, including both original research and reviews of studies on the impact of green buildings on productivity, sales and other worker performance measures. See Rocky Mountain Institute website, "Buildings & Land," Available at: http://www.rmi.org/sitepages/pid174.php. These include:

What Do Tenants Want?

Given the large impact that poor IEQ has on the health and comfort of office workers, it is not surprising that recent surveys of workers suggest that IEQ is one of the most important components of job satisfaction. For example, the study, *What Office Tenants Want: 1999 BOMA/ULI Office Tenant Survey Report*[230] is based on questionnaires from 1800 office tenant surveys in 126 metropolitan areas. Conducted by the Building Owners and Managers Association (BOMA) and the Urban Land Institute, the study affirms that office tenants highly value comfort in office buildings. Survey respondents attributed the highest importance to tenant comfort features, including comfortable air temperature (95%) and indoor air quality (94%). Office temperature and the ability to control temperature are the only features that were both "most important" and also on the list of things with which tenants are least satisfied. The BOMA/ULI study found that the number one reason that tenants move out is because of HVAC heating/cooling problems.

The BOMA/ULI survey found that office tenants also highly value intelligent building features. These include modern energy-efficient HVAC systems and automatic sensors for lighting. According to the BOMA/ULI study, over 75% of office buildings do not have these intelligent features. The survey found that 72% of tenants who want an intelligent feature would be willing to pay additional rent to have the feature made available.

This and other studies make it clear that a high percentage of office tenants are dissatisfied with the indoor air quality (IAQ) and comfort of their work environment and express a willingness to pay for a greener, more comfortable and productive one.

California has developed its own requirements for IAQ that differ from and are in some ways more stringent than IAQ prerequisites contained in LEED. Although the new California IAQ requirements have been adopted for use in the East End complex, they are not required in new construction and have, as yet, not been generally applied. Until these new standards are incorporated, the LEED approach to IAQ offers a significant improvement over current California practices.

"Greening the Building and the Bottom Line: Increasing Productivity Through Energy-Efficient Design," a compilation of widely quoted original research and review of 20 case studies on documented productivity gains, (Joseph Romm and Bill Browning, "Greening the Building and the Bottom Line: Increasing Productivity Through Energy-Efficient Design," RMI, 1994. Available at: http://www.rmi.org/images/other/GDS-GBBL.pdf. See also: Joseph Romm, "Cool Companies," *Island Press*, 1999 for a useful set of business case studies), and "Green Development: Integrating Ecology & Real Estate," a general overview of green building case studies with a focus on productivity and health in green buildings (Excerpts from "Green Development: Integrating Ecology & Real Estate" available at: http://www.rmi.org/sitepages/pid219.php).
Some good general databases on the subject include: http://www.ciwmb.ca.gov/GreenBuilding/Basics.htm; http://www.gbapgh.org/On%20Green%20Building/ogb_economic_benefits.html; http://www.conservationeconomy.net/content.cfm?PatternID=30; and http://www.ci.sf.ca.us/sfenvironment/aboutus/greenbldg/gb_productivity.pdf.
See also EPA's excellent database on indoor air quality: http://www.epa.gov/iaq/largebldgs/i-beam_html/bibliography.htm.

[230] "What Office Tenants Want: 1999 BOMA/ULI Office Tenant Survey Report." To order, call 1-800-426-6292, or order on-line at www.boma.org, item #159-TENANT-029.

While the full range of design practices encouraged by LEED is available in Appendix A, the following are some relevant attributes common in green buildings that promote healthier work environments:

1) Much lower source emissions from measures such as better siting (e.g., avoiding locating air intakes next to outlets, such as parking garages, and avoiding recirculation), and better building material source controls (e.g., required attention to storage). Certified and Silver level green buildings achieved 55% and Gold level LEED buildings achieved 88% of possible LEED credits for use of the following:[231]

    a. less toxic materials
    b. low-emitting adhesives & sealants
    c. low-emitting paints
    d. low-emitting carpets
    e. low-emitting composite wood
    f. indoor chemical & pollutant source control

2) Significantly better lighting quality including: more daylighting (half of 21 LEED green buildings reviewed provide daylighting to at least 75% of building space[232]), better daylight harvesting and use of shading, greater occupancy control over light levels and less glare.
3) Generally improved thermal comfort and better ventilation – especially in buildings that use underfloor air for space conditioning (see Section IX).
4) Commissioning, use of measurement and verification, and CO2 monitoring to ensure better performance of systems such as ventilation, heating and air conditioning (see Section IX).

The links between specific LEED credits and productivity are reviewed in other publications.[233]

One of the most authoritative studies to date quantifying potential health and productivity benefits from improved indoor environments was undertaken by William Fisk, head of the Indoor Environment Department at Lawrence Berkeley National Laboratory, and colleagues. Their findings, estimated across the US, are summarized below and reflect analyses and syntheses of a large number of prior studies. Fisk et al. divided the health benefits provided by better buildings into four principal areas: acute respiratory illness, allergies and asthma, sick building syndrome symptoms, and direct productivity gains. A summary of the rationale and supporting data and assumptions underlying Fisk's calculations is included as Appendix J.

---

[231] Capital E analysis of USGBC data (based on analysis of points actually achieved in building performance data submitted to USGBC), November and December 2002. For more detail on achievable reductions from some of these indoor emissions sources, please see: Hodgson AT. "Common Indoor Sources of Volatile Organic Compounds: Emissions Rates and Techniques for Reducing Consumer Exposures." University of California, Lawrence Berkeley National Laboratory. 1999.
Prepared for California Air Resources Board.
Available at: http://www.arb.ca.gov/research/apr/past/indoor.htm#Toxic%20Air%20Contaminants.

[232] Capital E analysis of USGBC data, November and December 2002.

[233] See for example: Jonathan Weiss, Kath Williams and Judith Heerwagen, "Human Centered Design for Sustainable Facilities," Available from authors: j.heerwagen@att.net or williams@global.net.

Figure VIII-2. Potential Productivity Gains from Improvements in Indoor Environments

Source of Productivity Gain	Potential Annual Health Benefits	Potential U.S. Annual Savings or Productivity Gain (2002 dollars)
1) Reduced respiratory illness	16 to 37 million avoided cases of common cold or influenza	$7 - $16 billion
2) Reduced allergies and asthma	8% to 25% decrease in symptoms within 53 million allergy sufferers and 16 million asthmatics	$1 - $5 billion
3) Reduced sick building syndrome symptoms	20% to 50% reduction in SBS health symptoms experienced frequently at work by ~15 million workers	$10 - $35 billion
4) Sub-total		*$18 - $56 billion*
5) Improved worker performance from changes in thermal environment and lighting	Not applicable	$25 - $180 billion
6) Total		*$43 - $235 billion*

Adapted from: William Fisk, "Health and Productivity Gains from Better Indoor Environments"[234]

The first two sources of productivity gain outlined in Figure VIII-2 are only partially attributable to the work environment, so this report assumes that potential health benefits are therefore reduced to a range of $12 to $45 billion annually. Productivity benefits from both health improvement and from improvement in thermal environment and lighting are reduced to a range of $35 to $225 billion. Note that there are other, less substantial sources of potential health related benefits that are not included in Figure VIII-2, making these estimates of benefits potentially low.

Assuming a low value of $25 billion, this translates into $385 in direct health improvement potential for each of the 65 million full time office workers and teachers in the US.[235] If one third of these benefits can be achieved in a green building, this translates into about $130 per year in health-related financial benefits. With 225 ft^2 in average space per worker, this suggests a potential annual productivity gain of $0.58/ft^2.

If we assume a mid-range value of $140 billion in potential productivity benefits (line 6 in Figure VIII-2), and assume that 1/3 of these benefits could be achieved from respiratory health benefits

[234] William Fisk, "Health and Productivity Gains from Better Indoor Environments," summary of prior publications (see Appendix J), with figures inflation-adjusted for 2002 dollars and rounded.
See also:
W.J. Fisk, "Health and Productivity Gains from Better Indoor Environments and Their Relationship with Building Energy Efficiency," *Annual Review of Energy and Environment* 25(1): pp. 537-566.
W.J. Fisk and A.H. Rosenfeld. "Estimates of Improved Productivity and Health from Better Indoor Environments," *Indoor Air* 7(3), 1997: pp. 158-172.

[235] Adjusted up from 63.5 million in Fisk. Note that Fisk includes ½ of military personnel, who are assumed to be office workers. For more on the size and composition of the US workforce, see: *Statistical Abstract of the United States*, US Census Bureau, 2001.
Available at: http://www.census.gov/prod/2002pubs/01statab/stat-ab01.html.

and thermal and lighting improvements in green buildings, this translates into about $718 per worker per year. This suggests a potential annual productivity gain of $3.19/ft^2 per worker, or slightly over 1% per year.

A review published by ASHRAE compares commonly used measures of productivity with HVAC system performance. In the study, the authors evaluate 262 references and feature the 53 most rigorous and significant ones. These demonstrate a positive correlation between measures common to green buildings and productivity, absenteeism, and related issues.[236]

A National Science and Technology Council project entitled *Indoor Health & Productivity* was established to collect and communicate research findings relating workplace attributes – including lighting, thermal comfort, air quality and ventilation – to human health and productivity. The database contains over 900 papers from more than 100 journals and conferences. There are abstracts for about 700 of these articles, and the entire database is searchable by fields such as author and category (e.g., acoustics, humidity, ventilation) or by keywords such as sick building, visual comfort or HVAC.[237] There is a very large body of technically sound studies and documentation linking health and productivity with specific building design operation attributes – e.g., indoor air quality and tenant control over work environment, including lighting levels, air flow, humidity and temperature. It is clear that green building measures that improve these attributes increase worker comfort, health, well-being and measured productivity.

Two studies of over 11,000 workers in 107 European buildings analyzed the health effect of worker-controlled temperature and ventilation. They found significantly reduced illness symptoms, reduced absenteeism and increases in perceived productivity over workers in a group that lacked these features.[238]

Seattle City Light has compiled over 30 projects that document productivity, increased retail sales and increased student learning resulting from incorporation of green design elements.[239] The program intends to create a database documenting the impact of green features on worker comfort, health, productivity and related measures for all municipal buildings that meet or exceed LEED Silver level and is preparing to release a study of a dozen Seattle green buildings, including costs and benefits.

Productivity Benefits for Specific Worker Control/Comfort Upgrades

One of the leading national centers of expertise on the benefits of high performance buildings is the Center for Building Performance at Carnegie Mellon University. The Center's Building Investment Decision Support (BIDS) program has reviewed over 1000 studies that relate

[236] Sensharma et al., "Relationships Between the Indoor Environment and Productivity: A Literature Review," published in *ASHRAE Transactions* 1998, Vol. 104.
[237] An online bibliography as well as more information about this project can be found at http://www.dc.lbl.gov/IHP/. The website includes 5 useful brief reviews of key findings in the area of health, productivity and school test scores that were published in ASHRAE Journal, May 2002.
[238] Judith Heerwagen, "Sustainable Design Can Be an Asset to the Bottom Line - expanded internet edition," *Environmental Design & Construction*, Posted 07/15/02. Available at: http://www.edcmag.com/CDA/ArticleInformation/features/BNP__Features__Item/0,4120,80724,00.html.
[239] See "High Performance Building Delivers Results," *The Sustainable Demand Project – A Project of the Urban Consortium Energy Task Force of Public Technology*, City of Seattle, Seattle City Light, December 2000. Available at: http://www.cityofseattle.net/light/conserve/sustainability/SDPFRa.pdf.

technical characteristics of buildings, in areas such as lighting and ventilation, to tenant responses, such as productivity. Of these studies, the Center has identified 95 that are sufficiently rigorous and quantitative to meet their criteria for inclusion in the BIDS database and decision making tool, making it perhaps the most valuable database of its kind.[240]

Collectively, these studies demonstrate that better building design and performance in areas such as lighting, ventilation and thermal control correlate to increases in tenant/worker well-being and productivity. The BIDS data set includes a number of controlled laboratory studies where speed and accuracy at specific tasks was measured in low and high performance ventilation, thermal control and lighting control environments. These studies used a range of speed and accuracy performance measures including: typing, addition, proof reading, paragraph completion, reading comprehension, and creative thinking.[241]

Increases in tenant control over ventilation, temperature and lighting each provide measured benefits from 0.5% up to 34%, with average measured workforce productivity gains of 7.1% with lighting control, 1.8% with ventilation control, and 1.2% with thermal control. Additionally, measured improvements have been found with increased daylighting, as discussed in the following section.

Figures VIII-3, VIII-4 and VIII-5 on the subsequent pages were supplied by the Department of Architecture at Carnegie Mellon University. They represent ongoing research, and as such should be considered interim.[242]

[240] Vivian Loftness et al., "Building Investment Decisions Support (BIDS)," *ABSIC Research 2001-2002 Year End report.* See: http://nodem.pc.cc.cmu.edu/bids. Carnegie Mellon's BIDS™, for Building Investment Decision Support, is a case-based decision-making tool that calculates the economic value added of investing in high performance building systems, based on the findings of building owners and researchers around the world.
[241] Communication with Vivian Loftness, CMU, February 2003.
[242] Data extracted from BIDS™. Carnegie Mellon University Department of Architecture. February 2003. (Vivan Loftness).

Figure VIII-3: Increased Ventilation Control

The 13 studies summarized below by CMU show a consistently significant positive correlation between increased control over ventilation and increased productivity – ranging between 0.5 % and 11%, with most studies clustering around 1% and an average of 1.8%.

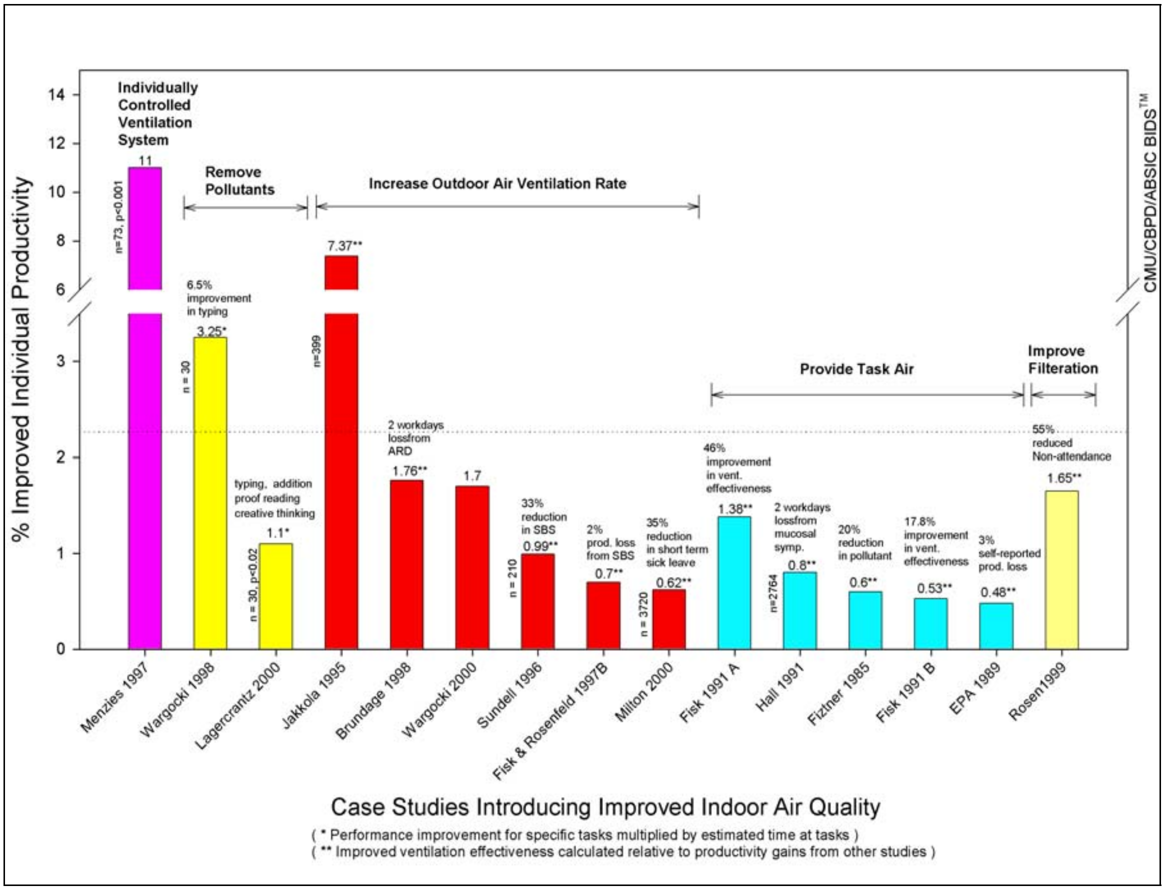


Figure VIII-4: Increased Temperature Control

The Center also looked at studies examining productivity impacts of worker control over temperature. As noted earlier, the BOMA/ULI study found that lack of control over temperature was one of only two features considered by respondents as both most important and of lowest tenant satisfaction. The mean productivity increase for temperature control in these seven studies is 1.2%.

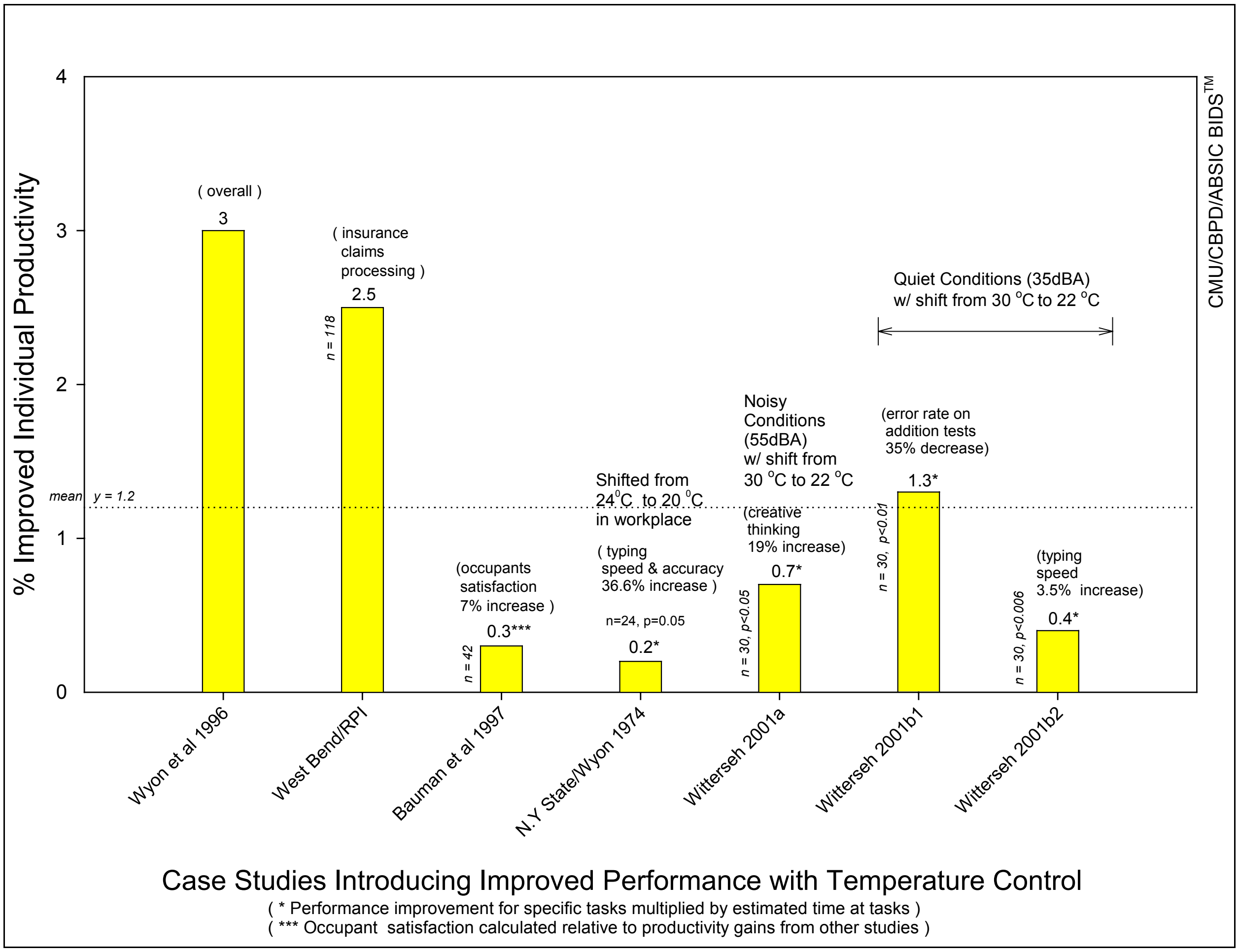
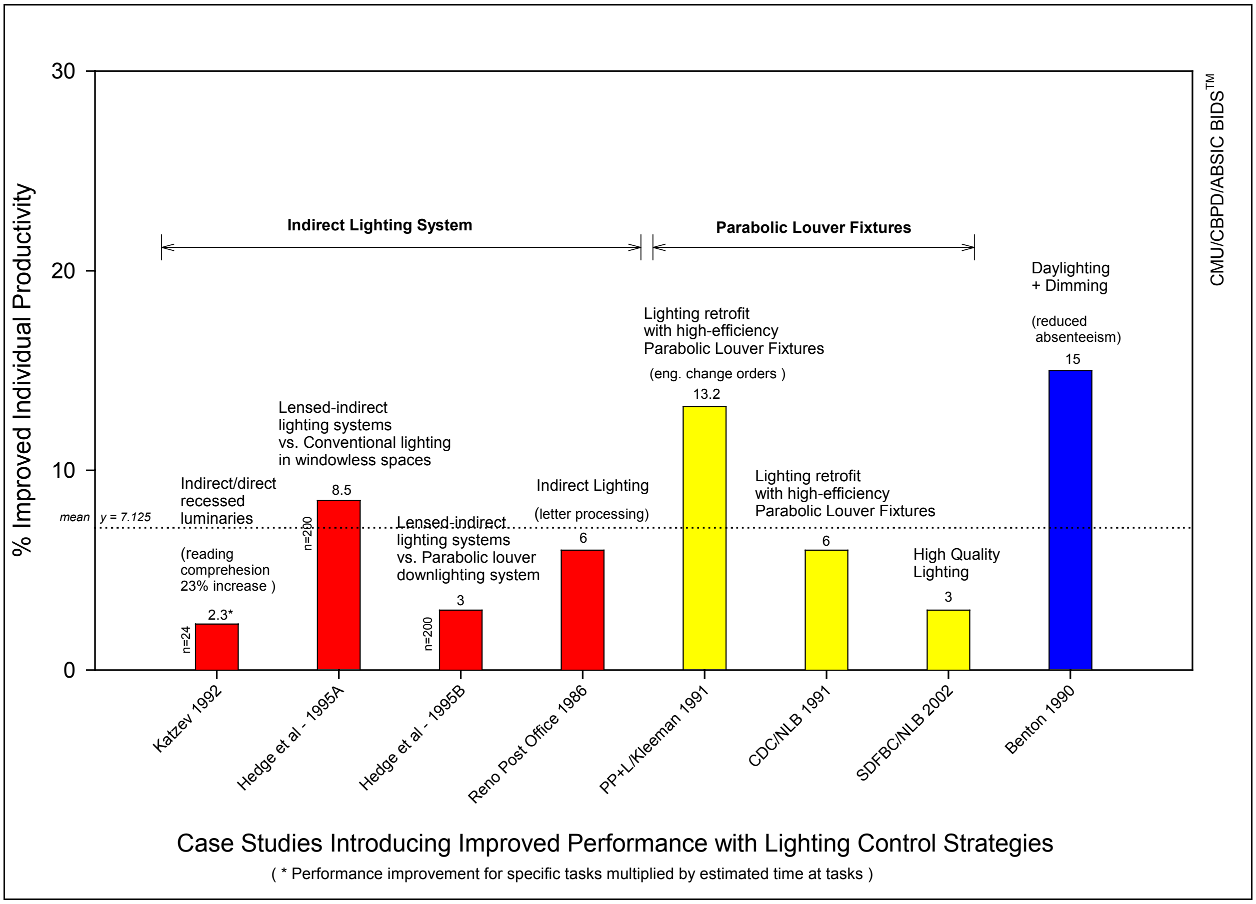


Figure VIII-5: Increased Lighting Control

Eight studies measured the relationship between increased lighting control and productivity, finding productivity gains ranging from 3% up to 34%, with a mean of 7.1%.



Increased Daylighting

A study by the Heschong Mahone Group evaluated the test score performance of over 21,000 students in three school districts in San Juan Capistrano, CA; Seattle, WA; and Fort Collins, CO. The study found that in classrooms with the most daylighting, students' learning progressed 20% faster in math and 26% faster in reading than similar students in classrooms with the least daylighting. The overall findings show that increased daylighting and generally improving quality of lighting significantly improves student test performance.[243] The study's results have been widely quoted, although the large impact of daylighting quality surprised some people and raised questions about the technical thoroughness of the report. To ensure the study's validity, California's Public Interest Energy Research (PIER) program, administered by the CEC, funded a follow up study, employing an independent technical advisory group to reanalyze the data. The reanalysis confirmed the initial study's findings with a 99.9% confidence level.[244]

The kind of work done by "knowledge workers" – most state employees – is very similar to the work students do. Tasks include: reading comprehension, synthesis of information, writing, calculations, and communications. Large-scale studies correlating daylighting with student performance on standard tests therefore provide relevant insight about the impact of increased daylighting on state employees.

This study is important for its size, rigor and the large measured impact of lighting quality on standardized test performance. Note that the study compares performance between students with the greatest amount of daylighting and those with the least daylighting – two extremes. Therefore it is difficult to use this study to predict benefits of enhanced daylighting common in green buildings relative to conventional buildings. The productivity benefits that could conservatively be expected are much less than 26% (which reflects extremes in daylighting), perhaps on the order of 2% to 6%.

Sick Building Syndrome

Following (see text box, *The cost of sick building syndrome for California state and school employees,* below) are the results of an analysis of the cost of sick building syndrome (SBS) for California state and school employees.[245] It assumes a "conservative" 2% productivity decrease due to SBS symptoms. By comparison, a 2000 evaluation of three buildings with a total of over 600 occupants for the Portland Energy Office estimated a 1% increase in productivity and noted that this is "a very conservative estimate." [246] A National Energy Management Institute (NEMI) study entitled *Productivity and Indoor Environmental Quality*, estimates that productivity gains

---

[243] Heschong Mahone Group, "Daylighting in Schools: An Investigation into the Relationship Between Daylight and Human Performance," 1999. Available at: http://www.h-m-g.com; Follow up studies verified the rigor of analysis and subsequent research continues to show positive correlation between daylighting and student performance.

[244] Heschong Mahone Group. 2002. "Daylighting in Schools Re-Analysis." Available at: http://www.newbuildings.org/pier/index.html.

[245] Original report by Leon Alevantis, Deputy Chief of Indoor Air Quality Section, California Department of Health Services, updated for this report by the author.

[246] "Green City Buildings: Applying the LEED Rating System," prepared for the Portland Energy Office by Xenergy, Inc and SERA Architects, June 18, 2000.
Available at: http://www.sustainableportland.org/CityLEED.pdf.

of 1.5% in "generally healthy" buildings are possible and even conservative.[247] As part of the state of California's Block 225 Capitol Area East End project, the Center for the Built Environment will be conducting a productivity analysis of workers related to indoor environmental quality efforts in that building. However, results from this study are not expected for approximately 2-3 years.[248]

The cost of sick building syndrome for California state and school employees
By Leon Alevantis, California Department of Health Services

SBS symptoms are most commonly reported by office and classroom workers. These workers make up about half of the state workforce. The impact of SBS to California office and classroom workers may be calculated as follows:

California office and classroom workers:

A telephone-based, state-wide survey of 14,729 adults (18 years or older) conducted in 1999 on behalf of the California Department of Health Services (DHS),[1] found that 54% of the adult population worked indoors. According to the 1999 California Current Population Survey, there were about 24 million adults living in California. Therefore, in 1999 there were about 13 million adults working indoors. Of those working indoors, according to the DHS survey, 54% or 7 million worked in an office or a classroom. This is about 44% of the annual average employment for 1999 (which was about 16 million).

SBS costs to California office and classroom workers:

Multiplying the number of California office and classroom workers by an annual average compensation of $43,000 (which was the annual average for these professions in 1998 according to data from the California Employment Development Department, excluding benefits and allocated O&M costs) and an estimated conservative decrease of 2% in productivity caused by SBS symptoms[2] the resulting cost of SBS symptoms to California is about $6 billion. Assuming that the average cost for benefits plus allocated O&M costs is an additional 50% of each worker's annual compensation, the resulting overall cost of SBS to California employers is about $9 billion.

Furthermore, published data indicate that 23% of office workers and teachers reported two or more frequent symptoms that improve when they leave their workplace. This implies that about 2 million California office workers and teachers are frequently affected by at least two SBS symptoms.

[1] California Department of Health Services, "1999 California Tobacco Surveys (CTS)."
[2] W.J. Fisk, "Health and Productivity Gains From Better Indoor Environments and Their Relationship with Building Energy Efficiency," *Annual Review of Energy and the Environment,* 25 (1): 537-566.

[247] Thomas Kelly, "Measuring the ROI of IAQ", *Buildings*, March 1999. And see: http://www.nemionline.org/.
[248] Field Study of Capitol Area East End Complex. Center for the Built Environment. See: http://www.cbe.berkeley.edu/research/briefs%2Deastend.htm.

Conclusion

There is no standard for estimating the exact productivity impact of a green building. Each green building has a different set of technologies and design attributes, and each building population has different health attributes and comfort needs.

However, four of the attributes associated with green building design – increased ventilation control, increased temperature control, increased lighting control and increased daylighting – have been positively and significantly correlated with increased productivity. Additionally, there is a large range in potential productivity and health gains from improved indoor environmental quality summarized in Figure VIII-2.

There are also quantifiable green building gains in attracting and retaining a committed workforce – an aspect beyond the scope of this report. Attracting and retaining the best employees can be linked to the quality of benefits that workers receive, including the physical, environmental and technological workplace. Green buildings are designed to be healthier and more enjoyable working environments. Workplace qualities that improve the environment of knowledge workers may also reduce stress and lead to longer lives for multi-disciplinary teams.[249]

It is beneficial for the state of California to maximize health and productivity benefits across a large number of employees and a large number of buildings. The studies cited above indicate significant and measured productivity benefits across a large population of workers and multiple green buildings. Productivity impacts could be even greater in California schools, which often exhibit poor environmental health conditions and a lack of adequate maintenance (and associated maintenance budgets).[250] Therefore improvements in air quality in schools could have significant economic and human health benefits.

LEED rated buildings all address some combination of measures that help reduce the pollutants that cause sickness and increase health care costs; improve quality of lighting and increase use of daylighting; and increase tenant control and comfort. A review of LEED prerequisites and credits (see Appendix A) indicates that LEED is designed to specifically address the materials, designs and operations affecting productivity and health issues discussed above. Credits directly relating to productivity are included in the Indoor Environmental Quality section with two prerequisites and 15 credits (about 22% of total credits available). A preliminary review of green buildings submitted for USGBC certification confirms that these buildings consistently include a range of material, design and operation measures that directly improve human health and productivity. Gold and Platinum level LEED buildings are more comprehensive in applying IEQ-related measures and therefore should be viewed as providing larger productivity and health benefits than Certified or Silver level green buildings.

Calculation

Given the studies and data reviewed above, this report recommends attributing a 1% productivity and health gain to Certified and Silver level buildings and a 1.5% gain to Gold and Platinum level buildings. These percentages are at the low end of the range of productivity gains for each of the

[249] Communication with Vivian Loftness, CMU, February 2003.
[250] California Air Resources Board and California Department of Health Services. Draft Revised Report to the California Legislature: "Environmental Health Conditions in California's Portable Classrooms." 2003. Available at: http://www.arb.ca.gov/research/indoor/pcs/pcs.htm.

individual specific building measures – ventilation, thermal control, light control and daylighting – analyzed above. They are consistent with or well below the range of additional studies cited above.

For state of California employees, a 1% increase in productivity (equal to about 5 minutes per working day) is equal to $665 per employee per year, or $2.96/ft^2 per year.[251] A 1.5 % increase in productivity (or a little over 7 minutes each working day) is equal to $998 per year, or $4.44/ft^2 per year. At $4.44 per year, over 20 years and at a 5% discount rate (assuming that state employee salaries are unchanged with respect to inflation), the PV of the productivity benefits is about $36.89/ft^2 for Certified and Silver level buildings, and $55.33/ft^2 for Gold and Platinum level buildings. Assuming a longer building operational life, such as 30 or 40 years, would result in substantially larger benefits.

Note on Education [252]

LEED is broadly applicable to most commercial type buildings, and in most cases aspects of LEED will translate easily into other infrastructure areas. However, there are several issues that are specific to education buildings, particularly classrooms and laboratories. The US Environmental Protection Agency and the Department of Energy have collaborated to develop the Laboratories for the 21st Century or Labs21[253] program, which outlines a series of Environmental Performance Critera specific to laboratories. The USGBC is working with Labs21 in the hopes of developing a joint "LEED for Labs." K-12 classrooms also present a special case not specifically addressed by LEED.

California's Collaborative for High Performance Schools (CHPS)[254] has already had a substantial and very positive impact on California schools. For example, the Los Angeles Unified School District is one of five districts throughout the state that have adopted CHPS for all new K-12 school construction.[255] The CHPS program has developed a three volume Best Practices Manual outlining a range of green design technologies and practices.

CHPS and LEED are very compatible, with limited differences between the two programs. CHPS is self-certifying whereas USGBC is responsible for LEED certification. CHPS addresses acoustics, requires greater attention to on-site toxics and requires a higher level of energy performance. LEED includes several measures not in CHPS, including post occupancy requirements such as measurement and verification.[256] CHPS focuses just on schools. While there is currently no direct interchangeability between the CHPS and LEED rating systems, CHPS is working with the USGBC to develop a Memorandum of Understanding, which would formally establish the relationship between CHPS and the USGBC. Internally, the USGBC has

---

[251] Average 2002 California employee compensation is $66,469 and average space per employee is 225 ft^2. Both numbers are discussed earlier in this section.

[252] This note on education was reviewed by Nigel Howard, VP of USGBC and Charles Eley, Executive Director of CHPS.

[253] Labs 21 Environmental Performance Criteria, Version 2.0. October 2002. Available at: http://labs21.lbl.gov/EPC/intro.htm.

[254] See page 7 for a more thorough discussion of CHPS. Also see: http://www.chps.net/ and http://www.dsa.dgs.ca.gov/Sustainability.

[255] Los Angeles Unified School District. Board of Education. "Resolution on the Design and Construction of High Performance Schools," November 2002. Available at: http://chps.net/chps_schools/pdfs/LAUSD_res.pdf. See also: http://chps.net/chps_schools/districts.htm.

[256] Discussion with Charles Eley, Eley & Associates, March 26, 2003. See also CHPS Criteria. Available at: http://chps.net/manual/index.htm#vol3.

considered developing a LEED for schools application guide. However, much of this work has already been completed through the development of CHPS performance criteria. Establishing consistency between LEED and CHPS, perhaps with CHPS serving the basis for a national LEED for schools application guide, will help ensure these two complementary programs work together.

Green building and sustainability has also started to influence construction of higher education facilities. In early 2002, the Los Angeles Community College District Board of Trustees committed to a 25% renewable energy standard and adopted a minimum LEED Certified level target for future construction. They allocated $35 million of an overall budget of $1.2 billion, or almost 3%,[257] for green construction.

Most recently, in July of 2003, the University of California Board of Regents, informed in part by an early draft of this report, adopted a green building and clean energy policy for all future new construction on campuses system wide.[258]

It is worth noting that:

- 6.2 million children, teachers and administrators – one fifth of California's population – spend their day inside schools.
- Only 43% of high-volume chemicals have been tested for potential human toxicity, and only 7% have been tested for their effect on children's development.[259]
- Asthma is the leading cause of admission of urban children into hospitals and the leading cause of days absent from school.[260]

LEED Gold design can be expected to provide a significant level of protection against potentially toxic chemicals and against a rising incidence of asthma and allergies. Gold level green buildings typically achieve much higher levels of compliance with LEED IEQ enhancement measures than Certified or Silver buildings. This could include the use of low emitting materials for adhesives and sealants, paints, carpets, and composite woods as well as establishing indoor chemical and pollution source control. As noted in the productivity section, 13 Certified and Silver level green buildings reviewed achieved an average of about 55% of these LEED measures, while 8 Gold level LEED buildings achieved 88% of these credits.

This report recommends that higher education systems target the LEED Gold level, as it will likely be cost-effective to do so. Savings could be expected in energy, waste, and water, and – critically – substantial gains can be expected in student health and productivity.

---

[257] Los Angeles Community College District. "Proposition A Sustainable Building Principles and Energy Policy." Available at: http://www.propositiona.org/PropAInfo/SustainableBuildingPrinciples.asp.
[258] See: http://ucop.edu/regents/aar/julyd.pdf.
[259] Philip Landrigan et al, "Environmental Pollutants and Disease in American Children: Estimates of morbidity, Mortality, and Costs of Lead Poisoning, Asthma, Cancer and Developmental Disabilities," *Environmental Health Perspectives*, Volume 110, Number 7, July 2002.
Available at: http://ehpnet1.niehs.nih.gov/docs/2002/110p721-728landrigan/abstract.html.
[260] *Ibid.*

Several recent studies have begun to address the impact of high performance school facilities on student learning and teacher performance:

- As discussed earlier, the Heschong Mahone study examined student performance improvement on standardized tests for 22,000 students in 2000 classrooms in California, Colorado and Washington. Data from California schools (which is considered the most detailed) shows with a 99% statistical certainty that students with the most daylight progressed 20% faster in math and 26% faster in reading than students with the least daylighting.[261]
- A study of Chicago and Washington, DC schools found that better school facilities can add 3-4 percentage points to a school's standardized test scores, even after controlling for demographic factors.[262] This and other studies reviewed in the productivity section confirm a widely held, common sense perception that the physical quality of the classroom environment greatly affects how well children learn.
- An analysis of two school districts in Illinois, one small and one large, found that student attendance improved by 5% after incorporating cost effective indoor air quality improvements – regardless of school size (specifically, each site implemented the US EPA's IAQ Tools for Schools Program[263]).[264]
- A study of several Illinois schools found that 20% of teachers were averaging 4 days per year of sick leave due to IAQ problems.[265]

Green building improvements – especially for new buildings – appear to be very cost effective compared with other available measures to enhance student performance. Under the recently adopted Federal Education Bill, schools and states stand to lose billions of dollars in federal funding if students do not perform well on annual standardized tests. School and university systems should consider adopting whole building green design at the Gold level as a standard requirement in new school design and school retrofits.

Because the school market is relatively heterogeneous, it may be more difficult to quantify financial benefits to schools as compared to state office buildings. Additional research should address specific attributes of schools and university buildings to better refine estimates of financial benefits.

---

[261] To view a 30 page condensed version of the study, see: http://www.pge.com/003_save_energy/003c_edu_train/pec/daylight/di_pubs/SchoolsCondensed820.PDF.

[262] Mark Schneider, "Public School Facilities and Teaching: Washington, DC and Chicago," November 2002. A Report Prepared for the Neighborhood Capital Budget Group (NCBG). Available at: http://www.ncbg.org/press/press111302.htm.

[263] US Environmental Protection Agency. "IAQ Tools for Schools," December 2000 (Second Edition). Available at: http://www.epa.gov/iaq/schools/.

[264] Illinois Healthy Schools Campaign, "Apparently Size Doesn't Matter: Two Illinois School Districts Show Successful IAQ Management." *School Health Watch*, Summer 2003. Available at: http://www.healthyschoolscampaign.org/school%20health%20watch_summer-2003.pdf.

[265] NCBG, 2002. Op. Cit.

IX. Spotlighted Technologies and Methodologies

This section contains a brief review of the impact of three specific green building features or systems: commissioning, underfloor air distribution systems, and cool roofs. The energy, environmental and health benefits of these technologies and practices are included in the relevant sections above. However, one additional benefit of underfloor air – reduced cost of churn – is not accounted for elsewhere in this report, and is calculated below.

Similarly, commissioning benefits include reduced operations and maintenance (O&M) costs, a benefit not captured above and therefore calculated here. Commissioning is a process that ensures proper system design and installation, and reduces costs by eliminating errors. It is an important part of the integrated design approach and helps ensure that green building systems perform as expected. Since all LEED buildings include commissioning (it is a prerequisite) and are likely to include other measures that help address operations and maintenance issues, the O&M benefits of commissioning can be included in calculations of the full financial benefits of green buildings.

Commissioning, and Measurement and Verification

Commissioning – a methodology to ensure that building systems are installed and operated as planned – is an increasingly common practice.[266] It has been defined as the "process of ensuring that systems are designed, installed, functionally tested and capable of being operated and maintained according to the owner's operational needs." [267]

Commissioning is particularly important for green buildings, because they are expected to achieve better performance (e.g., low energy use, better air quality) than conventional buildings. LEED requires "Fundamental Building Systems Commissioning," which currently entails hiring a commissioning expert, developing a commissioning plan and completing a commissioning report. In addition, LEED provides credits for additional commissioning and for including a building performance measurement and verification program. The measurement protocol referenced in LEED, the International Performance Measurement and Verification Protocol [268] is also used internationally as a way to demonstrate CO2 reductions benefits, providing a potentially helpful way to secure financial value through sale of CO2 reductions associated with green buildings.[269]

---

[266] See for example, Karl Sturm, "The Importance of Commissioning Green Buildings," *HPAC Heating/Piping/Air Conditioning Engineering*, Feb. 2000. See also: Jay Enck, "Preserving Our Natural Resources through Design, Maintenance and Commissioning," *Engineered Systems*, May 2002.

[267] "Building Commissioning: The Key to Quality Assurance," *US DOE Rebuild America guide series*, p.9. Available at: http://www.rebuild.org/attachments/guidebooks/commissioningguide.pdf.

[268] See www.ipmvp.org. For purposes of disclosure, the principal author of the present report, Greg Kats, co-founded the IPMVP and served as its Chairman until 2001.

[269] Edward Vine, Gregory Kats, Jayant Sathaye, and Hemant Joshi, "International Greenhouse Gas Trading Programs: A Discussion of Measurement and Accounting Issues," *Energy Policy*, January 2003. Available at: http://www.ipmvp.org.

Commissioning and green buildings share:[270]

- Use of a systems approach.
- Use of life cycle perspective.
- Greater attention to design.

Estimated cost of commissioning as a percentage of construction costs varies with building size and is typically viewed as a higher percentage for smaller buildings. However, there is evidence that resulting savings more than pay for the cost of commissioning for both green and non-green buildings. A recent report found that costs of commissioning, including travel expenses, range from 2% to 4% for buildings costing less than $5 million, down to 0.5 % to 1% for buildings costing over $50 million. The study used nine case studies to illustrate why savings from commissioning exceeded the cost of commissioning even before the projects were complete. Commissioning:[271]

- Helped eliminate costly change orders.
- Reduced requests for cost information.
- Helped ensure proper system/component selection.
- Improved performance of building systems.
- Reduced call backs.

Basic commissioning required for LEED costs even less. In six recent LEED office buildings and schools the average cost of "Fundamental Building Systems Commissioning" required for the LEED prerequisite was equal to 0.3 to 0.6 % of construction costs.[272]

The Portland Energy Conservation study cites cases – including a California commercial property and a California university building – in which commissioning led to identifying substantial design and operating problems, and opportunities for substantial savings.[273] Commissioning can also provide potentially significant insurance related benefits (see Section X).

LEED includes an additional credit for system metering. Detailed analysis of several hundred million dollars of energy building upgrades demonstrate that rigorous measurement and verification of energy and water efficiency and system retrofits tend to:[274]

- Increase initial savings level.
- Increase persistence of savings.
- Reduce variability on energy and water savings.

---

[270] Carolyn Dasher, Amanda Potter and Karl Sturm, "Commissioning to Meet Green Expectations." 2000. Available at: http://www.peci.org/cx/CxGreen.pdf.
Dan York, "Commissioning Green Buildings: Two Wisconsin Case Studies," *Proceedings of the 6th National Conference on Building Commissioning*, PECI, 1998.

[271] Chad Dorgan, Robert Cox and Charles Dorgan, "The Value of the Commissioning Process: Costs and Benefits", Farnsworth Group, Madison WI, paper presented at the 2002 *US Green Building Council Conference*, Austin, Texas.
Available at: http://www.usgbc.org/expo2002/schedule/documents/DS506_Dorgan_P152.pdf.

[272] Data provided by Bill Reed, Natural Logic, December 2002. http://www.natlogic.com/.

[273] Carolyn Dasher et al. Op. Cit.

[274] Greg Kats, Art Rosenfeld, and Scott McGaraghan, "Energy Efficiency as a Commodity: The Emergence of a Secondary Market for Efficiency Savings in Commercial Buildings," *1997 ECEEE Conference Proceedings*. Available at: http://www.ipmvp.org/info/ece397.pdf.

Commissioning and metering help ensure that buildings meet and maintain performance targets – including green performance targets. They make it easier to document and claim benefits in such areas as indoor air quality, productivity and emissions reductions. Improved metering allows building mangers to better manage upgrades and maintenance, helping to anticipate and avoid equipment failure, leaks and other costly operations and maintenance (O&M) problems.

Thus, commissioning and metering contribute to lower O&M costs, such as extended equipment life, though how much lower is not known. O&M costs in state buildings – $3,039 per person per year[275] or $\$12.25/ft^2/yr$ – are nearly an order of magnitude larger than energy costs. Therefore any reduction in O&M costs has a significant impact on financial benefits. For example, a reduction in O&M costs of 10% is equal to a savings of $304 per person, or $\$1.35/ft^2$ per year. There is not enough data to estimate with any precision the reduction in O&M costs that would occur in green buildings. Clearly the reduction is larger than zero but probably under 25%. To be conservative, this report assumes that green buildings experience an O&M cost decline of 5% per year. This equals a savings of $\$0.68/ft^2$ per year, for a 20-year PV savings of $\$8.47/ft^2$.

Additional research on the O&M impact of green buildings is strongly recommended. Note that the reported savings in areas other than O&M appear to entirely pay for the cost of commissioning, so commissioning costs do not need to be deducted from the O&M-related financial savings.

Underfloor Air

It is estimated that underfloor or raised floor HVAC systems are used in 58% of new commercial buildings in Japan and half of new commercial buildings in Europe, but in only 10% of new commercial buildings in North America.[276] Only 2 of 21 green buildings reviewed included underfloor air,[277] the same percentage as conventional buildings, although there are strong indications that the use of underfloor air is rising in all US construction, and rising more rapidly in new US green building construction. Advocates of underfloor air cite a range of benefits relative to conventional overhead air distribution systems, including:

- Reduced life cycle building costs.
- Improved ventilation efficiency and indoor air quality.
- Reduced energy use.
- Lower cost of churn.
- Quieter working spaces resulting in greater occupant satisfaction.

Underfloor air is "an innovative technology that uses the underfloor plenum below a raised floor to deliver space conditioning in offices and other commercial buildings."[278] Typically this involves either a pressurized underfloor plenum with a central air handler delivering air through

---

[275] Data provided by the California Department of General Services, Real Estate Services Division, December 2002.
[276] Andy Karvonen, "The Revolution is Underfoot," *Environmental Design & Construction*, posted 01/15/2001. Available at: http://www.edcmag.com/CDA/ArticleInformation/features/BNP__Features__Item/0,4120,18731,00.html.
[277] Data provided by the US Green Building Council. January 2003. (Brendan Owens)
[278] Fred Bauman and Tom Webster, "Outlook for Underfloor Air Distribution," *ASHRAE Journal*, June 2001.

passive grills or diffusers, or a zero pressure plenum with air delivered though local fans in combination with a central air handler.[279] The most significant cost savings from underfloor air is the lower cost of "churn" – the cost of moving employees within buildings. There are also significant HVAC energy savings as demonstrated at the Block 225 building in the Capitol Area East End Complex in Sacramento.[280]

Underfloor air has been adopted less rapidly in the United States than some experts had anticipated, due in part to its newness as a technology, limited applicability to retrofit construction and perceived higher costs. Published costs for specific projects range from negative first cost[281] to $3/ft^2 [282] and higher. The actual costs appear to be very dependent on when the underfloor air systems are integrated into building design and construction. In the case of the state of California's Department of Education building (Block 225 of the East End Complex), underfloor air was added late in the design process through a change order and ended up adding about $4 million to the total construction costs. Block 225 of the East End complex experienced construction costs of only 1.9% above conventional design due to green elements other than underfloor air.[283]

According to Oppenheim Lewis Inc., a well-respected construction cost estimating firm in the San Francisco Bay Area, underfloor air systems, when integrated from the start of design, cost *slightly less* than overhead systems. In these cases, the lowered costs of the architectural, mechanical, and electrical work more than offset the higher materials and installation costs. A more precise breakdown is presented in Figure IX-1 below:

Figure IX-1. Capital Cost Analysis of Overhead (conventional) Air Systems vs. Underfloor Air[284]

Cost Component	Overhead	Underfloor
Architectural Work	$17.00	$14.50
Raised Access Floor	$ N/A	$ 7.00
Mechanical Work	$16.50	$12.40
Electrical	$ 7.00	$ 6.00
Total Cost	**$40.50/ft^2**	**$39.90/ft^2**

Source: Vivian Loftness, "Energy Savings Potential," June 2002

Perhaps the most comprehensive and authoritative US study to date of underfloor air and its costs and benefits, *Energy Savings Potential of Flexible and Adaptive HVAC Distribution Systems for*

[279] These descriptions are drawn from "Technology Overview" of underfloor air posted on the Berkeley Center for the Built Environment Home Page. Available at: http://www.cbe.berkeley.edu/underfloorair/techOverview.htm.
[280] Data provided by 3D/I, Project consultant on Capitol Area East End Complex. March 2003. (Jim Ogden).
[281] Michael Maybaum, "A Breath of Fresh Air," *Building Operating Management, HVAC*, January 1999, p.21.
[282] Bauman and Webster. Op. Cit.
[283] See also: Anthony Bernheim, "Saving Resources," *Urban Land*, June 2001. Also, See: http://www.ciwmb.ca.gov/GreenBuilding/CaseStudies/GovtOffice/EastEnd.htm; "Greening" of the East End website: http://www.eastend.dgs.ca.gov.
[284] Oppenheim Lewis, Presentation by Kevin Hyde et al., "Life-cycle Cost Analysis & Green Buildings Completing the Picture." Data assembled from V. Loftness et al., "Energy Savings Potential," June 2002.

Office Buildings, was undertaken by a team of six experts from Carnegie Mellon's Center for Building Performance and Diagnostics and the Oak Ridge National Laboratory.[285] The report surveys over 300 relevant case studies worldwide and selects the most rigorous of these. In nine studies with detailed cost estimates, underfloor air came with a premium of \$0 to \$3/ft^2, with one study showing a cost of \$6/ft^2 and two studies showing a cost of \$1 to \$3/ft^2.[286] The churn savings in this study range from \$1 to \$5 per square foot per move, or an annual savings of \$0.40 to \$2.00/ft^2/yr.[287]

The report finds that underfloor air typically provides energy savings in the range of 5% to 30% below conventional overhead systems, and provides measurable benefits in air quality, ventilation effectiveness and productivity. These attributes are part of why underfloor air is promoted in green building design. This section will focus on determining a reasonable and conservative estimate of the benefits associated with reduced cost of churn – a benefit not usually included in building design decisions. Estimating the churn savings from underfloor air can help quantify the full value of green buildings.

Churn Costs

The most significant cost savings from underfloor air is lower cost of "churn" – the cost of moving employees within buildings. As a recent valuable review of churn by Herman Miller describes, with underfloor air "floor layouts can be changed quickly, because power and cabling can be quickly relocated: and simple, easy to use furniture can be used because it does not need to carry large amounts of power and cabling."[288]

In 1995, a study by the International Facility Management Association (IFMA) of its 2200 members found an average churn rate of 35%.[289] This rate rose above 40% in 1997, with a churn rate of 48% reported for service and manufacturing companies.[290] Churn is generally higher for high tech firms and is likely to be lower for government agencies. In California state agencies, the frequency of costly "mass relocation from one building to another" is approximately once every 8 years[291] or 12.5% per year. There appears to be little hard data about churn rate within state buildings or for smaller, less costly, and very probably more frequent moves. In the absence of harder data on churn rate in government agencies, this analysis assumes an average churn rate of 30% for state of California employees, well below the IFMA reported industry average.

In the early 1990s, T.R.York found an average cost premium of \$2.29/ft^2 for underfloor air, but a churn savings of \$257 per year per employee from the greater ease of employee relocation.[292] A

---

[285] Vivian Loftness et al., "Energy Savings Potential of Flexible and Adaptive HVAC Distribution Systems for Office Buildings," Center for Building Performance and Diagnostics and the Oak Ridge National Laboratory, prepared for the *Air-Conditioning and Refrigeration Technology Institute*, June 2002. Available at: http://www.arti-21cr.org/research/completed/finalreports/30030-final.pdf.

[286] *Ibid,* Figure 10, p. XIII.

[287] *Ibid*, p. 91. This assumes an industry average churn rate of 40%.

[288] "Churn in the Workplace Understanding and Managing Its Impact," Herman Miller, 2001. Available at: http://www.hmeurope.com/WhitePapers/wp_Churn_in_Workpl.pdf.

[289] See: http://www.ifma.org/profdev/research/report16.cfm?actionbig=7&actionlil=166.

[290] IFMA Research Report #18, Benchmakers III, p. 36 and other documents on http://www.ifma.org/. See also: http://www.datathing.com/amaze/Main.asp.

[291] Data provided by the California Department of General Services, Real Estate Services Division, December 2002.

[292] T.R. York, "Can You Afford An Intelligent Building?" *FM Journal*, September/October 1993, pp. 22-27. Summarized in the Carnegie Mellon BIDS database: http://nodem.pc.cc.cmu.edu/bids/index.asp.

1996 study by Flack & Kurtz of an Owens Corning building found a $2/ft^2 first cost savings from raised floor cooling,[293] as well as $1.50/ft^2 in annual savings from the lower cost of churn.[294] DowElanco Corporation (a partnership between Dow Chemical Company and Eli Lilly) found the cost of relocating a workstation in an office with underfloor air to be $2.35/ft^2 compared with $20/ft^2 for hard walled offices.[295]

A more recent detailed examination was made of the Soffer Tech Office Building, a 64,000 ft^2 speculative office building constructed in Pittsburg. A study of this building shows churn savings significantly outweighing the additional costs of installing underfloor air. The combination of high performance design elements – a raised plenum with relocatable diffusers and relocatable wiring – cost $29.03/ft^2, or an additional $0.27/ft^2 over a conventional system, which would cost $28.76.[296] This represents a cost difference of less than 1% between a conventional overhead system and an underfloor air system.[297] The cost savings in of each reconfiguration is estimated at $4.66/ft^2, or about 7 times the initial additional capital cost of the high performance design. Assuming an average churn rate of 0.3 times per year (30% of office workers move each year) an annual churn cost of $1.86/ft^2 is avoided. This indicates a payback ($0.27/$1.86)– assuming a $0.27 initial capital cost increment – of under two months.

Another example of reduced churn costs is provided by the Pennsylvania Department of Environmental Protection. In one conventional office building they measured a cost of about $2,500 per move. (This churn cost is high and reflects the varying costs of moving.) In a new building with raised access flooring, underfloor air, and quick-disconnect manufactured power and teledata cabling, this cost dropped to approximately $250 per workstation, or 90% less.[298]

Conclusions

According to the IFMA 1998 Experience Exchange Report, the average cost of a move is $1063 per employee.[299] Other reports indicate a somewhat lower average cost of moving, reflecting varieties in the definition of moving. According to IFMA, a simple move to and from existing workplaces costs $173, a move including relocation of furniture costs $712 per move, and a move requiring construction costs $2100. Actual yearly moving costs are therefore dependent on what types of moves occur. The reported cost for moving a California state employee is $350, including phone line. Installation of a data line costs $200, so a simple move involving data line installation would cost $550.[300] Larger moves, especially involving construction, cost significantly more. State employees have a 12.5% rate of mass moves to other buildings (cited above), which would typically involve much higher costs, probably on the order of $1000 to $2000 per move. This limited data suggests move costs may be consistent with or somewhat less

293 Flack & Kurtz, "Building Design and Construction," November 1996. Summarized in the Carnegie Mellon BIDS database: http://nodem.pc.cc.cmu.edu/bids/index.asp.

294 Communication with Bill Browning, RMI, March 10, 2003.

295 Herman Miller, p. 4.Op. Cit.

296 V. Loftness et al., "Sustainable Development Alternatives for Speculative Office Buildings: A Case Study of The Soffer Tech Office Building," undertaken collaboratively by Carnegie Mellon University, Gardner & Pope Architects, RAY Engineering and the Soffer Organizations, May 26, 1999. Available at: http://www.tate-cheapertobuild.com/pdf/sustainable_development_alternatives.pdf.

297 Ibid. Appendix B.

298 Andy Karvonen, 2001. Op. Cit.

299 "BOMA 1998 Experience Exchange Report." Available at: http://www.energy2001.ee.doe.gov/Technology/S5-Bohsali/tsld028.htm.

300 Data supplied by the California Department of General Services, Real Estate Services Division. December 2002.

than IFMA reported averages. Absent more specific data about California public employee move costs, estimated savings are \$300 per move in a building with underfloor air compared with a conventional building. This estimate is very likely to be low.

Assuming a churn rate of 30% (discussed above), this implies an annual savings of \$90 per year per employee, significantly below the estimated costs in other studies, such as those completed by Owens Corning and Ray Engineering.[301]

An average of $225ft^2$ per employee implies an annual savings of $\$0.40/ft^2/yr$ (\$90 per year for each employee's $225ft^2$, or $\$0.40/ft^2/$ year). This is significantly below the annual churn savings identified in the York and Souffer studies, and substantially lower than the DowElanco and Pennsylvania DEP estimated savings. This is also at the bottom of the range of the meta-study conducted by Carnegie Mellon/Oak Ridge, which identified average churn cost savings in the range of \$0.40 to $\$2/ft^2/yr$.[302] Based on a review of the range of case studies and existing data, this report therefore assumes a conservative value of $\$0.40/ft^2/yr$ per employee in reduced churn costs associated with underfloor air, with 20-year PV at 5% discount of $\$4.98/ft^2$. This indicates that it is cost effective to install underfloor air in state buildings where the cost per square foot is less than \$5.

Note that there is little data on churn costs in schools, so the above estimate should not be directly applied for schools. It is probable that churn is less frequent and/or less costly in schools, so churn reduction benefits of green buildings would be proportionally less. In the absence of good data, a reasonable estimate for churn reduction benefits in green schools might be about half that for state buildings, or a 20-year PV of $\$2.50/ft^2$. For specific educational buildings such as laboratories and administrative offices, churn costs are likely to be higher. Lack of data indicates the need for additional research in this area.

Additional analysis is recommended to obtain more accurate estimates of frequency and cost of churn, with type of churn (employee-only/phone/rewiring/construction) indicated.

Urban Heat Island Reduction – Cool Roofs

Extensive studies conducted by Lawrence Berkeley National Laboratory (LBNL), the California Energy Commission and others have documented large energy and health benefits from lighter color roofs, lighter color paving and tree planting. Darker surfaces absorb more sunlight, increasing temperature within buildings, and creating "heat islands" and an associated need for air conditioning. More air conditioning requires greater consumption of energy, which in turn leads to the release of more pollutants. In addition to increasing their own temperatures, dark roofs and surfaces also raise the temperatures in surrounding areas, increasing their needs for air conditioning as well. Since 1950, increased absorption of sunlight by dark buildings, roads and loss of tree coverage have played a large role in increasing the average temperature of Los Angeles by about 1ºC every 15 years.[303]

[301] Conversation with Vivian Loftness, December 2002. Lead author of comprehensive meta study, complete citation above.
[302] V. Loftness et al., June 2002. Op. Cit.
[303] A.H. Rosenfeld et al., "Cool Communities: Strategies for heat island mitigation and smog reduction," *Energy and Buildings*, 28, 1998.

The medical cost of poor air quality in Los Angeles is about $10 billion per year, of which 70% is from particulates and 30%, or $3 billion, is from health costs due to ozone.[304] High temperatures are a primary condition for the creation of smog (ozone). By reducing ambient urban temperatures, heat island reduction directly contributes to reduced ozone creation, in turn reducing the large human health costs associated with smog. For the city of Los Angeles, there are numerous estimated benefits of a comprehensive cool communities program:

- Direct savings of $100 million in annual residential air conditioning costs (A/C needs reduced by 10% to 30% as estimated by various studies). [305]
- $70 million reduction in indirect cooling costs (reduced air conditioning for other buildings due to lowered ambient air temperature).[306]
- $360 million from reduction of smog (12% ozone reduction).[307]

Most of the impacts and benefits of heat island reduction measures have been very extensively modeled and documented by LBNL, utilities such as PG&E,[308] cities and other entities. For example, the Southern California Air Quality Management District undertook an independent evaluation of the benefits of urban heat island mitigation before accepting heat island reduction measures as a legitimate option to meet their strict regulations restricting smog. At the same time, not all the benefits have been fully modeled statewide. The values for direct avoided energy costs have been modeled most extensively, while the health benefit values are somewhat less precise since they have not been fully modeled for all of California.

Potential heat island savings (both air quality and energy) for Northern California have not been fully modeled, but LBNL Senior Scientist Hashem Akbari, a leading expert on heat island reduction, estimates that potential savings from cool roofs in Northern California are at least half that of Southern California. His conservative estimate is that total statewide savings from heat reduction measures are at least $750 million per year, with $500 million from health improvements and $250 million from reduced energy use.[309]

The installation of "cool roofs" on buildings provides both energy and health benefits by reducing heat islanding. The technology is presented here because:

1) The financial benefits for California are significant and well documented.
2) It is an important feature in green building design systems such as LEED (75% of 21 LEED green buildings reviewed achieved one heat island reduction credit and 50% achieved both).
3) Perhaps because it is so simple, it is sometimes overlooked when compared with higher tech solutions.

---

[304] J.V. Hall, "Valuing the health benefits of clean air," *Science* 255, 1992.
[305] "Inclusion of Cool Roofs in Nonresidential Title 24 Prescriptive Requirements, Revised August 2002," Pacific Gas and Electric (2005 Title 24 Building Energy Efficiency Standards Update). Provided by Hashem Akbari.
[306] Data provided by Lawrence Berkeley National Laboratory. November 2002. (Hashem Akbari).
[307] Rosenfeld et al., 1998. Op. Cit.
[308] PG&E. "High Albedo (Cool) Roofs: Codes and Standards Enhancement Study." 2000. Available at: http://www.newbuildings.org/downloads/codes/CoolRoof.pdf.
[309] Data provided by Lawrence Berkeley National Laboratory. October 2002. (Hashem Akbari). See also: http://www.coolroofs.org/.

Cool (high albedo) roofs – roofs that have high thermal emittance (high radiation of heat) and high solar reflectance (high reflection of sunlight) – stay cooler in sunlight. They are also easy to incorporate and have a number of direct and indirect benefits.

Cool roofs come in several forms, including:

- Roofs painted or otherwise covered in a highly reflective surface (of light or metallic color).
- Roofs shaded by neighboring trees, PV panels, etc.
- Green roofs, which are densely planted for high sunlight absorbance and insulation.

In a report issued in 2000, PG&E modeled the effect of cool roofs on the energy usage of 990 California commercial buildings. They found an average 20-year present value energy savings from use of cool roof materials of $0.37/ft^2 for the roof area (not the whole building), resulting from reduced air conditioning requirements.[310]

In addition to energy and heat island impacts, cool roofs also experience less expansion and contraction than dark roofs, which contributes to statistically significant extension of the roof life. Typically, cool roofs last 20% longer than conventional roofs. LBNL has calculated that financial benefits of longer roof life are roughly equal to the value of energy savings.[311] Combining the benefits of direct reduction in air conditioning with the value of a longer roof life provides an estimated 20-year PV of $0.75/ft^2.

As indicated above, the average statewide health value (principally from reduced smog creation) is twice that from direct reduced energy use, or about $0.70/ft^2 in direct health benefits. This report will count one half of the estimated direct health benefits from cool roofs, or $0.35/ft^2. Combined with benefits of direct reduction in air conditioning and longer roof life value (calculated above) of $0.75/ft^2, this provides an estimated 20-year PV savings from cool roofs of $1.10/ft^2 of roof surface. Additional benefits such as lower waste costs due to longer roof life and benefits of reduced temperature on surrounding buildings are not included in this analysis, tending to underestimate the financial benefits of cool roofs.

An additional benefit of cool roofs is that lower cooling demands can allow downsizing of air conditioning in buildings, providing an additional savings of about $0.10/ft^2 in capital costs. This is roughly offset by the additional cost of a cool roof, which is between $0.00 and $0.20/ft^2, though average marginal cost is below $0.10/ft^2.[312] This means that the $1.10/ft^2 value as calculated above can be considered a true 20-year NPV value, where additional cost is subtracted from overall benefits.

Because schools sometimes do not operate in summer months, some of the benefits, especially in reducing air conditioning load, are not achieved. This report conservatively assumes that schools see only 25% of the direct reduction in cooling costs, or $0.09/ft^2, and 50% of the health benefits ($0.35/ft^2). Because schools tend to be located in more wooded areas, roof-life extension benefits will be less, perhaps $0.28/ft^2, or 75% of the estimate for commercial buildings. This set of perhaps overly conservative assumptions indicates 20-year NPV benefits of $0.72/ft^2 for cool roofs on schools.

---

[310] *Ibid*. Note that a 10 year life is assumed.
[311] Data provided by Lawrence Berkeley National Laboratory. December 2002. (Hashem Akbari).
[312] Data provided by Lawrence Berkeley National Laboratory. October 2002. (Hashem Akbari).

The large potential health and energy savings have resulted in the promotion of heat reduction measures by a number of organizations. This includes CEC incentives for application of cool roofs, incorporation of heat island reduction measures into the general air quality plans of the South Coast and Bay Area Air Quality Management Districts,[313] adoption of cool roofs in Title 24 as part of its non-residential perspective requirements, and inclusion of the following credits in LEED 2.1:

> Site credit 7.1 - 1 point for shade and/or reflectance and several other options.
>
> Site credit 7.2 - 1 point for energy star light colored/high reflectance roof with various restrictions added.

Despite the financial benefits and the inclusion of cool roofs in Tier 1 and CEC programs to support cool roof implementation, most new California state and school buildings are not built with them.[314] It seems clear that cool roofs and other urban heat island reduction measures are cost- effective and should be applied in new buildings.

To estimate benefits of urban heat island reduction measures for specific buildings, it is necessary to account for the number of floors. On a forty story building the average building-wide benefit of a cool roof is small. In contrast, the cool roof benefit of a one story building is relatively large. The average California state building has about 7 stories,[315] resulting in a cool roof NPV value of $0.15/ft^2 for the total building ($1.10/ft^2 of roof apportioned over seven stories, or about $0.15/ft^2 for the whole building). Note that school savings per square foot will be larger because schools typically have fewer floors. At an average of 2 floors per school,[316] the NPV benefits would be $0.36/ft^2 school-wide.

These estimates are almost certainly low. In addition urban heat island reduction measures other than cool roofs, including shading from tree planting and lighter surfaces surrounding buildings, such as parking lots, also reported to be very cost effective, but are not included in this study. A more thorough analysis should do so.

---

[313] Hashem Akbari and Malvin Pomerantz, "Implementation of Heat Island Reduction Measures: Where We Are and Where We Need to Go," *ACEEE Conference Proceedings*, Energy and Environment Policy - 9.1, 2002.
[314] Data provided by Lawrence Berkeley National Laboratory. October 2002. (Hashem Akbari).
[315] Data provided by the California Department of General Services, Real Estate Services Division, December 2002.
[316] Data provided by the California State Architect, Department of General Services, December 2002.

X. Insurance Benefits of Green Buildings[317]

Risk, and associated losses, is costly, with or without formal insurance. With conventional insurance, customer costs include deductibles, premiums and possible excess costs if the insured loss level is capped. If commercial insurance is not used, then the building owner is either formally or informally self-insured. Formal self-insurance implies that a distinct "premium" is paid from internal budgets and accumulated in the form of an earmarked loss reserve. If self-insurance is informal, then the risks are said to be "retained" and losses are paid from general operating budgets, without the creation of an anticipatory loss reserve.[318] Where formal or informal self-insurance is used, risk management is particularly important, since there is no hedge (upper limit) against loss costs.

Considerable untapped opportunities are suggested by the synergies between green-building technologies and risk management (Figure X-1).[319]

Figure X-1. Risk Management Benefits of Green Buildings

- **Worker Health & Safety.** Various benefits, including lower workmen's compensation costs, arise from improved indoor environmental quality, reduced likelihood of moisture damage, and other factors enhancing workplace safety.[320]
- **Property Loss Prevention.** A range of green building technologies reduce the likelihood of physical damages and losses in facilities.[321]
- **Liability Loss Prevention.** Business interruption risks can be reduced by facilities that derive their energy from on-site resources and/or have energy-efficiency features. This includes risks resulting from unplanned power outages.[322]
- **Natural Disaster Preparedness and Recovery.** A subset of energy efficient and renewable energy technologies make facilities less vulnerable to natural disasters, especially heat catastrophes.[323]

---

317 Adapted from a report written by Evan Mills, Senior Scientist, Lawrence Berkeley National Laboratory. "Green Buildings as a Risk Management Strategy," December 2002.

318 The basic difference between conventional insurance and self-insurance is that self-funded entities take responsibility for financing their own claims. The main advantages of self-insurance are: lower administrative costs, better claims control, meaningful claims statistics and potentially reduced losses through better loss control.

319 Extensive discussion and references on the subject can be found at http://eetd.lbl.gov/ea/mills/insurance/cifram.html.

320 Edward Vine et al., "Energy-Efficiency and Renewable Energy Options for Risk Management and Insurance Loss Reduction: An Inventory of Technologies, Research Capabilities, and Research Facilities at the U.S. Department of Energy's National Laboratories," LBNL Report No. 41432, 1998. Available at: http://eetd.lbl.gov/insurance/LBNL-41432.html.

321 Evan Mills, "The Insurance and Risk Management Industries: New Players in the Delivery of Energy-Efficient Products and Services," *Energy Policy* (in press), 2003. Available at: http://eetd.lbl.gov/emills/PUBS/Insurance_Case_Studies.html.

322 J. Eto et al., "Scoping Study on Trends in the Economic Value of Electricity Reliability to the U.S. Economy," prepared for the Electric Power Research Institute, 2001. Available at: http://eetd.lbl.gov/ea/EMS/reports/47911.pdf.

Lawrence Berkeley National Laboratory has mapped approximately 80 energy efficiency and renewable energy measures onto specific "lines" of insurance benefited by their use.[324] A number of forward-looking insurers have supported energy-efficient and renewable energy technologies, including 52 insurers and reinsurers, 5 brokers, 7 insurance organizations, and 13 non-insurance organizations in this arena.[325] The approaches can be grouped into eight categories:

- Information, education, and demonstration.
- Financial incentives.
- Specialized policies and products.
- Direct investment to promote energy efficiency and renewables.
- Value-added customer services and inspections.
- Efficient codes, standards, and policies.
- Research and development.
- In-house energy management in insurer-owned properties.

While the list is impressive, it should be stressed that it reflects a small fraction of insurance companies. Most insurers and risk managers have yet to make the connection between green buildings and reduced risk. There are instances where insurance companies have offered premium credits on the order of 10% for insured parties implementing selected energy savings strategies.[326] Little has been done, however, to quantify or monetize the benefits.

A more specific characterization of the potential insurance benefits of green buildings is included in Appendix K, where benefits are mapped onto the credits of the LEED system (Version 2.0). This provides an analysis of the precise insurance-related issues and benefits for the full range of green building attributes. Each LEED prerequisite and credit is evaluated against seven types of risk – property loss; general liability; business interruption; vehicular; health & workers comp; life; and environmental liability, along with related comments. Of the 64 LEED points possible in Design Areas 1-5 (excluding the Innovation and Design Process category, which is non-specific), 49 (77%) are associated with measures that have potential risk-management benefits. A few of these, however, are potentially associated with potential adverse consequences – an issue that merits more attention in the green buildings community.

Insurance and Risk Management in California[327]

Currently, most general government facilities and operations in the state of California do not purchase commercial insurance. The majority of state buildings are informally self-insured. The Capitol building itself is uninsured, as are other well-known properties such as Hearst Castle.

---

[323] Evan Mills, "Climate Change, Buildings, and the Insurance Sector: Technological Synergisms between Adaptation and Mitigation," *Building Research and Information* (in press), 2003. Available at: http://eetd.lbl.gov/emills/PUBS/Mitigation_Adaptation.html.

[324] Edward Vine, LBNL Report No. 41432, 1998. Available at: http://eetd.lbl.gov/insurance/LBNL-41432.html.

[325] Evan Mills, *Energy Policy* (in press), 2003. Available at: http://eetd.lbl.gov/emills/PUBS/Insurance_Case_Studies.html.

[326] *Ibid.*

[327] Unless otherwise noted, the observations in this section are taken from conversations between Evan Mills and the California's Office of Risk and Insurance Management (Gary Estrada).

Construction on the Capitol Area East End Complex, the largest state government project in California history and the first state buildings to pursue LEED silver and gold ratings, is now complete. As it is bond-funded, commercial insurance is required. The Office of Risk and Insurance Management (ORIM) is not aware of any insurance/risk-related problems with this project, but subscribes to the notion that green buildings will have happier and healthier occupants.

ORIM is located under the Department of General Services (DGS) and is responsible for all risk and insurance activities in state government. For buildings and other facilities constructed with bond-generated funds, the state purchases property insurance but not liability insurance. In this case, deductibles are generally set high (currently $500,000 - $2.5 million) to minimize the premium. Under California's "Master Policies," there is approximately $1.5 billion of property at 15-20 locations that is commercially insured for property and liability risks, plus roughly $3 billion of additional property currently under construction.[328] Total premiums paid for commercial insurance were $18 million in 2000, of which perhaps 15% were for buildings.[329] The state's primary provider is Affiliated FM, which has, in the past, shown interest in energy efficiency as a tool of risk management.[330]

One of ORIM's most important initiatives at present is their "Owner-Controlled Insurance Program," under which the state buys Workers Comp, General Liability, and Excess Liability coverage for construction projects. Of relevance to the discussion of green buildings, evidence from closed-claims studies suggests that the associated risks can be reduced through the use of building commissioning,[331] and potentially result in lower premiums for the state. Commissioning (see Section IX) is one of the procedures called for in the LEED green building rating system. It is worth noting that state initiatives to promote alternative transportation solutions (one of the criteria of the LEED system) would result in fewer person-miles driven and corresponding reductions in the likelihood of vehicle-related claims.

Lastly, ORIM sees mold as a "growing" issue, and as a potential driver for more proactive risk management and holistic thinking about buildings. According to the Chief Economist at the Insurance Information Institute, most insurers report a tripling of mold-related claims in the last year. More than 9000 claims related to mold are pending the nation's courts, though most involve family homes.[332] A special program provides California state property insurance of $4-5 million for the single family homes of military veterans. While the vast majority of this is for earthquake and flood risks, mold issues have become a real concern in this program. Improved ventilation in green buildings is likely to combat mold problems. Many insurance companies have dropped all coverage for mold and IAQ. Although there are a few policies that cover mold losses, these have become very costly and the state has yet to purchase one.

---

328 Insurance is discontinued once the bond is paid off.

329 "Annual Report," ORIM. 2001. Available at: http://www.orim.dgs.ca.gov/Publications/default.htm.

330 D. Avery et al., "Campus Lighting — Lighting Efficiency Options for Student Residential Living Units: A Study at Northeastern University, Boston, Massachusetts," LBNL Report PUB-816, 1998. Available at: http://eetd.lbl.gov/EMills/PUBS/arkwright.html.

331 R. Brady, "Commissioning Services Can Reduce Professional Liability Losses," Proceedings of the Third National Conference on Building Commissioning, Portland Energy Conservation, Inc., Portland, OR, 1995.

332 Ray Smith, "Mold Problems Grow in Shops, Hotels, Offices," *Wall Street Journal*, December 4, 2002. Available at: http://www.iuoe.org/cm/iaq_bpconc.asp?Item=356.

XI. Conclusions

This report has sought to define, document and analyze the costs and financial benefits of green buildings. It has attempted to identify gaps in current knowledge about green building costs and benefits and to identify recommended areas of future research and analysis.

The financial benefits estimated in this report are a measure of financial benefits to the state of California as a whole, rather than to specific building tenants or owners. While a government entity should care about the benefits their building may have for society, a private commercial entity may not. Private sector building owners, for example, may be less likely to care about health and environmental impacts, and hence might perceive lower financial benefits of building green. In addition, because of higher capital costs and hurdle rates, future financial benefits are discounted more heavily by private entities than by public ones, potentially further reducing the perceived value of future green building financial benefits for the private sector. These differences help explain the significant disparity between public and private sector adoption of green building design.

This report began with an aggregation of data on actual or modeled costs for 33 green buildings. Largely derived from several dozen conversations with architects, developers and others, the data indicates that the average construction cost premium for green buildings is almost 2%, or about $4/ft^2$ in California, substantially less than is generally perceived.

The body of this report focused on determining the financial benefits of a range of green building attributes, with the findings summarized below.

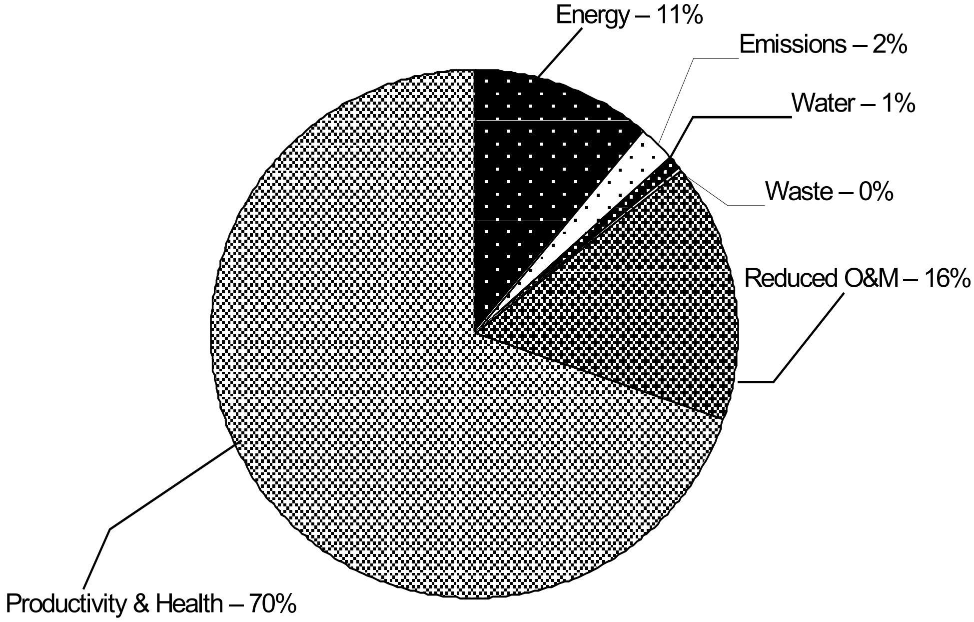
Figure XI-1. Summary of Findings (per ft^2)

Category	20-year NPV
Energy Value	$5.79
Emissions Value	$1.18
Water Value	$0.51
Waste Value (construction only) - 1 year	$0.03
Commissioning O&M Value	$8.47
Productivity and Health Value (Certified and Silver)	$36.89
Productivity and Health Value (Gold and Platinum)	$55.33
Less Green Cost Premium	($4.00)
Total 20-year NPV (Certified and Silver)	**$48.87**
Total 20-year NPV (Gold and Platinum)	**$67.31**

Source: Capital E Analysis

The relative percentages of the different benefit categories are shown in Figure XI-2 below.

Figure XI-2. Percentage Breakdown of Green Building Financial Benefits (LEED Certified and Silver Buildings)



Source: Capital E Analysis

The above pie chart is for Certified and Silver buildings. For Gold and Platinum buildings, a larger portion of benefits are represented by productivity and health, and the percentages of benefits from the other categories reduce correspondingly. The relatively large impact of productivity and health gains reflects the fact that the direct and indirect costs of employees are far larger than the costs of buildings and energy, so even small increases in employee productivity translate into large benefits. Note that this estimate does not include the financial benefits of reduced moving costs (churn) associated with underfloor air distribution systems because most green buildings do not currently use them.

As summarized above, total financial benefits of green design are estimated to be almost $50/ft^2 for Certified and Silver level green buildings, and over $75/ft^2 for Gold and Platinum level buildings. This is over ten times larger than the average 2% cost premium – about $3-5/ft^2 in California – for the 33 green buildings analyzed.

The financial benefits of green buildings include lower energy, waste, and water costs, lower environmental and emissions costs, lower operations and maintenance costs, and savings from increased productivity and health. These benefits range from being fairly predictable (energy, waste, and water savings) to relatively uncertain (productivity/health benefits.) Energy and water savings can be predicted with reasonable precision, measured, and monitored over time, so much so that commercial firms contract to buy streams of future energy and water savings. In contrast, productivity and health gains are much less precisely understood and far harder to predict with accuracy. This is due in part to the complexity of human health and performance issues, the large range in human reactions to indoor environmental quality changes, and the large range of ways that improvements can show up, including lowered insured or uninsured health costs, lower employee turnover or increased productivity.

There is now a very large body of research, reviewed in this report, which demonstrates significant and causal correlation between improvements in building comfort and control measures, and worker health and productivity. However, these studies vary widely in specific measured correlations. Further, there has been relatively little work completed to evaluate specific, measurable benefits from green building design in California in such areas as sick days, health costs, turnover and respiratory impacts such as asthma and allergies. Clearly, the benefits are significant and not zero, but the data supports a broad range of calculated benefits – in contrast to the more precisely measurable energy and water savings.

The financial benefits conclusions in this report should therefore be understood in this context. Energy, waste, and water savings and emissions reductions can be viewed as fairly precise, reasonably conservative estimates of direct benefits that alone significantly exceed the marginal cost of building green. Health and productivity benefits may be viewed as reasonable, conservative estimates within a large range of uncertainty that therefore justify additional research to better quantify and capture the associated benefits. These studies might include such measures as evaluating green building effects on insured and uninsured health effects, employee turnover, worker well being and, where relevant (e.g. in schools), test scores.

Schools are also an ideal application for green building. One-fifth of California's population spends weekdays in schools. Productivity and health are critically important, not just for the well-being of students and teachers, but also in order to enhance the learning environment and student performance. Some green building benefits (e.g., reduced cost of churn) are less relevant for school buildings. However, as discussed in the above *Note on Education*, children's increased vulnerability to toxic chemicals, allergens and other pollutants is a particularly compelling argument for green schools. Green buildings – especially at the Gold level – provide a significant degree of protection against potentially toxic chemicals that can lead to a rising incidence of asthma and allergies. The strong correlation between children's test scores and daylighting illuminates the large benefits available from greener design. Despite uncertainties about benefits of green design in schools, due to limited data and the large range of school building designs, this report concludes that green design up to LEED Gold level is now very cost-effective for school buildings.

There are additional benefits not evaluated in this report. As one example, the recent book *Small is Profitable*, identifies 207 benefits associated with use of distributed generation and energy efficiency,[333] only a few of which are reflected in this report. A range of other potentially significant benefits from building green include reduced medical costs from a healthier work/study environment and avoided school revenue losses due to higher student attendance. Additional studies should evaluate these and other potential benefits. Similarly, there are a few areas of potential health-related costs associated with green buildings. In particular, there is the possibility of higher indoor concentrations of pollution from lower air exchange rates, which are sometimes associated with more efficient buildings. This is addressed in LEED through reducing introduction of pollutants and toxics and enhanced ventilation. These issues should be examined more fully in a future analysis.

Constructing green buildings cost-effectively requires integrated green building design and a careful commissioning process. The commonly higher initial cost of green design and construction can be expected to drop as designers and builders gain experience in building green. The benefits of green buildings are greatest for public entities that have explicit responsibility to be concerned about broader societal benefits such as health.

[333] See: http://www.smallisprofitable.org/. Op. Cit.

There are a number of areas that warrant additional research to refine our understanding of the costs and financial benefits of green buildings. The following section includes a list of over thirty specific areas for recommended additional research.

Faced with limitations in available data, this report has attempted to make consistently conservative assumptions, and found that the financial benefits of green buildings are approximately ten times larger than the average additional cost of building them. Further research and analysis of areas of potential additional benefits would refine costs and benefits estimates (and probably increase estimated financial benefits). Despite gaps in data and analysis, the findings of this report point to a clear conclusion: building green up to the LEED Gold level makes financial sense today.

XII. Recommended Next Steps

After the general section, recommendations are grouped by category, in alphabetical order, followed by recommendations for research on private sector buildings.

General

1) *Fund Optimized Design.* Green buildings may be more complicated and more expensive (especially when including energy modeling and commissioning) to design than conventional buildings. Ensuring adequate resources for integrated design, use of charettes, modeling, etc., is critical to the construction of cost-effective green buildings. Money spent in the early design phase ensures future financial benefits and optimized building performance. The state should try to understand how to optimize the design process and ensure adequate resources for the early design phase in California green buildings. In doing so, the state should build on work completed by Eley & Associates, Natural Logic and others on performance-based fees – providing a better understanding of the most effective allocation of fees to different phases of the design process. This would allow more cost-effective and fair compensation for all participants including clients and the design team.
2) Support and participate in a more refined evaluation of the cost-effectiveness of adopting a LEED Gold level target for state buildings and academic institutions. Consider whether green building benefits can offset budget limitations, such that operations and productivity savings prevent an increase in expenditures. This could include mapping LEED Gold level points onto financial benefits and other targets specific to the state of California.
3) Evaluate the cost-effectiveness of adopting California's *LEED Supplement for California State Facilities*. Research should address whether additional elements need to be added (e.g., higher minimum energy reduction or peak demand reduction targets).
4) *Baseline Data Collection.* The state does not maintain easily retrievable data about standard design practice for its building projects and generally does not evaluate and catalogue building performance over time. Both of these endeavors are important to gain an accurate understanding of the full value of green building strategies.
5) Identify information sources and tracking mechanisms for green building cost data that are closer to the actual projects, instead of potentially biased second and third-hand sources. This might include obtaining construction records and original estimates, developing a transparent method of interpreting the cost data, and including an explanation of that method with the findings.
6) Support analysis and development of recommendations for the most cost effective policies to promote adoption of green buildings in California.
7) Analysis of data on California and public buildings should be expanded and updated in late 2003 to reflect a growing body of LEED submissions and other data available since this report analysis was undertaken (October-December, 2002). This expanded analysis should identify trends and provide additional cost and financial benefit insights related to green building elements and additional areas of benefits.

Commissioning

8) Support ongoing commissioning efforts at DGS. Encourage evaluation of the cost-effectiveness of commissioning in new non-green buildings as well as advanced commissioning in green buildings in California.
9) Support work to develop a commissioning template, including a checklist of recommended/required commissioning steps that are most important and cost-effective. The checklist could focus on ensuring environmental and health benefits.
10) *Maintenance.* Green buildings provide greater health, productivity, and/or enhanced learning and other benefits than conventional buildings. Green buildings also emphasize the importance of maintenance and periodic planned preventative commissioning. Additional work should be done to develop an approach to improved building maintenance, especially for green buildings, that maintains building benefits and also meets California state budgeting requirements. The cost-effectiveness of periodic re-commissioning as well as improved durability and ease of maintenance of green products and systems should also be examined.

Emissions

11) This paper roughly assumes an "Average California Emissions Factor" (ACEF) approach to quantify cost of emissions from electricity generation. However, a more detailed analysis would look at variations across electricity generators, and assign greater benefit to reducing consumption from the dirtiest sources.
12) Emissions calculations generally cover only pollution at time of generation. However, considerable emissions are created during extraction/production, purification, and other steps in energy life cycle as well. A more thorough analysis would include these. See Appendix E.
13) *Financial Impact of Reduced Non-Fossil Fuel Electricity Generation*. Explore impact of emissions and/or other environmental costs associated with nuclear (16% of California generation) and large hydro (20% of CA generation).[334]
14) Reductions in V
15) olatile Organic Compounds (VOCs), mercury and other emissions from building materials, office machines, nearby traffic and other sources may have significant value but are not explicitly calculated in this preliminary report. A fuller report should quantify the benefits of these reduced emissions including operations and maintenance benefits and the incidence and costs of human productivity and health effects. Specifically, estimate reductions of indoor levels of carcinogens in green buildings and use cancer cost estimates (developed by US EPA) to calculate resultant economic benefit.
16) *Indirect effect of building siting on transportation:* Future work should explore this impact of inappropriate siting of buildings in light of the dominant influence of vehicle emissions on outdoor air quality in California, lost productivity due to gridlock, loss of agricultural land resources, and the growing importance of exposure to high levels of pollutants on or near roadways.

---

[334] California electricity generation profile: http://www.green-e.org/your_e_choices/ca.html, April 2003. Data compiled by US Environmental Protection Agency.

Energy

17) *Better Understanding of the Potential of Green Building to Cut Peak Electric Load.* This is an important and largely overlooked issue and it is recommended that additional work be undertaken to more accurately value green building peak demand reduction.

18) *Leased Properties.* The California state government leases one third of the commercial buildings it occupies and provides building performance guidelines to the renting firms.[335] It appears that there is no formal cost analysis for the incorporation of these "green lease" guidelines. Analysis should be done to determine the cost-effectiveness and plausibility of requiring that leased space be green.

    Rising energy costs have a significant impact on the profitability of leasing agencies and therefore on the availability and cost of properties for lease to the state. In 2001, nine of California's eleven real estate investment trusts (REITs) underperformed the market average. One reason for this is California's high energy costs. A survey of California REITs found that for office properties, energy costs amounted to 9.5% of their net operating income, the highest portion for any of the building classes reported. This reflects both high energy costs and lower operating margins for office buildings, underlining the potential value of greater energy efficiency in state-leased office properties.[336]

    Additional work should be undertaken to evaluate the impact of greening on leased properties, including: value of buildings, lease rate impacts, and net operating impacts for the state.

Insurance

19) *Better Quantification of the Insurance-related Benefits of Green Buildings.* The minimal use of commercial insurance in California means that data must be collected from less formal agency-level sources, which may or may not be available. Efforts could be focused on analyzing insurance loss data (often referred to as "data mining") for a broader market, and extrapolating the results to California state-owned buildings and to educational institutions. Specifically, the impact on insurance premiums of reduced mold liability through the construction of moisture resistant buildings, improved quality control of construction and improved maintenance, should be examined.

20) Develop a resource for state risk managers and other decision makers, catalog what is known about the risk and risk-management aspects of green building technologies (expanding on the list of 80 technologies prepared in 1998 for DOE).[337]

21) Use state's purchasing power to negotiate better insurance premiums for existing and future green buildings, e.g., lower premiums for liability insurance under the "Owner-Controlled Insurance Program."

---

[335] Exhibit B is now the standard for leased spaces. See:
http://www.ciwmb.ca.gov/GreenBuilding/TaskForce/Blueprint/ExhibitB.pdf.
Exhibit C contains the building performance goals used by DGS. See:
http://www.ciwmb.ca.gov/GreenBuilding/Design/ExhibitCLEED.doc.

[336] "Are California REITs Getting Zapped by the Electricity Mess?" Green Street Advisors, 2001. Available at: http://www.greenstreetadvisors.com.

[337] The DOE database is available at: http://eetd.lbl.gov/insurance/welcome.html.

22) Identify adverse interactions associated with green building technologies and create corresponding risk-management/reduction protocols to mitigate the risks. A common example is concern over adverse linkages between energy efficiency measures and indoor air quality or moisture problems. Whether real or perceived, these "downside" aspects are a significant barrier to the acceptance of innovative green building strategies. Relay the results to the CEC's Public Interest Energy Research (PIER) Program so that they are better addressed in the state's major energy-efficiency R&D efforts. Current research efforts in the PIER program are attempting to more precisely determine this relationship.

23) Participate in the next Risk Management Conference (sponsored periodically by the California Office of Insurance and Risk Management). Other relevant venues are the Public Agency Risk Mangers Association (PARMA) [338] meeting for state risk managers and the national public sector insurance meeting of Public Risk Management Association (PRIMA).[339]

Productivity and Health

24) Support a team in gathering more data about productivity issues. A study of green buildings might include the measurement of thermal comfort parameters and application of better monitoring – with quality control measures. Other data that could be gathered include: absenteeism, overall satisfaction, health symptoms, and school test scores.

25) Because productivity and health gains can be the dominant benefits of green buildings, more work should be done to assess and expand upon the findings of this report. A greater sensitivity should be paid to variances between specific cases, with error bars attached to benefits to show nominal and worst case conclusions. Consider supporting R&D to develop a set of predictor considerations for what factors specifically impact productivity.

26) California should consider participating in Seattle's "human factors commissioning" database project, which is measuring the impact of greening on worker comfort, health, productivity and related measures for all new or renovated municipal buildings that meet or exceed the LEED Silver level.[340]

27) Expand upon CBE analysis aggregating data from state buildings on:

    - Occupant satisfaction.
    - Absence rates.
    - Number of days actually sick.

    This might involve evaluation and measurement of ventilation rates, pollutants, human output, comfort, absence and sickness in green office buildings. A baseline could be selected (newer, nicer buildings) from the EPA database survey of 100 office buildings.[341]

---

[338] See: http://www.parma.com/.
[339] See: http://www.primacentral.org/default.php.
[340] See:
http://www.edcmag.com/CDA/ArticleInformation/coverstory/BNPCoverStoryItem/0,4118,19794,00.html.
[341] The "EPA Base Study" measured IAQ parameters and collected data on occupant health symptoms (via questionnaires). William Fisk, Senior Scientist, LBNL, December 2002.

Residential

28) There is no national consensus definition and guide for green residences. Participate in the development of a LEED residential application, including evaluation of cost-effectiveness of applying LEED for residences (including low income housing) with a focus on improving health.

Schools

29) Identify a senior-level state expert on schools to help lead an effort to evaluate the value that a LEED schools application guide might have for California. This would build upon and be coordinated with CHPS.

Water

30) *True Marginal Cost*. Currently available full cost estimates for new water supplies are inadequate. The state should commission a study that re-examines this issue and includes all of the considerations discussed in this document. Any new study examining marginal cost should also consider the marginal cost numbers used by water agencies in their grant applications for Proposition 13 funds. These were scheduled to be submitted to DWR in December 2002.
31) *Impact of Conservation*. The value of a conserved acre-foot varies depending on a range of factors, including: the alternative uses for the conserved water, the location of the conserved water, and timing of the conservation.[342] These factors ought to be examined more closely in any future investigation of value of conserved water.
32) *Cost of Conservation*. Analyze the cost of implementing conservation measures to determine their cost-effectiveness.

Waste

33) *California Environmental Data.* While the Massachusetts report[343] is quite comprehensive in its approach to environmental costs and benefits, its conclusions may or may not be appropriate for the state of California. A comparable California-specific study should be conducted.
34) *Economic Data*. While the UCB and NRC/REI reports provide significant insight into the economic impacts of diversion and disposal in California, they do not evaluate the following important areas: the actual retail price of C&D diversion vs. disposal in all regions of the state, the value to the state of recycled vs. virgin building materials, and cost to the building owner of implementing an office recycling program.
35) *Value of Enforcing Current Ordinances*. Determine the result of meeting current California waste reduction guidelines (Exhibit C – Tiers 1 & 2). Determine the cost to state agencies of implementing recycling and other waste reduction practices.

---

[342] Ray Hoagland, DWR, memo to the authors, January 13, 2003.
[343] Lisa Skumatz and Jeffrey Morris, "Massachusetts Recycle 2000: Baseline Report." See Section VII: Waste Reduction.

Research Opportunities for Private Sector Benefits of Green Buildings[344]

- *Increased Rent and Lower Vacancy*. Green buildings are more comfortable and healthier for building occupants, in addition to supporting increases in productivity. Therefore they should be in greater demand than conventional buildings: achievable rents should be higher and vacancies lower. A study that tracks green buildings in the marketplace could confirm or deny this.
- *IRR Case Studies*. Owners need more case studies on the internal rate of return (IRR) of green buildings. The San Diego Ridgehaven building is a good example – showing a 57% IRR on investment. [345]
- *Faster Tenant Lease-Up*. With higher press attention and greater tenant value, it is likely that green buildings will lease-up faster than non-green buildings. If proven, it could demonstrate substantial financial savings to the user.
- *Green Appraisals*. Very few appraisers understand green buildings and their benefits, including potentially increased income, lower expenses, and lower future liability. The state could meet with a few of the largest appraisal firms and discuss the impact of green buildings on their business.

[344] Excerpted from work completed by David Gottfried, Gottfried Technology Inc. Re: Future Green Building Research Needs. January 2003.
[345] See for example: http://www.ciwmb.ca.gov/GreenBuilding/CaseStudies/Commercial/Ridgehaven.htm.

Appendices

Appendix A: The LEED System[346]

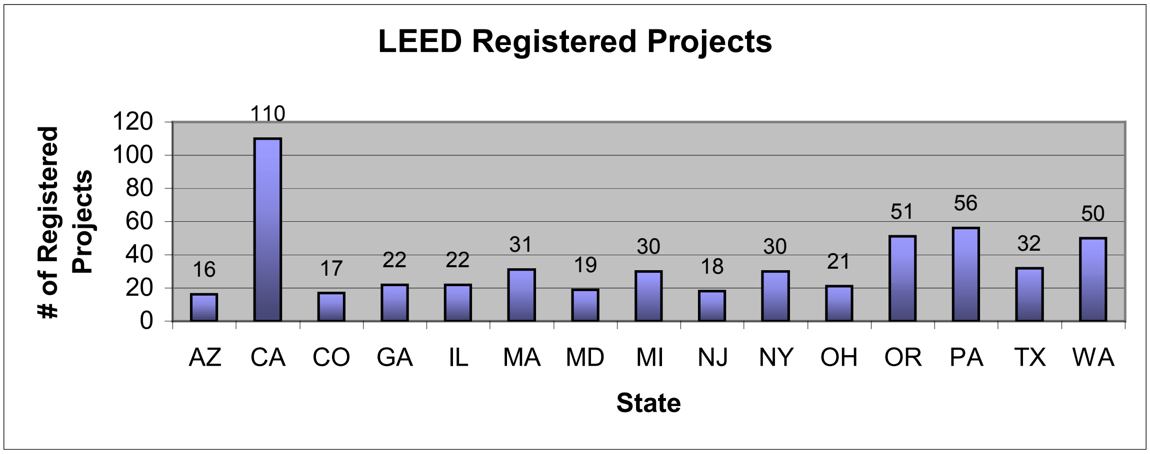
LEED provides four award levels based on the number of environmentally related points achieved by a new building project. The four levels include: Certified (26-32 points) Silver (33-38 points), Gold (39-51 points) and Platinum (52-69 points).

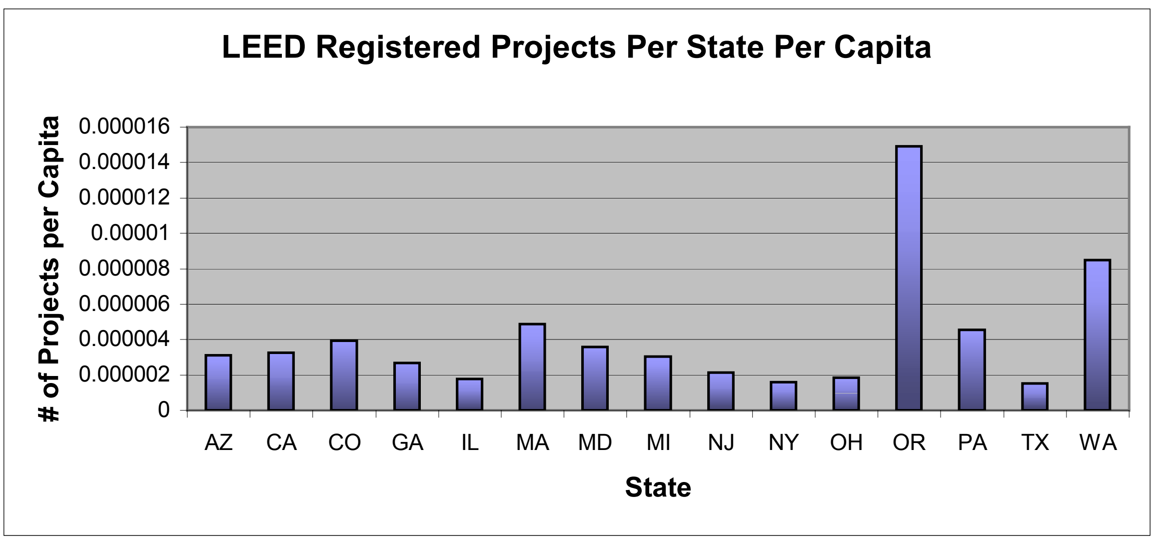
LEED Version 2.1		
Design Area 1	**Sustainable Sites (14 Points possible)**	
	Prereq 1	Erosion & Sedimentation Control (Required)
	Credit 1	Site Selection (1 point)
	Credit 2	Urban Redevelopment (1 point)
	Credit 3	Brownfield Redevelopment (1 point)
	Credit 4.1	Alternative Transportation, Public Transportation Access (1 point)
	Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms (1 point)
	Credit 4.3	Alternative Transportation, Alternative Fuel Vehicles (1 point)
	Credit 4.4	Alternative Transportation, Parking Capacity (1 point)
	Credit 5.1	Reduced Site Disturbance, Protect or Restore Open Space (1 point)
	Credit 5.2	Reduced Site Disturbance, Development Footprint (1 point)
	Credit 6.1	Stormwater Management, Rate and Quantity (1 point)
	Credit 6.2	Stormwater Management, Treatment (1 point)
	Credit 7.1	Landscape & Exterior Design to Reduce Heat Islands, Non-Roof (1 point)
	Credit 7.2	Landscape & Exterior Design to Reduce Heat Islands, Roof (1 point)
	Credit 8	Light Pollution Reduction (1 point)
Design Area 2	**Water Efficiency (5 Points possible)**	
	Credit 1.1	Water Efficient Landscaping, Reduce by 50% (1 point)
	Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation (1 point)
	Credit 2	Innovative Wastewater Technologies (1 point)
	Credit 3.1	Water Use Reduction, 20% Reduction (1 point)
	Credit 3.2	Water Use Reduction, 30% Reduction (1 point)
Design Area 3	**Energy & Atmosphere (17 Points possible)**	
	Prereq 1	Fundamental Building Systems Commissioning (Required)
	Prereq 2	Minimum Energy Performance (Required)
	Prereq 3	CFC Reduction in HVAC&R Equipment (Required)
	Credit 1	Optimize Energy Performance (1 to 10 points)
	Credit 2.1	Renewable Energy, 5% (1 point)
	Credit 2.2	Renewable Energy, 10% (1 point)
	Credit 2.3	Renewable Energy, 20% (1 point)
	Credit 3	Additional Commissioning (1 point)
	Credit 4	Ozone Depletion (1 point)
	Credit 5	Measurement & Verification (1 point)
	Credit 6	Green Power (1 point)

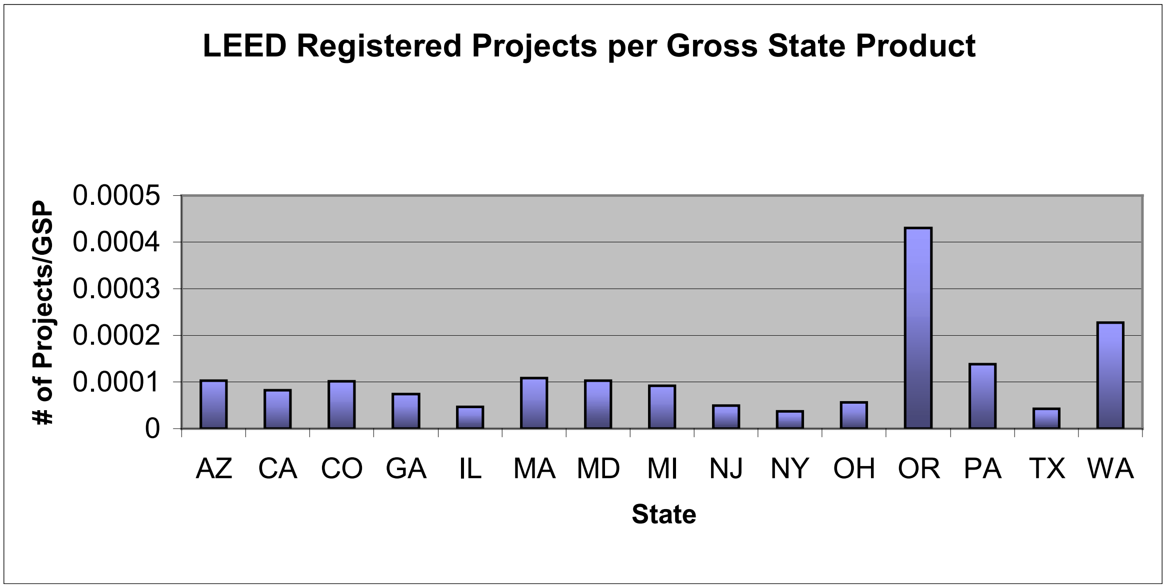
[346] See: www.usgbc.org.

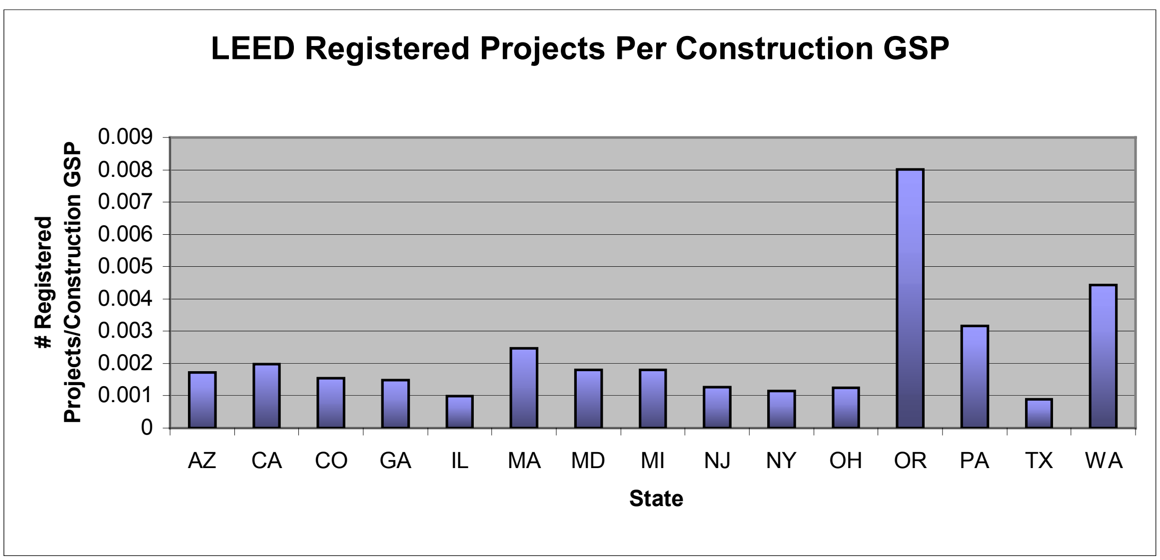
Design Area 4	**Materials & Resources (13 Points possible)**	
	Prereq 1	Storage & Collection of Recyclables (Required)
	Credit 1.1	Building Reuse, Maintain 75% of Existing Shell (1 point)
	Credit 1.2	Building Reuse, Maintain 100% of Shell (1 point)
	Credit 1.3	Building Reuse, Maintain 100% Shell & 50% Non-Shell (1 point)
	Credit 2.1	Construction Waste Management, Divert 50% (1 point)
	Credit 2.2	Construction Waste Management, Divert 75% (1 point)
	Credit 3.1	Resource Reuse, Specify 5% (1 point)
	Credit 3.2	Resource Reuse, Specify 10% (1 point)
	Credit 4.1	Recycled Content, Specify 5% p.c. or 10% p.c. + 1/2 p.i. (1 point)
	Credit 4.2	Recycled Content, Specify 10% p.c. or 20% p.c. + 1/2 p.i (1 point)
	Credit 5.1	Local/Regional Materials, 20% Manufactured Locally (1 point)
	Credit 5.2	Local/Regional Materials, of 20% Above, 50% Harvested Locally (1 point)
	Credit 6	Rapidly Renewable Materials (1 point)
	Credit 7	Certified Wood (1 point)
Design Area 5	**Indoor Environmental Quality (15 Points possible)**	
	Prereq 1	Minimum IAQ Performance (Required)
	Prereq 2	Environmental Tobacco Smoke (ETS) Control (Required)
	Credit 1	Carbon Dioxide (CO_2) Monitoring (1 point)
	Credit 2	Ventilation Effectiveness (1 point)
	Credit 3.1	Construction IAQ Management Plan, During Construction (1 point)
	Credit 3.2	Construction IAQ Management Plan, Before Occupancy (1 point)
	Credit 4.1	Low-Emitting Materials, Adhesives & Sealants (1 point)
	Credit 4.2	Low-Emitting Materials, Paints (1 point)
	Credit 4.3	Low-Emitting Materials, Carpet (1 point)
	Credit 4.4	Low-Emitting Materials, Composite Wood
	Credit 5	Indoor Chemical & Pollutant Source Control (1 point)
	Credit 6.1	Controllability of Systems, Perimeter (1 point)
	Credit 6.2	Controllability of Systems, Non-Perimeter (1 point)
	Credit 7.1	Thermal Comfort, Comply with ASHRAE 55-1992 (1 point)
	Credit 7.2	Thermal Comfort, Permanent Monitoring System (1 point)
	Credit 8.1	Daylight & Views, Daylight 75% of Spaces (1 point)
	Credit 8.2	Daylight & Views, Views for 90% of Spaces (1 point)
Design Area 6	**Innovation & Design Process (5 Points possible)**	
	Credit 1.1	Innovation in Design: Specific Title (1 point)
	Credit 1.2	Innovation in Design: Specific Title (1 point)
	Credit 1.3	Innovation in Design: Specific Title (1 point)
	Credit 1.4	Innovation in Design: Specific Title (1 point)
	Credit 2	LEED™ Accredited Professional (1 point)

Appendix B: Analysis of LEED Registered Projects






LEED Registered Projects per Gross State Product
# of Projects/GSP
0.0005
0.0004
0.0003
0.0002
0.0001
0
AZ CA CO GA IL MA MD MI NJ NY OH OR PA TX WA
State


LEED Registered Projects Per Construction GSP
Registered Projects/Construction GSP
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
AZ CA CO GA IL MA MD MI NJ NY OH OR PA TX WA
State

Appendix C: List of 33 Green Buildings, Green Cost Premiums, and Level of Green Standard

Project	Location	Type	Date Completed	Green Cost Premium	Green Standard
Energy Resource Center[1]	Downey, CA	Office	1995	0.00%	Level 1-Certified
KSBA Architects[1]	Pittsburgh, PA	Office	1998	0.00%	Level 1-Certified
Brengel Tech Center[1]	Milwaukee, WI	Office	2000	0.00%	Level 1-Certified
Stewart's Building[2]	Baltimore, MD	Office	2003	0.50%	Level 1-Certified
Pier One[3]	San Francisco, CA	Office	2001	0.70%	Level 1-Certified
PA EPA S. Central Regional[1]	Harrisburg, PA	Office	1998	1.00%	Level 1-Certified
Continental Towers[11]	Chicago, IL	Office	1998	1.50%	Level 1-Certified
Cal EPA Headquarters[3]	Sacramento, CA	Office	2000	1.60%	Level 1-Certified
EPA Regional[4]	Kansas City, KS	Office	1999	0.00%	Level 2-Silver
Ash Creek Intermed. School[10]	Independence, OR	School	2002	0.00%	Level 2-Silver
PNC Firstside Center[1]	Pittsburgh, PA	Office	2000	0.25%	Level 2-Silver
Clackamas High School[10]	Clackamas, OR	School	2002	0.30%	Level 2-Silver
Southern Alleghenies Museum[2]	Loretto, PA	Office	2003	0.50%	Level 2-Silver
DPR-ABD Office Building[5]	Sacramento, CA	Office	2003	0.85%	Level 2-Silver
Luhrs Univ. Elementary[2]	Shippensburg, PA	School	2000	1.20%	Level 2-Silver
Clearview Elementary[2]	Hanover, PA	School	2002	1.30%	Level 2-Silver
West Whiteland Township[2]	Exton, PA	Office	2004	1.50%	Level 2-Silver
Twin Valley Elementary[2]	Elverson, PA	School	2004	1.50%	Level 2-Silver
Licking County Vocational[2]	Newark, OH	School	2003	1.80%	Level 2-Silver
3 Portland Public Buildings[1*]	Portland, OR	Office	since 1994	2.20%	Level 2-Silver
Nidus Center of Science[1]	Creve Coeur, MO	Office	1999	3.50%	Level 2-Silver
Municipal Courts[1]	Seattle, WA	Office	2002	4.00%	Level 2-Silver
St. Stephens Cathedral[12]	Harrisburg, PA	School	2003	7.10%	Level 2-Silver
4 Times Square[6]	New York City	Office	1999	7.50%	Level 2-Silver
PA DEP Southeast[2]	Norristown, PA	Office	2003	0.10%	Level 3-Gold
The Dalles Middle School[10]	The Dalles, OR	School	2002	0.50%	Level 3-Gold
Dev. Resource Center[8]	Chattanooga, TN	Office	2001	1.00%	Level 3-Gold
PA DEP Cambria[2]	Ebensburg, PA	Office	2000	1.20%	Level 3-Gold
PA DEP California[2]	California, PA	Office	2003	1.70%	Level 3-Gold
East End Complex-Blk 225[7]	Sacramento, CA	Office	2003	6.41%	Level 3-Gold
Botanical Garden Admin[9]	Queens, NY	Office	2003	6.50%	Level 4-Platinum

1 Cost data from "Resource Guide for Sustainable Development in an Urban Environment: A Case Study in South Lake Union, Seattle, WA," prepared by UEI, Oct 22, 2002, p.42. http://www.usgbc.org/Resources/research.asp. Note that many of these 33 data points typically came from more than one source and/or were checked with more than one source.
2 Cost data from presentation and discussions with John Boecker, Vice President, L. Robert Kimball & Associates, November 20 and December 20, 2002, and May 2003.
3 Cost data from Anthony Bernheim, "Saving Resources," Urban Land, June 2001 and Anthony Bernheim and Scott Lewis, "Measure and Cost of Green Building," presented at the AIA National Convention, May 2000.
4 C. C. Sullivan, "Off-the-Shelf Ecology," Building Design & Construction, May 2001, pp 57-60.
5 Communication with David Gottfried, WorldBuild, December 27, 2002, forwarded information from Craig Greenough, DPR Inc.
6 Communication with Pam Lippe, Environmental Consultant to the Durst Organization, Dec 19, 2002.
7 Cost data from Jim Ogden, 3D/I, "Summary of Green Building Costs - Block 225," 2003.
8 Communication with Randy Croxton, Croxton Collaborative, November 20, 2002.
9 David Kozlowski, "Urban Green," Building Operating Management, December 2001. Indicated cost increase 5-8%.
10 Communication with Heinz Rudolf, Principal, BOORA Architects, November 2002, June 2003. Bill Harper, Assoc. Principal, BOORA Architects, May, 2003. For more info, see: http://www.energy.state.or.us/school/highperform.htm
11 Communication with Kevork Derderian, Continental Offices Ltd., Nov 21, 2002.
12 Communication with Vern McKissick, Architect, McKissick Asssociates. May become gold, but silver for now.
* Without more complete information than that the buildings were completed between 1994-2001, the three were attributed to 1997 in this analysis.

Appendix D: Non-energy Value of Peak Demand Reduction

Below are updated numbers for 11 utility studies on the value of peak demand reduction in lowering T&D and related costs. The result is an average current value of $600/kW for peak power demand reduction. These savings can be realized with peak-shaving energy efficiency improvements and/or the installation of on-site distributed generation, such as solar photovoltaics.

A first set of studies from six utilities (Georgia Power, Florida Power & Light, Green Mountain Energy, New Mexico, and two from Southern California Edison), analyzed by Zaininger Engineering and presented in Figure D-1, indicate an average T&D-related benefit of $549/kW (2002 dollars).

Figure D-1. Non-energy Benefits of Peak Reduction/kW[347]

	Georgia	FPL	Green Mount.	New Mexico	So Cal Ed 1*	So Cal Ed 2*	CA Avg. (*)	Average of all 6
Environmental Externalities					$414	$634	$524	
Distribution facility deferral	$0	$0	$0	$1,033	$227	$0	$113	$210
Distribution Losses	$76	$55	$73	$18	$65	$265	$165	$92
Voltage Regulation	-$5	-$4	-$2	-$4	-$5	-$5	-$5	-$4
Transmission Capacity	$105	$0	$244	$0	$344	$107	$226	$133
Transmission losses	$39	$0	$0	$0	$46	$54	$50	$23
TOTAL NON-ENERGY BENEFITS	$215	$51	$315	$1,048	$677	$421	$549	$454
As % of generation capital cost ($600/kW)	36%	9%	52%	175%	113%	70%	92%	76%

The second set of data are from studies undertaken at five utilities (including two at Southern California Edison in California) and indicate average T&D and line loss benefits of $673/kW (2002 $), or about 110% of the current cost of marginal generation peaking plants.

Figure D-2. Non-energy Value of Peak Reduction[348]

	APS	COA	SRP	PG&E*	SMUD*	CA Avg. (*)	Average of all 5
Losses	$218	$95	$85	$89	$0	$45	$98
Distribution	$780	$18	$637	$62	$172	$117	$334
Transmission	$445	$0	$153	$548	$65	$306	$242
TOTAL NON-ENERGY VALUE	$1,443	$113	$875	$699	$237	$468	$673
% of generation capital cost ($600/kW)	241%	19%	146%	117%	39%	78%	112%

[347] Henry W. Zaininger, Zaininger Engineering Co., Inc., 9959 Granite Crest Ct., Granite Bay, CA 95746, taken from *CEC Energy Innovations '99*, October 25 - 27, 1999. Personal communication with Hank Zaininger, November 2002, CPI inflation adjusted.
[348] Howard Wenger, Tom Hoff & Dale Furseth, Pacific Energy Group; Christy Herig, National Renewable Energy Laboratory; John Stevens, Sandia National Laboratory. Data assembled by US DOE. Personal communications with study co-author Tom Hoff, November, 2002, CPI inflation adjusted.

Appendix E: Emissions

Some Assumptions

a) This report focuses on four pollutants: NOx, SO2, PM10 and CO2. While other pollutants impose significant costs and should be evaluated in a more thorough study, these four pollutants probably represent most of the damage from burning fossil fuels. Further research should analyze the value of reducing all emissions, including the waste products of nuclear reactors, which supply 16% of California's power.[349] This report also focuses on electricity and leaves out the cost of using gas in state buildings, both because gas represents a small percentage (<5%) of energy use in commercial buildings and because pollution from gas is well within the range of pollution intensity for the statewide mix of electricity sources.

b) California imports between 20% and 35% of its power (at peak) from out-of-state and this is roughly twice as dirty as in-state generation.[350] Of 50,000 MW total in-state generating capacity, only 500 MW, or 1% is generated from coal. However some 2000 MW of LADWP power that is sold in California is from coal burning power plants located out-of-state.[351] Emissions factors developed by Tellus were used in this analysis because these include out-of-state emissions. (See Section V.)

c) Emissions calculations generally cover only pollution at time of generation. However, considerable emissions are created during the extraction/production, purification and other steps in energy life cycle as well. For example, a recent PhD thesis at the Harvard School of Public Health estimated that a substantial portion of the damaging emissions from natural gas actually occur during extraction and production phases (that is, prior to combustion), but that these emissions are generally not included in calculation of emissions costs associated with energy production. See Figure D-1 below.

Figure E-1. Air Pollutant Emissions from Natural Gas Fuel Cycle (ton/ft^3)[352]

Stage	NOx	SOx	Total PM	CO_2
Extraction/ Production[a]	8.5×10^{-8}	1.4×10^{-6}	1.9×10^{-9}	3.3×10^{-6}
Purification[b]	4.1×10^{-8}	5.4×10^{-12}	1.6×10^{-10}	-
Power plant combustion	1.2×10^{-7}	1.7×10^{-9}	3.5×10^{-9}	6.2×10^{-5}
TOTAL	2.5×10^{-7}	1.4×10^{-6}	5.6×10^{-9}	6.6×10^{-5}
End-use fraction of total	0.49	0.0013	0.63	0.95

[349] Source: http://www.green-e.org/your_e_choices/ca.html, April 2003. Data compiled by the US Environmental Protection Agency.
[350] Communication with Joe Loyer, Environmental Unit of the State Energy Siting Division, on October 23, 2002. jmloyer@energy.state.ca..us. See also Tellus Study. Op. Cit.
[351] Data provided by the California Energy Commission, Systems Assessment and Facilities Siting Division. December 2002.
[352] Jonathan Levy, "Environmental Health Effects of Energy Use: A Damage Function Approach." Thesis submitted to the Faculty of The Harvard School of Public Health in Partial Fulfillment of the Requirements for the Degree of Doctor of Science in the Departments of Environmental Health and Health Policy and Management Boston, Massachusetts, May, 1999, Table 15. This report kindly provided by Bob Berkebile of BNIM.

These and similar studies indicate the need to evaluate the life cycle emissions impact of fossil fuel consumption in order to achieve a more accurate environmental accounting of emissions and costs. It is not within the scope of this study to do so, tending to underestimate the financial benefits associated with lower emissions from reduced issue of purchased electricity in green buildings.

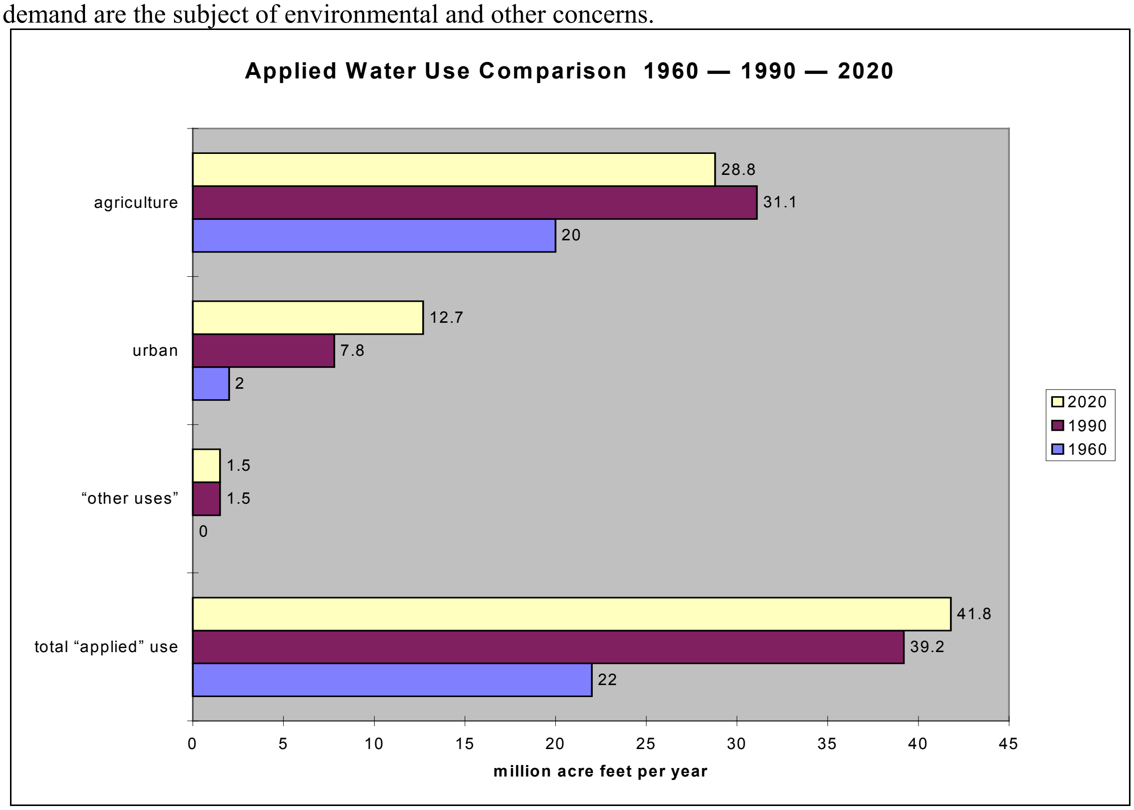
Appendix F: Water Use in California

The following is excerpted and adapted from the work of Bob Wilkinson, UC Santa Barbara.[353]

Water in California is extracted from natural systems primarily for use in the urban and agricultural sectors. The urban water use sector includes residential, commercial, industrial, and institutional uses, as well as municipal uses such landscaping and fire-fighting. As the state's population continues to grow, urban uses of water are steadily increasing. The state now projects a continued decline in water use for agriculture. Land retirement, crop shifting, water transfers, and improved efficiencies in irrigation as well as conveyance and management will all contribute to a reduction in water used for irrigation. Despite this decline, however, total extractions from the state's water systems have increased through the years, with flows for the environment decreasing as a result.

With very real limits to the state's water system, and every major supply source being reduced, the state's water systems may be fairly said to be stressed. Every major water supply source in California is currently beyond the physical or legal capacity to be sustained. California's entitlement to Colorado River water is 4.4 mafy, but it has been taking 5.2 mafy. An average of 1.3 mafy of groundwater extraction is overdraft (extractions exceed recharge by more than 18 percent). In severe drought years, this overdraft may be as high as four to 10 mafy, which drastically depletes economically recoverable groundwater resources.

The municipal and industrial (M&I) sector accounts for approximately 20% of the state's developed water use. The costs of water supply options have increased significantly, and water supplies to meet urban demand are the subject of environmental and other concerns.



* Total of "other outflow" and "environmental," a category which is not disaggregated for 1960. Assumes total water resources of 85 mafy for 2020, consistent with 1960 and 1990 data.

Source: California Department of Water Resources. California Water Plan Update, Bulletin 160-93, 1994.

353 Robert Wilkinson, "Methodology for Analysis of the Energy Intensity of California's Water Systems, and an Assessment of Multiple Potential Benefits Through Integrated Water-Energy Efficiency Measures," January 2000, p. 16-17. (mafy = million acre-feet per year).

Appendix G: Water Calculations

Weighted Average Value (WAV) Calculation

Population data is based on projections from 1995-2020.[354]

	Total 20-year PV ($/af)	% of CA population	Component of WAV
Bay Area	$9,546	8.1%	$769.36
Central Coast	$5,576	3.9%	$216.24
Sacramento	$1,783	9.3%	$166.35
San Joaquin	$3,098	9.3%	$287.39
South Coast	$9,074	45.5%	$4,128.23
S. Lahontan	$4,837	8.5%	$408.93
Tulare	$3,200	10.1%	$322.71
	Weighted Average Value:		**$6,299.21**

For the following calculations, doubling this WAV number seems to make sense because of the numerous unaccounted for costs in the studies on which these numbers are based, as outlined in Section VI.

Value of Potential Water Savings – An Example

Determining the value of potential water savings in a typical new building project requires making multiple assumptions about the size of the structure, its intended use, and its location within the state and baseline design elements. For the purposes of this example, assume the following:

Building Size:	100,000 ft^2
Building Type:	Standard Commercial Office w/ Cooling Tower
Number of Employees:	400 (250 ft^2/employee)
Baseline Building Practice:	Code
Baseline Indoor Water Usage:	25 gallons per employee per day[355]
Use Reduction through Green Design:	30%[356]
Baseline Landscape Water Usage:	1.46 million gallons per acre per year[357]
Average size of landscaped area:	0.75 acres per building[358]

[354] Source: "Bulletin 160-98: California Water Plan," California Department of Water Resources, Table 4.1.

[355] The amount of water used in California's commercial buildings varies widely by building type and use. Cooling towers and restaurants have the greatest impact on consumption. Average daily per capita consumption ranges from 15 to 40+ gallons. From conversation with Dale Lessick, Irvine Ranch Water District, October 2, 2002.

[356] Indoor savings of 30% are considered typical when incorporating relatively simple green design features. Source: USGBC, http://www.usgbc.org.

[357] Landscape water usage is even more difficult to generalize than indoor use. Planted landscapes range in size from a few potted plants (mostly in urban centers) to several acres (mostly in the suburbs). In addition, plant types require vastly different amounts of water. From http://www.cimis.water.ca.gov/, the average ETo in California across all 18 zones is 51.6 inches per year. According to the CUWCC, typical turf grass requires roughly 70% of ETo – 36 inches per year. Assuming that water delivery systems, are on average 50% inefficient, this hypothetical turf grass would require 54 inches of water applied per year. Calculations: 4.5 ft^3 x 43,460 ft^2/acre x 7.48 gallons/ft^3 = 1.46 million gallons per year (mgpy). We assume that through more efficient irrigation systems and better plant selection, conservation can achieve a 50% water use reduction, resulting in a required application of 730 mgpy.

Use Reduction through Green Design:	50%[359]
Marginal 20-yr PV cost of water:	$12,598/af

Calculations:
(1 af = 325,851 gallons)

Indoor Water Conserved:
25 gallons x 30% = 7.5 gpd savings
400 people x 7.5 gpd savings x 260 work days/yr = 780,000 gpy (2.39 af)
2.39 af x $12,598/af = $30,109

Irrigation Water Conserved:
(1,460,000 gallons per acre x .75 acres) x 50% = 547,500 gpy (1.68 af)
1.68 af x $12,598/af = $21,164

Figure G-1. 20-Year NPV of Water Savings

Total Value Per 100,000 ft^2 Building		
Indoor	**Irrigation**	**Total**
$30,109	$21, 164	$51,271
Total Value Per ft^2 of Building		
Indoor	**Irrigation**	**Total**
$0.30	$0.21	$0.51

The PV values were calculated by multiplying the PV value of one acre-foot of water, as derived in Section VI, with the amount of savings (in acre-feet) that are achieved in this hypothetical example. The total 20-year PV for both Indoor and Outdoor water savings is calculated as follows:

PV of 1 af = $12,598	(from Section VI)
($12,598 x 2.39 af)	(savings from indoor water reduction)
+ ($12,598 x 1.68 af)	(savings from outdoor water reduction)
= $51,271	
$51,271 / 100,000 ft^2 = **$0.51/ft^2**	(20-year PV)

[358] Conversation with Dale Lessick. This is the average landscaped acreage of over 800 commercial buildings in the Irvine Ranch Water District.
[359] Outdoor landscaping savings of 50% are considered typical when incorporating relatively simple green design features. Source: USGBC, http://www.usgbc.org.

Appendix H: Value of Waste Reduction – A State Building Example

The following example shows the economic impact of C&D diversion in a hypothetical new state green building project. The calculated value is in downstream product manufacture and sales, real tax revenues, and environmental impacts. It is important to note that some of the assumptions in this calculation are based on values for curbside recycling. Due to the relatively higher quality of most C&D materials, C&D recycling is generally more financially beneficial than curbside residential or commercial recycling service. Ultimately, this is a calculation of the benefits of waste diversion, of which recycling is one part.

The Impact of Construction and Demolition Waste Diversion

Assumptions

Building Size:	100,000 ft^2
Construction Waste Generated:	200 tons (400,000 lbs) [360]
Demolition Waste Generated:	775 tons (1,550,000 lbs)
Baseline Case:	50% Diversion Rate[361]
Green Case:	75% Diversion Rate
Value of Ton of Diverted Waste:	
Output Impact:	\$325/ton[362]
Income Impact:	\$70/ton
Value Added Impact (taxable):	\$111/ton
Environmental Impact:	\$47/ton[363]
State Income Tax:	3%
State Sales Tax:	8.25%

Calculations

Full Value of Ton Diverted (Output + Environmental): \$325 + \$47 = \$372
Tax Value of Ton Diverted: \$2.10 (e.g.\$70 x 3%) + \$9.16 (e.g.\$111 x 8.25%) = \$11.25

Conclusions for the whole building, assuming additional 25% diversion over baseline

Construction Diversion		
Full Value:	\$18,600	(200 tons x 25% x \$372)
Environmental Value:	\$2,350	(200 tons x 25% x \$47)
Tax Value:	\$563	(200 tons x 25% x \$11.25)
Demolition Diversion		
Full Value:	\$72,075	(775 tons x 25% x \$372)
Environmental Value:	\$9,106	(775 tons x 25% x \$47)
Tax Value:	\$2,180	(775 tons x 25% x \$11.25)

---

[360] For nonresidential buildings: 155 lbs/ft^2 demolition waste, about 4 lbs/ft^2 construction waste. US Environmental Protection Agency Municipal and Industrial Solid Waste Division, Office of Solid Waste. *Characterization of Building-related Construction and Demolition Debris in the United States*. June 1998.
[361] Note: Statewide estimated overall diversion rate in 2002 was 48% (CIWMB) – and green buildings can often reach the 75% diversion threshold.
[362] Average Output Impact average from UCB and NRC study.
[363] The environmental cost number for California is probably similar to the environmental cost number from the Massachusetts study plus or minus 25%. A conservative estimate of 75% of the Massachusetts number is used here. This number is similar to the curbside recycling environmental value.

The savings of C&D waste diversion are presented in Figure G-1 below.

Figure H-1. Value of C&D Waste Diversion in 100,000 ft^2 Office Building

		Building	Per ft^2
Construction	**Full Value**	$18,600	$0.19
	Eco Value	$2,350	$0.02
	Tax Value	$563	$0.01
Demolition	**Full Value**	$72,075	$0.72
	Eco Value	$9,106	$0.09
	Tax Value	$2,180	$0.02

For construction on barren land, use only the construction values. For construction on already developed land where an existing structure must first be demolished, use the demolition values plus the construction values.

Which metric is the right one to use?

The most accurate number for the state to use when evaluating the value of waste diversion is the Tax Value[364] plus the Eco-Value, according to the following rationale. The Tax Value is the most precise and conservative metric. It represents actual revenue earned by the state as a result of diversion. The Eco-Value also represents real avoided cost to the state even if it is, in part, speculative (e.g., reduced green house gas emissions). The Full Value includes all the multiplier effects of diversion (e.g., income effects, product value effects, taxes, etc.) – many of which accrue to individual actors within the state, but not to the state itself.

Using this approach, then, the potential values for reaching a 50% C&D diversion rate (25% over baseline) are:

$0.03/ft^2 or $3,000 per 100,000 ft^2 building for construction only.

$0.11/ft^2 or $11,000 per 100,000 ft^2 building for demolition only.

$0.14/ft^2 or $14,000 per 100,000 ft^2 building for construction preceded by demolition.

All numbers reflect the value that occurs in the year of the construction. This is not an NPV calculation. While there undoubtedly are effects from landfill reduction that reverberate through the future years, they are not included in this analysis and assumed to be small. A more thorough study should analyze this further.

Note on Office Recycling

In this example, office recycling has been removed from calculations of green building waste reduction benefits. It is not clear that the tenants of green buildings would reduce disposed waste beyond California's already relatively aggressive statewide recycling goals.

---

[364] The tax value refers to the additional taxes the state is likely to collect as a result of the economic activity generation through diversion activities.

Appendix I: Total User Costs for California State Buildings

Calculations follow the chart.

Figure I-1. DGS Data for California State Buildings

2002 data for 9.25 million square feet of California state office space with 27,428 employees.

Total User Costs	Annual $/Employee					
BLDG.#	Electricity	O&M	Other Energy	Rent	Employee	Total
001	$555	$22,132	$0	$175	$65,141	$88,003
002	$432	$2,589	$0	$2,477	$65,141	$70,340
003	$557	$3,060	$16	$7,239	$65,141	$75,595
004	$619	$3,585	$0	$0	$65,141	$68,958
006/056	$771	$2,958	$0	$5,747	$65,141	$73,975
008	$406	$2,373	$0	$8,367	$65,141	$75,991
009	$117	$1,812	$0	$932	$65,141	$67,929
010	$189	$1,609	$0	$4,603	$65,141	$71,436
011	$202	$6,476	$0	$4,445	$65,141	$76,247
013	$183	$979	$0	$3,349	$65,141	$69,651
018	$223	$806	$0	$2,962	$65,141	$69,595
019	$351	$1,612	$147	$0	$65,141	$67,018
021	$387	$2,442	$0	$4,959	$65,141	$72,625
025	$725	$5,997	$5	$13,893	$65,141	$85,354
028	$335	$167	$14	$0	$65,141	$66,020
030	$335	$1,166	$24	$5,705	$65,141	$72,371
036	$1,570	$4,563	$5	$0	$65,141	$70,232
039/045	$231	$1,024	$1	$3,061	$65,141	$69,804
075	$516	$1,862	$19	$3,320	$65,141	$71,117
091	$325	$17,112	$0	$0	$65,141	$82,270
330	$376	$6,308	$18	$6,346	$65,141	$77,946
402	$602	$2,631	$0	$15,044	$65,141	$83,869
460	$633	$7,164	$52	$6,275	$65,141	$78,663
461	$290	$1,424	$19	$2,540	$65,141	$69,163
470	$628	$5,486	$0	$5,695	$65,141	$76,479
480	$313	$4,921	$47	$3,226	$65,141	$73,439
512	$397	$2,356	$21	$8,296	$65,141	$76,145
530	$540	$5,177	$31	$6,489	$65,141	$76,972
602	$634	$1,959	$19	$9,063	$65,141	$77,133
701	$515	$3,237	$53	$5,258	$65,141	$73,861
753	$1,039	$3,392	$88	$9,915	$65,141	$78,587
801	$701	$4,999	$96	$6,994	$65,141	$77,391
901	$615	$3,780	$41	$3,995	$65,141	$73,048
Averages	**$408**	**$3,039**	**$12**	**$4,755**	**$65,141**	**$73,355**

Assembled for this report by the California Department of General Services and the Real Estate Services Division.

Energy Use Calculations
For purposes of calculating emissions from energy for Section V, it was necessary to determine a conservative value for electricity used per square foot. This can be derived by first determining electricity consumption per employee, then multiplying electricity consumption per employee by number of employees and dividing by the number of total square feet, as follows:

$408/0.12kWh/ft^2	=	3400 kWh/employee/year
3,400 x 27,428	=	93,255,200 kWh/year (for all building area)
93,255,200/9,250,000	=	**10 kWh/ft^2/yr**

Office energy costs for California state employees in 2002 were about:[365]
$1.60/ft^2 or $360/employee/year

This paper assumes an expected drop in electricity prices from $0.12/kWh to $0.11/kWh.[366] Therefore these figures are discounted to:
$1.47/ft^2/yr or $330/employee/year

Figure H-1 shows total energy costs per employee of $420.
Electricity + Other Energy = Total Energy: $408+$12=$420

Additionally, according to the Real Estate Services Division, average office space per worker is:
225 ft^2/employee

However, the information in Figure H-1 seems to imply more space than this:
9,250,000/27,428 = 337 ft^2/employee

These discrepancies can be explained as follows:

The total energy costs from Figure H-1 are understood to be the total energy consumed by the buildings divided by the number of employees. Therefore, energy costs for all buildings are:

27,428 x $420 = $11,519,760

This doesn't account for two factors:

1. The influence of "transients" or non-employees in the building, thereby increasing the effective number of employees.
2. Non-office space such as stairwells, elevator shafts and hallways, which are communal and generally unconditioned.

State buildings, in providing services, often have many non-employees inside them. Assuming a "transient factor" of 5% (on average there is space for 5% more people in the building than reported employees) results in a higher number of "effective employees":

[365] Data provided by the California Department of General Services, Real Estate Services Division, Building Property Management Brach, December 2002.
[366] California Energy Commission. Office of the Supervisor of Rates. December 2002. $0.11/kWh is a conservative estimate. Higher rates would increase green building benefits.

$27,428 \times 1.05 = 28,799$ effective employees

All office buildings have a significant amount of non-office space. This space is generally both shared by all and less heavily conditioned (requiring less energy in heat and electricity) than office space. Assuming 30% of these state office buildings are non-office space delivers:

9.25 million ft^2 x 70% = 6.475 million ft^2 office space

Assuming non-office space requires 1/3 the energy of office space, this means that, while office space only makes up 70% of the building, it consumes 90% of the energy, thus:

\$11,519,760 x 90% = \$10,367,784 (energy cost of conditioning office space)

It is only this energy cost that should be attributed to employees, as energy costs of non-office space can't be assumed to scale evenly with number of employees.
Thus, energy costs per effective employee are:

\$10,367,784/28,799 = \$360/employee/year

Furthermore, office space per employee is:

6,475,000/28,799 = **225 ft^2/employee/year**

And energy costs per square foot are:

\$10,367,784/6,475,000 = \$1.60/ft^2/yr

These numbers are for 2002, when electricity cost (and therefore most of the cost of energy) was \$0.12/kWh. However, estimates for future electricity cost are \$0.11/kWh. Scaling the above figure down delivers:

\$1.60 x (11/12) = **\$1.47/ft^2/yr**

This is the number used throughout this report.

Appendix J: Health and Productivity Gains from Better Indoor Environments[367]

This is a direct excerpt from the work of William J. Fisk and Satish Kumar.

Acute Respiratory Illness (ARI)

No high quality studies identified had investigated but failed to find a link between building characteristics and acute respiratory illnesses (ARIs) such as influenza and common colds. Eight studies reported statistically significant 23% to 76% reductions in ARIs among occupants of buildings with higher ventilation rates, reduced space sharing, reduced occupant density, or irradiation of air with ultraviolet light. These changes to buildings or building use were considered technically feasible and practical, given sufficient benefits. One study found a 35% reduction in short-term absence, a surrogate for ARI, in buildings with higher ventilation rates. Because some of these studies took place in unusual building types, such as barracks and a jail, reductions in ARIs were adjusted downwards, and ranged from 9% to 20%. Multiplying this range by the annual cases of common colds and influenza resulted in an estimated 16 million to 37 million potentially avoided cases of common cold and influenza. Given the $70 billion annual cost of ARIs, the associated potential productivity gains were $6 billion to $14 billion.

Allergies and Asthma

The scientific literature reports statistically significant links between prevalence of allergy and asthma symptoms and a variety of changeable building characteristics or practices, including indoor allergen concentrations, moisture and mold problems, pets, and tobacco smoking. The reported links between these risk factors and symptoms were often quite strong. For example, parental smoking was typically associated with 20% to 40% increases in asthma symptoms. In numerous studies, mold or moisture problems in residences were associated with 100% increases in lower respiratory symptoms indicative of asthma. These moisture and mold problems are common; for example, about 20% of U.S. houses have water leaks. Based on these data, the estimated potential reduction in allergy and asthma symptoms from improved IEQ was 8% to 25%, among a large population -- 53 million with allergies and 16 million asthmatics. Given the $15 billion annual cost of allergies and asthma, the potential economic gains are $1 billion to $4 billion.

Sick Building Syndrome (SBS) Symptoms

SBS symptoms are acute symptoms, such as eye and nose irritation and headache, associated with occupancy in a specific building, but not indicating a specific disease. Risk factors for SBS symptoms identified in many studies include lower ventilation rates, presence of air conditioning, and higher indoor air temperatures. Increased chemical and microbiological pollutants in the air or on indoor surfaces, debris or moisture problems in HVAC systems, more carpets and fabrics, and less frequent vacuuming were risk factors in a smaller number of studies. One large study suggests that a 10 cfm per person increase in ventilation rates would decrease prevalences of the most common SBS symptoms on average by one third. Practical measures could diminish all these risk factors. Based on these data, the estimated potential reduction in SBS symptoms was 20% to 50%. The affected population is very large – in a survey of 100 U.S. offices, 23% of office workers (64 million workers) frequently experienced two or more SBS symptoms at work. The estimated productivity decrement caused by SBS symptoms in the office worker population was 2%, with an annual cost of $60 billion. A 20-50% reduction in these symptoms, considered feasible and practical, would bring annual economic benefits of $10 billion to $30 billion.

---

[367] Excerpted directly from: Satish Kumar and William J. Fisk, "The Role of Emerging Energy Efficient Technology in Promoting Workplace Productivity and Health: Final Report," LBNL, February 13, 2002, pp. 20-21. Available at: http://www-library.lbl.gov/docs/LBNL/497/06/PDF/LBNL-49706.pdf.

Direct Productivity Gains

Published literature documents direct linkages of worker performance with air temperatures and lighting conditions, without apparent effects on worker health. Many but not all studies indicate that small (few ^{o}C) differences in temperatures can influence workers' speed or accuracy by 2% to 20% in tasks such as typewriting, learning performance, reading speed, multiplication speed, and word memory. Surveys have documented that indoor air temperature is often poorly controlled, implying an opportunity to increase productivity.[368] It is estimated that providing ± 3^{o}C of individual temperature control would increase work performance by 3% to 7%. A smaller number of studies have documented improvements in work performance with better lighting, with benefits most apparent for visually demanding work. Increased daylighting was also linked in one study to improved student learning. Based on these studies and recognizing that performance of only some work tasks is likely to be sensitive to temperature and lighting, the estimated potential direct productivity gain is 0.5% to 5%, with the factor of ten range reflecting the large uncertainty. Considering only U.S. office workers, the corresponding annual productivity gain is \$20 billion to \$200 billion.

[368] Wyon. 1996. Op. Cit.

Appendix K: Insurance and Risk Management Benefits of Green Building Attributes

From: Evan Mills, "Green Buildings as a Risk-Management Strategy," *Energy Associates*, Prepared for Capital-E, December 2002.

Category of Green Buildings Insurance/Risk-Management Benefits										
			Property Loss	**General Liability**	**Business Interruption**	**Vehicle (Prop or Liab)**	**Health & Workers Comp.**	**Life**	**Environmental Liability**	**Notes**
Design Area 1	**Sustainable Sites (14 Points possible)**		**1**			**4**	**3**	**2**	**3**	
	Prereq 1	**Erosion & Sedimentation Control** (Required)	+						+	Reduced likelihood of property damage due to mudslides and soil subsidence.
	Credit 1	**Site Selection** (1 point)								
	Credit 2	**Urban Redevelopment** (1 point)								
	Credit 3	**Brownfield Redevelopment** (1 point)		-	-		-		-	
	Credit 4.1	**Alternative Transportation**, Public Transportation Access (1 point)				+				Reduced number of personnel using insured transportation infrastructure.
	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms (1 point)				+				Reduced number of personnel using insured transportation infrastructure.
	Credit 4.3	**Alternative Transportation**, Alternative Fuel Refueling Stations (1 point)				+/-				Reduced number of personnel using insured transportation infrastructure. Potential new risks associated with alternate fuels and vehicles.
	Credit 4.4	**Alternative Transportation**, Parking Capacity (1 point)				+				Reduced number of personnel using insured transportation infrastructure.
	Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space (1 point)								
	Credit 5.2	**Reduced Site Disturbance**, Development Footprint (1 point)								
	Credit 6.1	**Stormwater Management**, Rate or Quantity (1 point)							+	Reduced likelihood of environmental risks associated with runoff.
	Credit 6.2	**Stormwater Management**, Treatment (1 point)							+	Reduced likelihood of environmental risks associated with runoff.
	Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof (1 point)	-				+	+		Reduced stormwater runoff due to water retention by vegetation. Reduced risk of heat-catastrophe mortality. Elevated fire risk due to added vegetation near building.
	Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof (1 point)					+	+		Reduced interior temperatures; increased roof lifetime. Reduced risk of heat-catastrophe mortality.
	Credit 8	**Light Pollution Reduction** (1 point)					+			Reduced labor for lamp replacements and maintenance (workers compensation exposure).
Design Area 2	**ater Efficiency (5 Points possible)**								**1**	
	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50% (1 point)								
	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation (1 point)								
	Credit 2	**Innovative Wastewater Technologies** (1 point)							+/-	Potential beneficial or adverse

Category of Green Buildings Insurance/Risk-Management Benefits										
			Property Loss	**General Liability**	**Business Interruption**	**Vehicle (Prop or Liab)**	**Health & Workers Comp.**	**Life**	**Environmental Liability**	**Notes**
										consequences of alternative technologies.
	Credit 3.1	**Water Use Reduction**, 20% Reduction (1 point)								
	Credit 3.2	**Water Use Reduction**, 30% Reduction (1 point)								
Design Area 3	**nergy & Atmosphere (17 Points ossible)**		**6**	**6**	**9**		**6**	**3**	**6**	
	Prereq 1	**Fundamental Building Systems Commissioning** (Required)	+	+	+		+			Facilitates detection of property and/or health risks associated with project that could lead to service interruptions or physical damages. Reduces liability of architects and engineers.
	Prereq 2	**Minimum Energy Performance** (Required)	+/-	+	+		+/-	+		Diverse set of benefits ranging from reduced fire risk due to multi-pane windows or non-halogen light sources, or reduced business interruption. Isolated potential adverse consequences.
	Prereq 3	**CFC Reduction in HVAC&R Equipment** (Required)							+	
	Credit 1.1	**Optimize Energy Performance**, 20% New / 10% Existing (2 points)	+/-	+	+		+/-	+	+	(See above).
	Credit 1.2	**Optimize Energy Performance**, 30% New / 20% Existing (2 points)	+/-	+	+		+/-	+	+	(See above).
	Credit 1.3	**Optimize Energy Performance**, 40% New / 30% Existing (2 points)	+/-	+	+		+/-	+	+	(See above).
	Credit 1.4	**Optimize Energy Performance**, 50% New / 40% Existing (2 points)	+/-	+	+		+/-	+	+	(See above).
	Credit 1.5	**Optimize Energy Performance**, 60% New / 50% Existing (2 points)	+/-	+	+		+/-	+	+	(See above).
	Credit 2.1	**Renewable Energy**, 5% (1 point)	-		+				+	Increased reliability for on-site generation. Possible reduced environmental liability associated with on-site fossil-fuel (e.g., diesel) systems. New insurance costs and risks associated with added on-site technologies.
	Credit 2.2	**Renewable Energy**, 10% (1 point)	-		+				+	(See above).
	Credit 2.3	**Renewable Energy**, 20% (1 point)	-		+				+	(See above).
	Credit 3	**Additional Commissioning** (1 point)	+	+	+		+			(See notes on commissioning under Prereq 1).
	Credit 4	**Ozone Depletion** (1 point)								
	Credit 5	**Measurement & Verification** (1 point)	+	+/-	+		+		+	Reduced risk of underattainment of savings (see notes on commissioning - possible adverse effects on liability of service providers, ESCOs, etc.).
	Credit 6	**Green Power** (1 point)								
Design Area 4	**aterials & Resources (13 Points ossible)**					**2**	**3**		**8**	
	Prereq 1	**Storage & Collection of Recyclables** (Required)	-						+/-	Fire risks from stored flammables. Pollution risks or benefits.
	Credit 1.1	**Building Reuse**, Maintain 75% of	-				+		+	Reduced exposure to environmental risks

Category of Green Buildings Insurance/Risk-Management Benefits										
			Property Loss	**General Liability**	**Business Interruption**	**Vehicle (Prop or Liab)**	**Health & Workers Comp.**	**Life**	**Environmental Liability**	**Notes**
		Existing Shell (1 point)								associated with waste handling and disposal, as well as occupational risks to construction workers (assuming reduced new construction). Buildings may not meet current codes for earthquake, etc.
	Credit 1.2	**Building Reuse**, Maintain 100% of Shell (1 point)	-				+		+	Reduced exposure to environmental risks associated with waste handling and disposal, as well as occupational risks to construction workers (assuming reduced new construction). Buildings may not meet current codes for earthquake, etc.
	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell (1 point)	-				+		+	Reduced exposure to environmental risks associated with waste handling and disposal, as well as occupational risks to construction workers (assuming reduced new construction). Buildings may not meet current codes for earthquake, etc.
	Credit 2.1	**Construction Waste Management**, Divert 50% (1 point)							+	Reduced exposure to environmental liability issues from waste disposal.
	Credit 2.2	**Construction Waste Management**, Divert 75% (1 point)							+	Reduced exposure to environmental liability issues from waste disposal.
	Credit 3.1	**Resource Reuse**, Specify 5% (1 point)							+	Reduced exposure to environmental liability issues from waste disposal.
	Credit 3.2	**Resource Reuse**, Specify 10% (1 point)							+	Reduced exposure to environmental liability issues from waste disposal.
	Credit 4.1	**Recycled Content**, Specify 25% (1 point)								
	Credit 4.2	**Recycled Content**, Specify 50% (1 point)								
	Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally (1 point)				+				Reduced freight-mileage. Of benefit if state-owned vehicles used.
	Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally (1 point)				+				Reduced freight-mileage. Of benefit if state-owned vehicles used.
	Credit 6	**Rapidly Renewable Materials** (1 point)								
	Credit 7	**Certified Wood** (1 point)								
Design Area 5	**door Environmental Quality (15 oints possible)**		**6**	**11**	**10**		**17**	**2**	**13**	
	Prereq 1	**Minimum IAQ Performance** (Required)	+	+	+		+	+	+	Diverse health benefits, formerly excluded by many insurance policies but increasingly being successfully litigated. Reduced risk of moisture damage (e.g., toxic mold). Reduced risk of liability to designer/builder/operator. Can avert absenteeism, shutdowns, or forced relocation due to IAQ problems.
	Prereq 2	**Environmental Tobacco Smoke** (ETS)		+			+	+	+	(See above).

			Category of Green Buildings Insurance/Risk-Management Benefits							
			Property Loss	**General Liability**	**Business Interruption**	**Vehicle (Prop or Liab)**	**Health & Workers Comp.**	**Life**	**Environmental Liability**	**Notes**
		Control (Required)								
	Credit 1	**Carbon Dioxide** (CO_2) **Monitoring** (1 point)		+			+		+	(See above).
	Credit 2	**Increase Ventilation Effectiveness** (1 point)	+	+			+		+	(See above).
	Credit 3.1	**Construction IAQ Management Plan**, During Construction (1 point)	+	+	+		+		+	(See above).
	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy (1 point)	+	+	+		+		+	(See above).
	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants (1 point)		+	+		+		+	(See above).
	Credit 4.2	**Low-Emitting Materials**, Paints (1 point)		+	+		+		+	(See above).
	Credit 4.3	**Low-Emitting Materials**, Carpet (1 point)		+	+		+		+	(See above).
	Credit 4.4	**Low-Emitting Materials**, Composite Wood		+	+		+		+	(See above).
	Credit 5	**Indoor Chemical & Pollutant Source Control** (1 point)		+	+		+		+	(See above).
	Credit 6.1	**Controllability of Systems**, Perimeter (1 point)	+				+		+	(See above).
	Credit 6.2	**Controllability of Systems**, Non-Perimeter (1 point)	+				+		+	(See above).
	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992 (1 point)					+			(See above).
	Credit 7.2	**Thermal Comfort**, Permanent Monitoring System (1 point)					+			(See above).
	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces (1 point)			+		+			(See above).
	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces (1 point)			+		+			(See above).
Design Area 6	**novation & Design Process (5 Poi ssible)**									
	Credit 1.1	**Innovation in Design**: Specific Title (1 point)								Amplifies benefits noted above.
	Credit 1.2	**Innovation in Design**: Specific Title (1 point)								Amplifies benefits noted above.
	Credit 1.3	**Innovation in Design**: Specific Title (1 point)								Amplifies benefits noted above.
	Credit 1.4	**Innovation in Design**: Specific Title (1 point)								Amplifies benefits noted above.
	Credit 2	**LEED™ Accredited Professional** (1 point)								Amplifies benefits noted above.

Appendix L: Annotated Bibliography

The following is a guide to primary sources in areas for which there are no comprehensive internet resources: Water Conservation and Waste Reduction.

Water Conservation

Water Use in Buildings

Pike, Charles. *Study of Potential Water Efficiency Improvement in Commercial Business*. US EPA/DWR, April 1997.
Sweeten, Jon and Ben Chaput. *Identifying the Conservation Opportunities in the Commercial, Industrial, and Institutional Sector*. Paper delivered to the AWWA, 1997.

These studies conclude that there is considerable opportunity for cost effective water conservation technology adoption in most commercial building types.

Sustainable Use of Water: California Success Stories. Publication of the Pacific Institute, January 1999. Available online at: http://www.pacinst.org/water.html

This document identifies, describes, and analyzes examples of sustainable water policies and practices throughout the state. Many of the 28 "stories" highlighted offer specific examples of water utilities that have adopted innovative water conservation policies. Others present an overview of a particular water conservation issue area. The most useful "story" for our purposes is Chapter 6: *An Overview of Water – Efficiency Potential in the CII Sector*. It finds that significant cost-effective water conservation potential currently exists in the CII building sector.

Externalities of Water Use and Public Policy

Renzetti, Steven. "Municipal Water Supply and Sewage Treatment: Costs, Prices, and Distortions." *Canadian Journal of Economics*, May 1999. Available online at: http://economics.ca/cje/

This empirical study in Canada estimated that the price charged for fresh water was only one-third to one-half the long-run marginal supply cost, and the prices charged for sewage were approximately one-fifth the long run cost of sewage treatment

---

CUWCC. *Guidelines for Preparing Cost-Effectiveness of Urban Water Conservation Best Management Practices*. September 1996. Available online, with many other resources related to urban water conservation, at: http://www.cuwcc.org/home.html.

This document contains the Total Society Cost Model of water conservation. It is designed to capture all avoided future economic, environmental, and social costs of urban water conservation in order to determine its true avoided cost. The CUWCC is currently conducting workshops to assist water utilities in using this model.

Economic Evaluation of Water Management Alternatives. Prepared for the CALFED Bay-Delta Program, October 1999. See: http://calwater.ca.gov/Archives/WaterManagement/WaterManagementArchive.shtml.

Available online at: http://calfed.ca.gov/Programs/WaterManagement/adobe_pdf/Calfed.pdf.

This document evaluates the cost-effectiveness of different water management options that would meet the state's anticipated water needs in 2020. The perspective taken is that of the end user of water in each region where SWP or CVP water is expected to be needed in 2020. The study analyses seven scenarios, each one assuming different policy decisions leading up to year 2020.

Fiske, Gary and Associates. *California Urban Water Agencies Urban Water Conservation Potential - Final Report,* August 2001. Available online at: http://www.cuwa.org/publications.html.

This study determines marginal cost numbers for new water supplies for every region of the state for each year from 2000 – 2040, from the perspective of the regional utility. It includes wastewater facility expansion and O&M expenses in these estimates. Many water experts in the state believe that the marginal cost numbers presented in this study are too low.

Bulletin 160-98: California Water Plan. California Department of Water Resources, 1998.
Available online at: http://rubicon.water.ca.gov/b160index.html.

This document, which is updated every five years, evaluates water supplies and assesses agricultural, urban, and environmental water uses to quantify the gap between water supplies and uses. It also evaluates options for meeting the state's future water needs. The next update will be released in 2003.

The Clean Water and Drinking Water Infrastructure Gap Analysis. Published by the EPA, August 2002.
Available online at: http://www.epa.gov/safewater/gapreport.pdf.

This document evaluates our country's current water delivery and treatment systems, and the financial health of the agencies that operate them. It concludes that the expected gap between future revenues (based on historical price increases) and infrastructure needs for potable water and wastewater treatment will be approximately $148 billion over the next twenty years.

Field, Christopher. *Confronting Climate Change in California: Ecological Impacts on the Golden State.* Publication of the Union of Concerned Scientists, 1999. Available online at http://www.ucsusa.org/.

This document summarizes the likely impacts of climate change in California. It indicates that changes in precipitation patterns will have a dramatic affect on the state's ecology and economy. Specifically, more precipitation will fall as rain, rather than snow, causing massive flooding in the spring and droughts by late summer. Reduced summer runoff of fresh water would also increase summer salinity in San Francisco Bay.

Gleick, Peter. *Water: The Potential Consequences of Climate Variability and Change for the Water Resources of the United States*. Publication of the Pacific Institute, September 2000.
Available online at: http://www.pacinst.org/.

This document summarizes the results of nearly 1,000 peer-reviewed studies on climate change. Consensus conclusions are similar to those presented in the UCS study above.

Bulletin 132: Management of the California State Water Project. Publication of DWR, 1999.
Available online at: http://wwwdwr.water.ca.gov/.

This is part of a series of annual reports that describe the status of State Water Project (SWP) operations. Each annual report updates information regarding project costs and financing, water supply planning, power operations, and significant events that affect the management of the State Water Project. The publication aggregates SWP energy costs associated with pumping water throughout the state.

Preparing for California's Next Drought. Publication of DWR, July 2000.
Available online at: http://wwwdwr.water.ca.gov/.

Between 1987-1992, California experienced its longest drought in more than a century. Over 85% of the counties in the state declared local emergencies. This document presents the lessons learned from this experience and offers policy recommendations to better prepare for future drought years.

Notably, the document states the following:
Article X, Section 2 of the California Constitution prohibits waste or unreasonable use or unreasonable method of use of water. ... Water Code Section 275 directs the Department [of Water Resources] and the SWRCB to take appropriate actions before courts, administrative agencies, and legislative bodies to prevent waste or misuse of water.

Multi-Agency Benchmarking Project. Published by the King County Department of Natural Resources, publication 1282, September 1999.

This document presents the findings from a collaborative effort among seven large West Coast wastewater utilities to collect, compare and analyze cost and operational data. The investigation examines all aspects of sewage treatment facility operation. For example, in 1997, the average direct operating cost among these utilities was $729 per million gallons of treated water. Operations and Maintenance (O&M) accounted for roughly half of this amount. O&M includes direct operational labor, as well as energy and chemicals. Notably, power purchases were the second largest cost factor within O&M.

Waste Reduction

Skumatz, Lisa, SERA Inc, and Jeff Morris, SRMG. *Massachusetts Recycle 2000: Baseline Report* (Excerpts). Prepared for the Executive Office of Environmental Affairs, State of Massachusetts, December 1998.

This document compares the economic and environmental costs of waste disposal and curbside recycling in Massachusetts. This is the only analysis that we have seen that attempts to quantify the "hard to quantify" environmental costs from a state's perspective. It concludes that the total benefits of recycling, net of disposal benefits, are worth $270 - $379 per ton to the state.

Goldman, George and Aya Ogishi. *The Economic Impact of Waste Disposal and Diversion in California.* Department of Agricultural and Resource Economic, UC Berkeley, April 2001.
Available online at: http://are.berkeley.edu/coopext/EconImpWaste.pdf.

This study quantifies and compares the economic impacts of disposal and diversion in six regions within the state. The results show both that on average, diversion has twice the economic impact of disposal and that the benefits of diversion vary greatly among regions in the state. In general, recycling has a greater impact in regions with well-developed recycling infrastructure and mature recycling industries.

California Recycling Economic Information Study (REI), prepared for CIWMB by the National Recycling Coalition in association with R.W. Beck, Inc, July 2001.
Available online at: http://www.ciwmb.ca.gov/agendas/mtgdocs/2002/01/00007124.pdf.

This study uses a broader definition of diversion than the UCB study to quantify the size and makeup of the diversion industry in California and its economic impacts. It also compares diversion to other sectors of the economy and shows how the economic impacts from diversion in California fit within the nationwide economy. It reaches similar conclusions about the economic impact of diversion as the UCB study.

Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste, Final Report. Prepared by the US EPA, September 1998.

This document summarizes and assesses air emission data from different forms of waste management including incineration, landfilling and recycling.

Disposal Cost Fee Study, Final Report. Prepared by the Tellus Institute for the California Integrated Waste Management Board, February 1991.

Before the UCB and REI studies were released, this study provided the most comprehensive data on California's waste disposal system. It categorizes and analyzes the types of waste found in California's waste stream, and identifies environmental threats associated with waste diversion and disposal of various products/types of waste.

Construction Waste Management Section of the California Sustainable Design Training Manual, 2001.

This document provides an overview of waste management and all of the relevant green issues associated with it. It also provides an extensive list of internet sites with additional resources on the topic.

Glossary of Acronyms

A number of acronyms are referred to or used in this report. They are spelled out below, and when they first appear in the text.

ACEEE – American Council for an Energy Efficient Economy
ADL – Arthur D. Little Consultants
af – acre-foot (of water)
ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ARB – Air Resources Board (CA)
ASTM – American Society for Testing and Materials
BEPAC – Building Environmental Performance Criteria (Canada)
BEES – Building for Environmental and Economic Sustainability
BIDS – Building Investment Decision Support
BOMA – Building Owners & Managers Association
BREEAM – British Research Establishment Environment Assessment Method
C&D – construction & demolition
CalTrans – Department of Transportation (CA)
CBA – cost benefit analysis
CEC – California Energy Commission
CIWMB – California Integrated Waste Management Board
CO2 – carbon dioxide
CUWA – California Urban Water Agencies
CUWCC – California Urban Water Conservation Council
DGS – Department of General Services (CA)
DOE – Department of Energy (US)
DOF – Department of Finance (CA)
DSA – Division of the State Architect (CA)
DWR – Department of Water Resources (CA)
EIA – Energy Information Administration (US)
EPA – Environmental Protection Agency
FEMP – Federal Energy Management Program
GHG – greenhouse gases
GW(h) – gigawatt (hour) = 1 billion watts
HVAC – heating, ventilation and air conditioning
IAQ – indoor air quality
IEQ – indoor environmental quality
IFMA – International Facilities Management Association
IPCC – Intergovernmental Panel on Climate Change
IPMVP – International Performance Measurement & Verification Protocol
IRR – internal rate of return
ISO – International Organization for Standardization
kW(h) – kilowatt (hour) = 1000 watts
LADWP – Los Angeles Department of Water and Power
LBNL – Lawrence Berkeley National Labs
LCA – life cycle assessment
LEED – Leadership in Energy & Environmental Design (USGBC)
MW(h) – megawatt (hour) = 1 million watts
MWD – Metropolitan Water District
NIST – National Institute of Standards and Technology
NOx – oxides of nitrogen
NPV – net present value
NREL – National Renewable Energy Labs
O&M – operations & maintenance
PG&E – Pacific Gas & Electric Company
PIER – Public Interest Energy Research (CA)
PM10 – particulate matter
PUC – Public Utilities Commission
PV – solar photovoltaics
PV – present value
SBTF – Sustainable Building Task Force (CA)
SCE – Southern California Edison
SDG&E – San Diego Gas & Electric Co.
SMUD – Sacramento Municipal Utility District
SOx – oxides of sulfur
T&D – transmission & distribution
USGBC – US Green Building Council
VOC – volatile organic compound

DUNSKY EXPERTISE EN ÉNERGIE
énergie | environnement | économie

5492, Hutchison | Montréal
Quebec Canada H2V 4B3
dunsky@vif.com
514 779 7445

Appendix L:
McCarty Presentation Slides

Demand Side Portfolio Management

Steve McCarty
Director
Demand Side Policy, Planning and Analysis

Midwest Energy Efficiency Alliance
September 27, 2004

PG&E Pacific Gas and Electric Company®

Overview

- California's Energy Action Plan
- CEE Portfolio Design
- Energy Efficiency–Demand Response Integration

California's Changing Regulatory Climate

California's recovery from 2000-2001 energy crisis has created a path for increased utility reliance on energy efficiency:

- Rates-earnings decoupling mechanisms reinstituted
- Public Goods Charge energy efficiency funding guaranteed for extended period (10 years)
- Energy efficiency funding augmented with utility energy procurement funds

Pacific Gas and Electric Company®

California Energy Action Plan "Loading Order"

Conservation and demand response are at the top of the "loading order" for new energy resources under procurement plans filed by the California IOUs

- "The Action Plan envisions a "loading order" of energy resources that will guide decisions made by the agencies jointly and singly. First, the agencies want to optimize all strategies for increasing conservation and energy efficiency to minimize increases in electricity and natural gas demand." (p. 4)

Pacific Gas and Electric Company®

Integrating Supply & Demand Side Resource Planning

CEE funding levels now addressed in procurement proceedings:

- Energy efficiency integrated into IOU resource plans
- IOUs must consider all cost-effective energy efficiency in their procurement plans
- IOUs to come together on a common approach to integrating energy efficiency activities into overall procurement forecasts and resource acquisition strategies

Pacific Gas and Electric Company®

CEE Portfolio Design

Overall Approach

- Portfolio will be cost-effective and achieve savings targets set forth in the long-term plan
- Non-savings programs will continue to be funded
  - Information
  - Codes & Standards
  - Emerging Technologies
  - Local Government
- Bid 20% of 2006 funds (PGC + Procurement)
  - RFP will allocate 35% of funds to residential and 65% to commercial/industrial programs
  - Lowest cost programs will be selected consistent with threshold requirements and technical feasibility

Pacific Gas and Electric Company

CEE Portfolio Design

Energy efficiency programs will focus on reducing demand during peak periods:

Residential

- More efficient new air conditioners
- Advanced window systems
- Improved efficiency of existing air conditioning systems through better maintenance

Commercial and Industrial

- New lighting systems
- Chillers, motors, maintenance

New Construction

- Improved insulation and air-flow systems
- Automatic daylighting systems

Pacific Gas and Electric Company®

Target MW Savings per Year by IOU

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
PG&E	139	167	163	165	192	202	191	174	179	191
SCE	167	178	219	236	247	199	188	169	168	168
SDG&E	54	54	38	34	28	26	24	22	22	22
TOTAL	**360**	**399**	**420**	**435**	**467**	**427**	**403**	**365**	**369**	**381**

Pacific Gas and Electric Company

Total Funding per Year by IOU

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
PG&E	145	173	178	210	243	249	256	263	271	279
SCE	158	167	203	224	258	277	278	252	254	235
SDG&E	63	63	58	54	48	45	44	42	42	42
TOTAL	**366**	**403**	**439**	**488**	**549**	**571**	**578**	**557**	**567**	**556**

(Public Goods Charge + Procurement Funds)

Pacific Gas and Electric Company

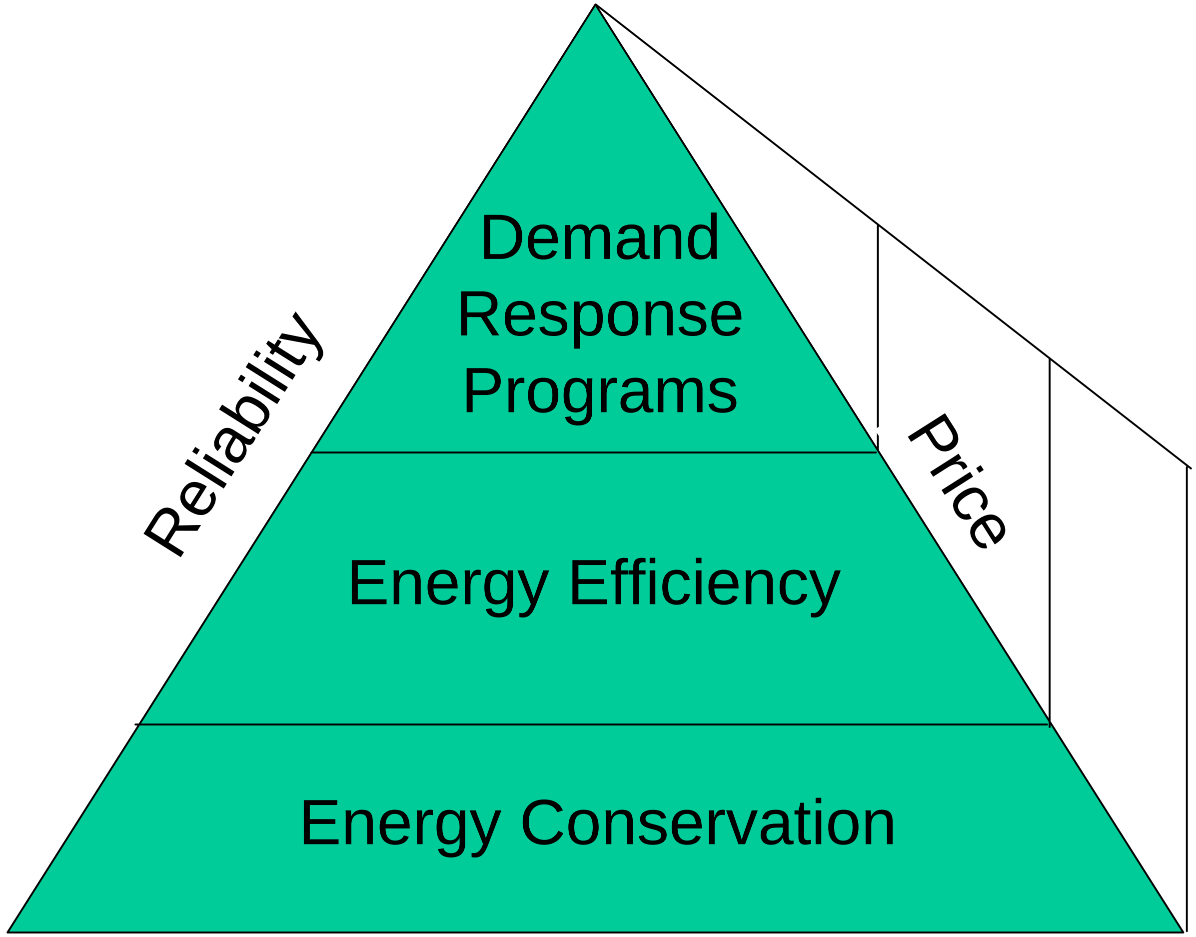
Energy Efficiency and Demand Response Integration

Integrated program design & delivery:

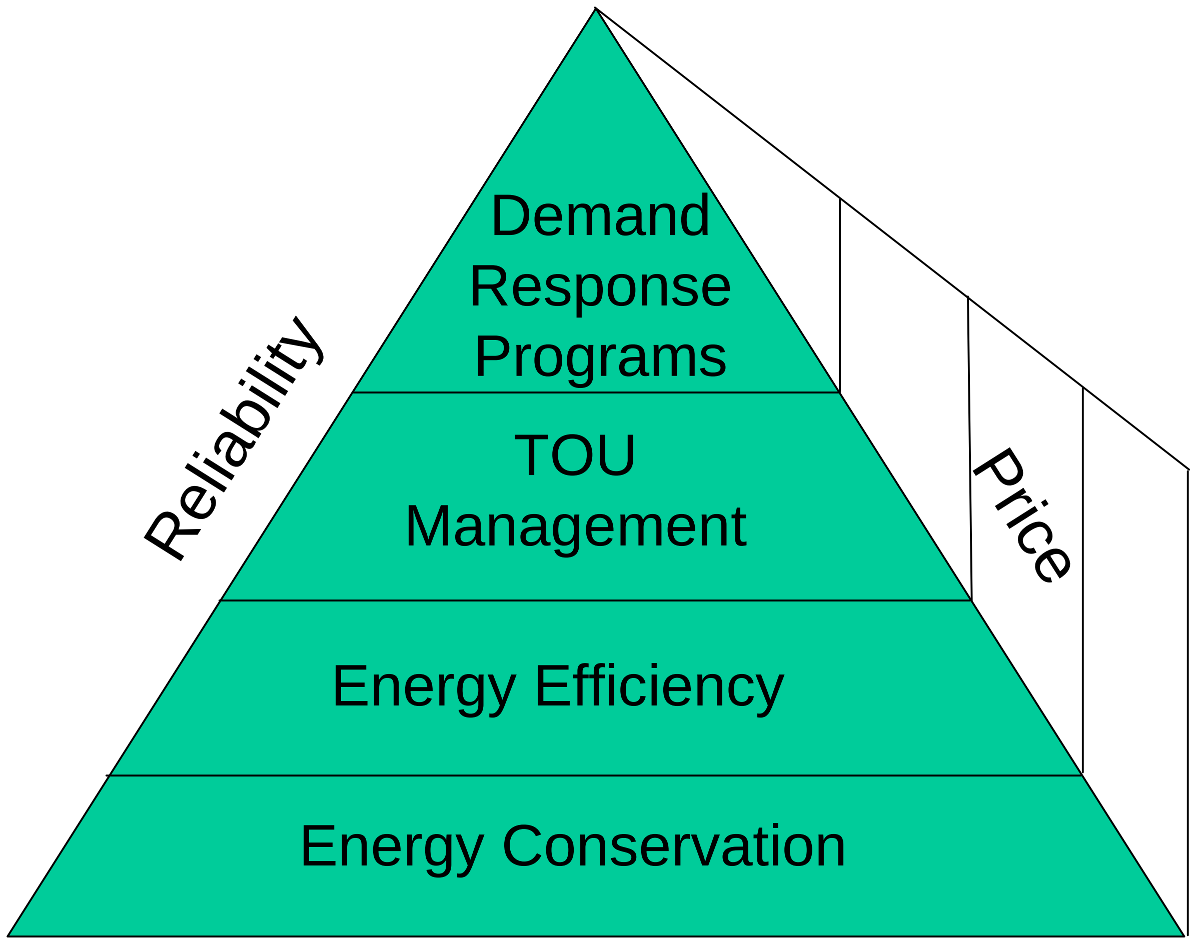
- Offerings designed to complement one another & integrated across programs
- Moves away from “a la carte” program marketing to a more strategic approach:
  - Assesses each customer’s needs
  - Presents only the “best mix” of our programs
  - Helps the customer optimize his/her energy management plan

Pacific Gas and Electric Company

Integrated DSM Model

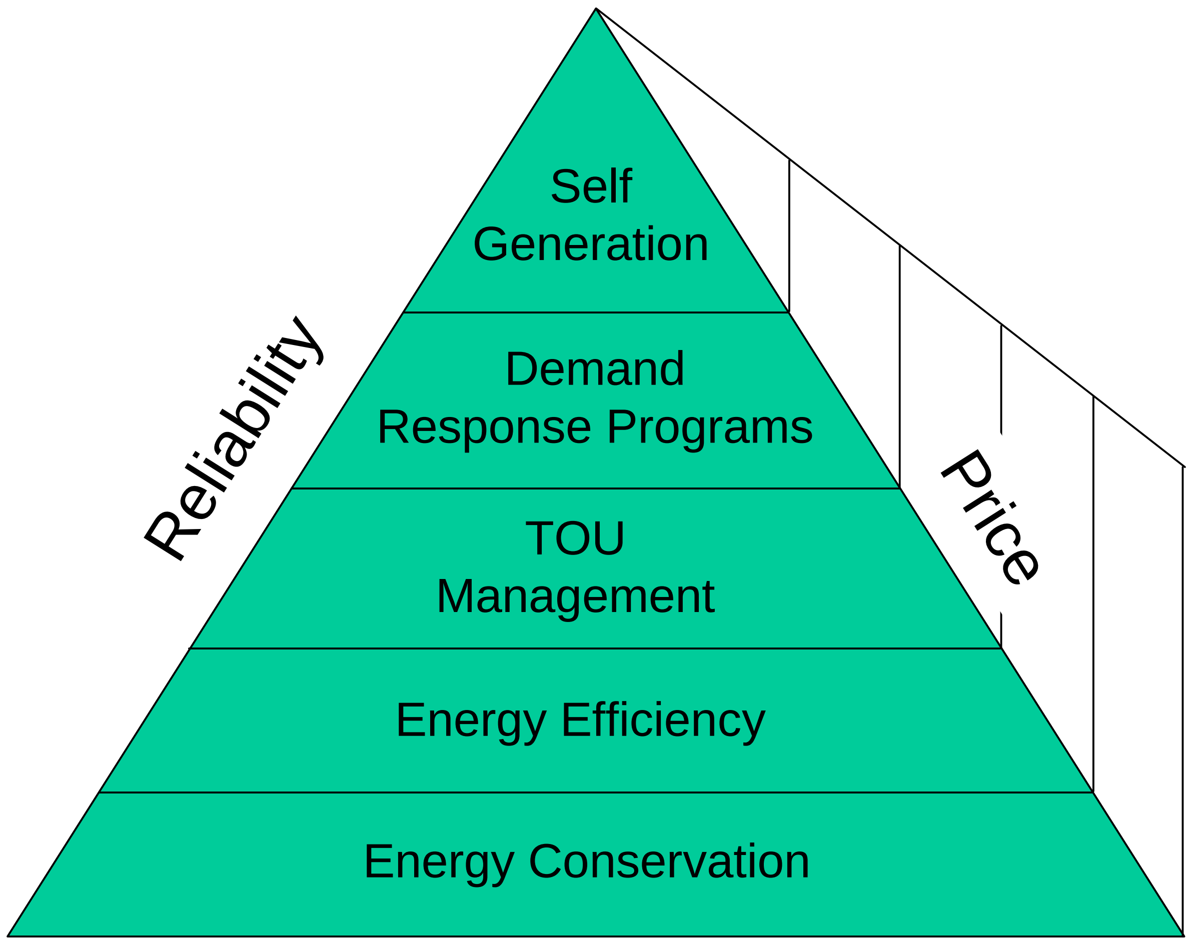


Integrated DSM Model



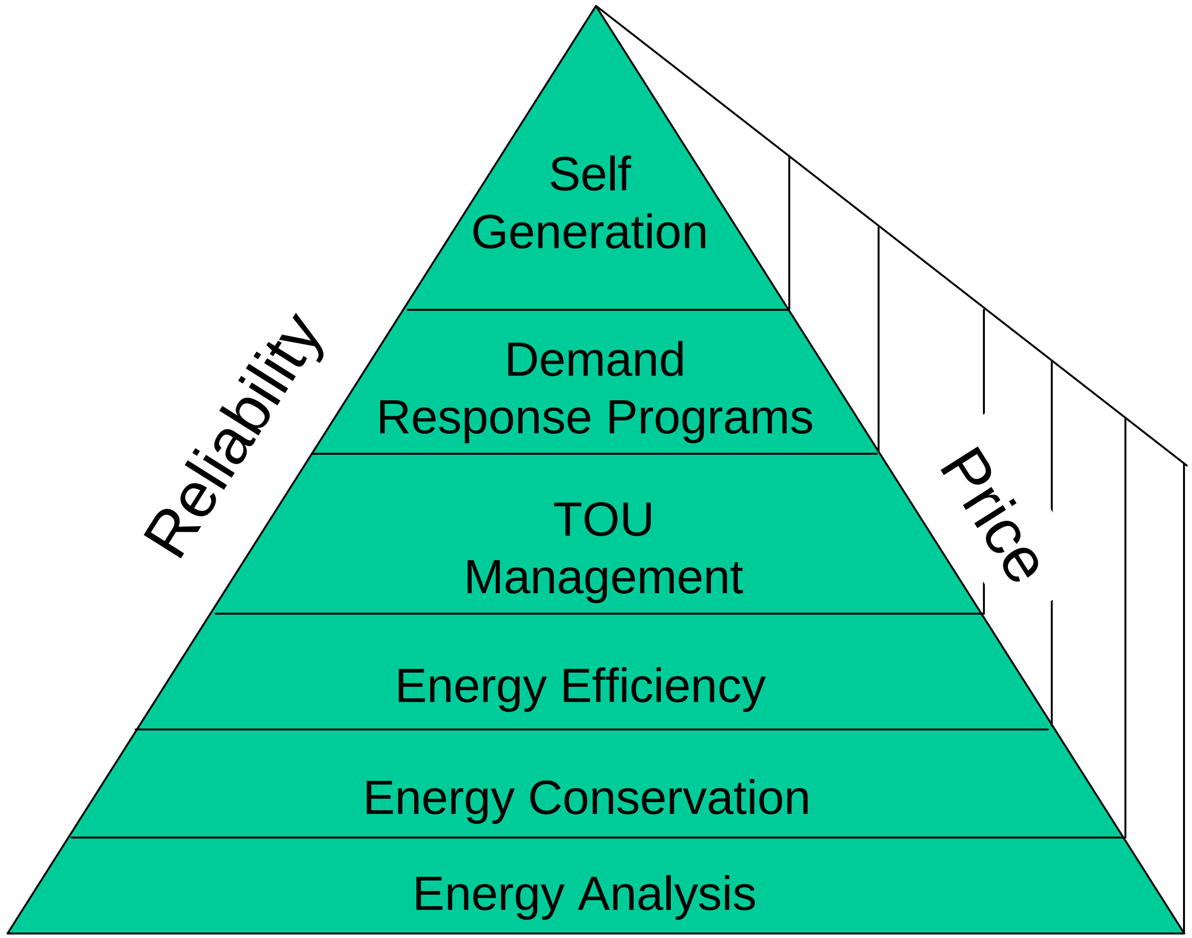
Pacific Gas and Electric Company®

Integrated DSM Model



Pacific Gas and Electric Company®

Integrated DSM Model



Pacific Gas and Electric Company®

Looking Ahead: Price-based Demand Response

- Vision
  - "*All California electric consumers should have the ability to increase the value of their electric expenditures by choosing to adjust usage in response to price signals, by no later than 2007*"
- Principles
  - New advanced metering systems
  - Real-time or near real-time access to usage data
  - New rate and program options
  - Reliable peak demand reductions
- Business cases filed at CPUC December 2004