SMART METERS SURVEY REPORT

Contents

1 CONTEXT

In decision D-2005-34 concerning the Request relating to the establishment of electricity rates for the rate year 2005-2006[1], the Régie came to a conclusion about advanced meters: [2]

> "… .>.>, the Régie requires the Distributor to closely follow the pricing reform evolution started in Ontario with the installation of smart meters. In the long run, smart meters, while making it possible for the customers to get the necessary information to better understand and manage their electricity load, is one of the possibilities to carry out enlightened choices and to adopt rational behaviours supporting energy efficiency. The Régie wishes to see the Distributor be inspired by external experiments, in particular the Ontario experiment, in its search for an optimal pricing leading to an effective use of electricity. The Régie requires the Distributor to submit a survey report with the next rate request."

In response to the Régie's concerns , this document constitutes a survey of the main foreign experiments specific to advanced meters. The Distributor however further extends its analysis and presents a discussion paper on dynamic pricing and its impact on electricity consumption.

2 SMART METERS

There are several definitions of what a smart meter is. In fact, this definition changes as technology evolves. In a general way, one could say that a smart meter is a component

[1] R-3541-2004

[2] In the English literature, the expression SmartMeter indifferently relates to the meters that allow the remote-collection (AMR to indicate Automatic Meter Reading) as well as smart meters (Smart Metering) which are generally associated with dynamic pricing. However, although it raises the issue of remote-collection, this document is more particularly directed to dynamic pricing. This is why the expression "advanced meters" will be used throughout this document.

of an information system which would allow, among other things, the transmission of an accurate price signal via dynamic pricing and savings to the customer service costs. In fact, the complexity of the information system is limited only by the available technology[3].

Advanced meters have been installed by many public service distributors (electricity, gas, water) throughout the world. The justifications at the origin of these installations are of two different natures.

On the one hand, the massive installation of advanced meters initiated by distributors have mainly the objective to reduce the service costs to the customers or to ensure the service quality.

Indeed, in the current market context, particularly in the United States, electricity suppliers are no longer integrated companies responsible for the supply, transmission and distribution of electricity. The cost reductions, particularly with regard to the costs of supply and transmission, is no longer the main concern of electricity distributors[4] who are not directly responsible for the supply, nor for the other industry players.

> "*….that part of the problem with demand response is that no one is clear whose job it is to enact such plans. Utilities say it's generally not in their best interest,*

3Appendix A presents an example of a complex information system associated with smart meters.

[4] See on this subject: Essential Services Commission (Australia), Mandatory Rollout of Interval Meters for Electric Customers, Final Decision, July 2004, http://www.esc.vic.gov.au/apps/page/user/pdf/IMRO_FinalDecisionFinal9July04.pdf page 16. " *The benefits of introducing interval meters would, in the first instance, be shared or dispersed among a number of entities. In particular, the introduction of interval metering would increase the scope for cost-reflective pricing that could be expected to provide benefits to customers, retailers, distributors and transmission businesses. However, if the interval metering decisions are left to the market participants it is not clear that any one of these entities could capture all the associated benefits and therefore would have an appropriate incentive to install interval meters.*"

generators say it's not their responsibility, and while RTOs may take it up, the rules can be confounding to anyone interested in reading them." [5]

Consequently, the electricity distributors, whose distribution rates however continue to be regulated, install advanced meters if such activity is profitable, that is to say if it reduces the distribution and customer service costs or if it permits the revenue increase in a profitable way. This is the case for the distributor Enel, among others, who replaced its customers' 27 million meters with advanced meters. [6]

The main reason for the deployments of advanced meters in the United States is justified by the potential reduction of distribution operational costs and not by the necessity of sending a price signal to customers allowing them to manage their load.[7] Appendix B indicates, on a purely illustrative basis, the main areas of potential savings thanks to advanced meters: reporting cost, energy theft detection, invoice precision, outage detection. It should be however specified that the profitability of advanced meters deployment is directly dependent on the meter replacement costs (residual value of the existing meters, internal capacity to proceed with the replacement, possibility of subcontracting, meter localization, etc), on already existing technologies and the possibility of realizing real savings (labour mobility, control mechanism already in place, work organization, etc).

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[5]Platts Electricity Week Business, June 27th 2005, page 10.

[6] See for example: ECA Group Task one Metering & Regulations, Industry Initiative: Electricity Measurement Accuracy Program (E-map) Proposal, July 2001 http://www.canelect.ca/english/ Pdfs/CEA%20EMAP%20Report.pdf " *In Europe, the world's largest publicly traded utility, Italy's Enel, has installed the world's largest direct control networking system, connecting 27 million homes and buildings via smart meters. Enel is transforming the Italian power grid into an intelligent service delivery platform providing energy-related and value-added services such as: appliance level load control; intelligent load shifting within the home to limit maximum demand while minimizing inconvenience; three new pricing options; remote security monitoring; emergency medical signalling; and, vending machine statistics/faults/out-of-stock. Revenue from the new services will pay for the system in four years.*"

[7] See on this subject State of California Joint Agency Workshop Smart metering and dynamic rates – The issuesSmartSmart. September 2004. http://www.energy.ca.gov/demandresponse/documents/2004-09-30_workshop / 2004-09-30_THE_ISSUES.PDF: "smartU.S. utilities have installed smart metering systems for over 15 millions customers. All system-wide deployments were justified on the basis of reduced utility operating costs and improved service ".

On an illustrative basis as well, table 1 presents a few examples of advanced meter deployments carried out in the United States. Not only, in certain cases, is no dynamic pricing offered but no distributor sets dynamic pricing enrolment mandatory for all.

TABLE 1
EXAMPLES OF ADVANCED METER DEPLOYMENTS IN THE UNITED STATES

		Meters installed	Installation completed in	Dynamic rating
Duquesnes Light	Electricity	580,000	1998	Notn
Puget Sound Energy	Electricity /gas	1,500,000	2000	Notn
PECO (Exelon)	Electricity /gas	2 100, 000	2002	Optional
WE Energy	Electricity /gas	1,000,000	2005	Mandatory for the customers > 60 MWh
JEA	Electricity /water	600,000	2005	Optional
PPL Electric	Electricity	1,300,000	2004	Optional

Note: Excerpted from King, C, "Advanced metering infrastructure, Overview of system features and capabilities" Oregon PUC advanced metering workshop, January 2005. http://www.puc.state.or.us/elecnat/010605/king.pdf. Information on Pricing options are drawn from texts on the rates that appear on the companies' websites.

On the other hand, with the ultimate goal of managing the electricity demand via dynamic pricing, certain governments or public commissions have issued (or are close to issue) the mandatory and universal installation of advanced meters for all customers. In this respect, section 1252 of the USA Energy Policy Act proposes that the states require that the electricity distributors under their jurisdiction offer an option for dynamic pricing and advanced meters to the consumers who request it. It is however only a proposal and each state remains free to adhere to it or not. [8]

The most publicised examples of advanced meter installations dictated by governments or public commissions will be described hereafter (Ontario and California).

3 DYNAMIC PRICING

3.1 Main types of dynamic pricing

Dynamic pricing implies a variation in energy prices according to different time periods (season, month, day, hour). The prices then reflect the variability of supply, and in certain cases, network costs, according to peak and off-peak periods.

Two elements distinguish the main dynamic pricing options from each other: the variability of the prices and the variability of the periods when the prices will apply.

3.1.1 Time of Use Pricing (TUP)

Time of Use pricing implies various rate levels predetermined according to predetermined consumption periods. Simply, that could be:

- a price for the week and another for the weekend;
- a price for the day and another for the night;
- a rate for summer days and another for winter days.

[8] See http://www.nera.com/publication.asp?p_ID=2562

The judicious use of TUP will depend on the supply conditions as well as demand pattern. For example, if the residential load is suddenly very high every day between 5 PM and 9 PM and that this daily peak incurs significant costs, it could be profitable to offer TUP. Conversely, TUP would be inappropriate to regulate a very occasional peak which lasts only a few hours per year. Nevertheless, the TUP does not offer a lot of flexibility with regard to price adjustments in relation to the supply cost variations.

> "The rates for each time block (usually called peak, shoulder, and off-peak) are adjusted infrequently, typically only two or three times per year. As a result, the price is the same at a given time of day (on a weekday) throughout the month or season for which the prices are set. Thus, for instance, the retail price signal is the same on a very hot summer afternoon, when demand may be at its annual peak, as it is on a mild summer afternoon when demand is much lower." [9]

TUP is particularly appropriate for the residential market since the price structure is stable and predictable, which facilitates supply management.

Finally, the application of TUP does not necessarily entail the installation of advanced meters. A meter with a double register, one for the high price and the other for the low price, is sufficient to meter consumption. As an indication, the Distributor's DH (*hourly-weekly-seasonal*) and DT rates (residential bi-energy) have a structure which varies in time and consumption is simply meterred with a double register meter.

3.1.2 Real Time Pricing (RTP)

With Real Time Pricing the rate is established according to supply conditions. This type of rate options are generally offered to industries in order to stimulate sales and seldom

[9] Hewlett Foundation, Energy Series, Dynamic Pricing, Smart Metering, and Demand Response in Electricity Markets, October 2002, http://www.ef.org/documents/DynamicPricing.pdf

proposed to residential customers.[10] RTP requires the transmission of information to the customers either via the Internet, telephone, fax machine or an advanced meter. On the other hand, consumption must be recorded using an interval meter.

3.1.3 Critical Peak Pricing (CPP)

Critical Peak Pricing is halfway between RTP and TUP.

> "CPP programs usually start with a TOU rate structure, but then they add one more rate that applies to “critical” peak hours, which the utility can call on short notice." [11]

Indeed, although there are many variances to CCP, it is essentially TUP applied the majority of the days of the year, paired with a high price for the critical days according to the distributor’s needs. The number of critical days is fixed in advance but the distributor can use them as he sees fit; he has in this case only to inform the customers that the rate changes to critical mode and that the supply prices increase.

> "CPP programs typically limit the utility to call no more than 50 or 100 critical peak hours per year. CPP is a clear improvement on TOU with demand charges, because the additional charges are based on consumption when the system is actually constrained, rather than when the particular customer’s demand peaks." [12]

This type of dynamic pricing requires a transmission of information from the Distributor to the customer as well as a specific metering of consumption during critical periods. This

[10] Ernest Orlando Lawrence Berkeley National Laboratory, A survey of utility experience with real time pricing, December 2004, http://eetd.lbl.gov/EA/EMP/reports/54238.pdf
[11] Ibid.
[12] Ibid.

type of dynamic pricing thus implies the use of an advanced meter.

3.2 Presumed and observed Savings

Reference literature abounds about the realised or potential savings, thanks to advanced meters.

Sarah Darby, from Oxford University, whose research especially relates to the social and behavioural aspects of energy households consumption, in 2000 did an analysis of studies carried out since 1975 on the effect of consumption information feedback.[13] She concludes that the fact of having information on their level of consumption leads individuals to modify their consumption behaviours and to realize 10% "savings" (energy saving, savings on invoice, peak reduction). This analysis however does not specifically relate to advanced meters since consumption information came from various sources (for example: itemized bills, energy analysis, advanced meters or audible signal to indicate that the outside temperature falls below a threshold). Moreover, she covers the information problems and feedback in a very broad way and does not limit herself solely to energy consumption, but also the water consumption and heat (district heating). Thus the results cannot be used to deduce the amount of realizable savings, thanks to advanced meters. Darby herself places a critical look on her own conclusions.

> "A number of difficulties arise in comparing, and even categorising, these studies: all contain a different mix of elements such as sample size (from three to 2 000), housing

[13] Darby S., "Making it obvious: designing feedback into energy consumption ". Proceedings, 2nd International Conference on Energy Efficiency in Household Appliances and Lighting. Italian Association of Energy Economists/EC.-SAVE programme, 2000.

> type, additional interventions such as insulation or the provision of financial incentives to save, and feedback frequency and duration. The timing of the study itself may also be significant in relation to the energy politics and research paradigms of the period."

Studies are different from one another, so one cannot conclude to a significant trend. For example, still according to Darby, the study which shows the greatest consumption reduction implied an amalgam of information techniques as well as a toll meter: [14]

> "The highest savings - in the region of 20% - were achieved by using a table-top interactive cost- and power- display unit; a advanced meter for prepayment of electricity (coinciding with a change from group to individual metering) and an indicator showing the cumulative cost of operating an electric cooker."

Indeed, the importance of the price signal, the prevailing energy situation, investments in progress and already carried out energy saving programs, invoicing practices (frequency, precision, estimation/actual), the availability of prior comparative consumption information[15], cultural biases[16], the possibility of reducing consumption on peak are as many factors which makes the results not easily transposable.

On the other hand, the Darby's study raises significant problems when one wants measure the effect of information on consumption: the importance to distinguish between invoice saving, energy saving and peak reduction (load displacement).

[14]"Prepayment meter".

[15]For example, those customers of the Distributor who have a personal page on Hydro-Quebec Distribution's Internet site have access to various historical and comparative information on their consumption.

[16]See on this subject, Wilhite H. and H. "Social Loading and Sustainable Consumption", Consumption, Everyday Life and Sustain ability, http://www.lancs.ac.uk/fss/sociology/esf/index.htm

3.2.1 Invoice saving

The GRAME, in its report presented within request R-3552-2004 , specifies that the new rate options offered by ENEL, in Italy, will allow an 8% energy savings.

> "Enel's new pricing for those customers equipped with these intelligent meters was officially launched this year. These meters would make it possible to set up a time of use pricing system with 6 different variations according to customer requirements' needs so as to reach additional energy saving reaching 8%." [17]

However, if one deeply consults the article to which GRAME was referring to in its brief[18], it is instead cited as an 8% invoice saving. The ENEL rates probably fit in a marketing strategy connected to the market openings and are calibrated to obtain savings on customers invoices who choose one of the TUP offered options and having specific consumption profiles.[19] There are thus no declared saving in kWh.

An 8% invoice reduction[20], obtained from to load displacement but without any reduction in the energy consumption, can be observed in another survey.

> "EA Technology quote a small survey based on tariffs that varied by time of day, month of year, and between weekdays and weekends. This led consumers to make significant changes in their use of household appliances flattening the

[17] Request of the 2005 budget for the global energy effectiveness plan approval, R-3552-2004, Grame-2, Document 2.

[18]http://lanazione.quotidiano.net/2005/01/13/pages/artI5367063.html."L' Enel lancia ufficialmente the nuove ratee ' ' known will misura '' che prevedono risparmi per chi consumed nelle ore ' morte' - notte, weekend, festivi E periodi feriali - E promises risparmi fino has 80 euro the anno has famiglia. Vale has to say a taglio di circa the 8% known una voce, quella della spesa per the bollette elettriche, che vede Italia will tra I paesi piu' penalizzati has livello europeo nel caro-elettricita '. "

[19]See on this subject the examples given in the site http://www.energysaving.it/Ratee_Biorarie.htm

[20]Percentage with no relation to GRAME's assertions.

> evening load peak and almost eliminating the morning one. Whilst overall energy consumption was not reduced, consumers' average bills were reduced by 8 per cent." [21](our underlined)

Energy saving associated with toll meters constitutes another subject of interest when discussing advanced meters[22]. Toll is one of the many functions which a meter can fulfill. In fact, it does not need to be "smart" for that purpose. Thus, at the beginning of the 20th century, already electricity distributors could install toll meters for some of their customers:

> "The early 'dumb meters' had relatively limited functionality – they simply measured resource consumption in standard units - therms, gallons, kWh - at one standard tariff. Communication with the meter required a physical visit by a meter reader to manually record energy consumption and relay the information back to the utility for processing in labour intensive administrative and accounting systems. Those households who operated on credit terms were subsequently issued with a bill for payment, while households who the utilities preferred not to supply on credit terms were supplied with prepayment coin meters to avoid debt. supply."[23]

Woodstock Hydro, who is being perceived as a forerunner in that area in Canada, specifies on its Internet site that the toll meter would have allowed, in some places, savings from 10 to 20% without however specifying which savings are made by its customers.

> "In fact, many of our prepaid power customers save that amount every month through careful monitoring of their

[21] The U.K. Department of Trade and Industry, Smart metering working group report, September 2001.http://www.dti.gov.uk/energy/environment/energy_efficiency/smartmeter.pdf

[22] See, amongst other things, transcriptions of the hearings of February 18, 2004 of the case R-3519-2003, Request for approval of budget 2004 by Hydro-Quebec and follow-up of the global Plan in energy effectiveness http://www.regie-energie.qc.ca/audiences/3519-03/NS3519/NS _ Audience18fev04.pdf

[23] Guy S. and Marvin S. Pathways to "Smarter" Utility Meters: the Socio-Technical Shaping of New Metering Technologies. Global Urban Research Unit. University of Newcastle. Page 9. http://www.ncl.ac.uk/guru/Working%20Papers/EWP%2023.pdf

> consumption. Studies conducted by electrical utilities in areas around the world where prepaid power is an option, indicate savings in energy consumption of 10% - 20%." [24]

When one speaks about toll, one initially speaks about bad credits and the most convincing experiment on the subject, because it was amply documented, in England. Between 1991 and 1998, the number of toll meters went from 1.1 million to 3.7 million. During the same period, the number of interruptions per year for non-payment went from 48,000 to 4,000. The toll meters have thus replaced service interruptions. According to a consultation document from the Office of Gaz and Electricity Market[25], 27% of the customers having a toll meter had lived thru an "auto interruption" during the previous twelve months. Among them, 21% lost electricity because they did not have any money. Taking these results into account, an observed reduction of the electricity consumption is not surprising. However, the Distributor submits that a consumption reduction which results from an "auto interruption" of this nature cannot be regarded as an energy saving.[26]

3.2.2 Energy Savings

In a recent experiments review on dynamic pricing, King and Delurey[27] analyzed the results of hundreds of studies and pilot projects dealing with dynamic pricing that were

[24] http://www.woodstockhydro.com/index2.htm

[25] Office of Gaz and Electricity Market (OFGEM), Prepayment meter – A consultation document, October 1999 http://www.ofgem.gov.uk/temp/ofgem/cache/cmsattach/2250_ppoct.pdf

[26] The following quotation is, in this respect, very eloquent: "What this effectively means is that in Britain we have no problem of disconnection. We have a negligible problem of disconnection. We have none. Basically, consumers who can't pay their electricity disconnect themselves. They don't use any electricity. This morning I think I heard someone saying that consumers buy as much electricity as they want. The reality is, actually, that they buy as much as they can afford, and if what they can afford is not enough, then you have a social problem." Legislative debate in the Ontario Parliament, Wednesday on August 25, 2004 HTTP:// www.ontla.on.ca/hansard/committee_debates/38_parl/session1/SocialPol/SP006.htm

[27] Chris King and Dan Delurey "*Twins, Siblings, or Cousins –Analyzing the conservation effects of demand response programs* ", Public Utilities Fortnightly, march 2005, pages 54-60.

carried out during the last 30 years. Among these hundreds of studies, only 23 specifically tackled the question of residential energy savings. According to authors, the average consumption observed saving would be about 4%.

Although no indication is given on the used research methods (number of participants, duration of experiment, control groups …), it is noteworthy to specify that, among the 23 studies,

- 6 pilot projects did not indicate any reduction in consumption (this number goes up to 9 if the results expressed in terms of intervals are also considered);
- 4 pilot projects implied the installation and use of programmable or "smart" thermostats, which were perhaps enough to reduce the energy consumption;
- finally, we associate StateWide Pricing Pilot in California [28] with savings of 5.7 to 8.7% whereas the final report/ratio of this pilot project stipulates:

> "There was essentially no change in total energy use across the entire year based on average SPP prices. That is, the reduction in energy use during high-price periods was almost exactly offset by increases in energy use during off-peak periods." [29]

The researchers finally recommend to the reader the greatest prudence regarding the evaluation of the possible savings.

> "..., the extent to which a particular demand response program results in a net conservation effect is dependent on

[28] For a description of the SPP see section 4.2.

[29] Charles River Associates, Impact Evaluation of the California Statewide Pricing Pilot, March 2005, 7.http://www.energy.ca.gov/demandresponse/documents/group3_final_reports/2005- page 03-24_spp_final_rep.pdf

> a number of factors that may not yet be completely understood, again due to lack of focus in program design and evaluation.

In his final report to the Energy Minister, the Ontario Energy Board also admits the possibility of appreciable energy savings associated to the installation of advanced meters.

> "In a study conducted for EA Technology, the authors concluded that for residential applications:
>
> "Better billing feedback produced savings of up to 10% in electrically heated homes in cold climates, mainly using simple manual methods. In the absence of electric space heating, smaller savings are likely, but some of the automatic measures here [in the U.K.] could produce new types of saving - for example in refrigeration - which would not be possible manually. Load shifting is easier than load reduction so cost savings are easier to achieve than energy savings, but both would probably lie in the 0 - 5% range for a home without electric heating." [30]

Looking a little more closely to the study and more specifically to the 10% savings mentioned in the report, we note that it relates to a study carried out in Norway in 1987 at a time when customers received, throughout the year, only electricity invoices based on consumption estimates.[31] Once a year, the customers would pay the difference between the estimate and the actual invoice.

> "On the final bill, customers pay for the difference between invoiced sum and the cost corresponding to actual consumption for the year. Thus people are only confronted with their actual consumption and costs once a year. The bill

[30] Ontario Energy Board, Smart Meter Implementation Plan, Report of the Board To the Minister, Appendices, January 26, 2005 http://www.oeb.gov.on.ca/documents/press_release_sm_appendices_260105.pdf

[31] Wilhite, H, and all, Advances in the use of consumption feedback information in energy billing: the experiences of a Norwegian energy utility, European Council for an Energy Efficient Economy, Summer Study proceedings, Panel 3 Dynamics of Consumption. http://www.eceee.org/library_links/proceedings/1999/pdf99/Panel3/3-02.pdf

> comes too infrequently to stimulate interest, and the way information is presented makes bills difficult to understand."

The study consisted in sending, every 60 days, to customers chosen randomly, various types of detailed bills with information on consumption.

> "The bill incorporated a graphical representation of this versus last year's electricity use (weather corrected) every days. Energy conserving tips were placed on the bill of one of the experimental groups. Electricity consumption was monitored during the period, and both post-experiment questionnaires and telephone interviews were conducted with participants in all groups.
>
> At the end of the first year, the experimental groups saved on average 10% electricity relative to the control group and those savings held steady over the three year course of the study. "

To the Distributor's opinion, there is no obvious correlation between this study and possible energy savings associated with dynamic pricing (whether they are in the order of 5 or 10%).

3.2.3 Peak Reduction

The peak reduction objective via dynamic pricing seems to be achieved in the jurisdictions where such options have been proposed. On the other hand, the results of these first experiments are considered with prudence, particularly with regard to the persistence of the reductions.

> "Price response" programs have been the focus of many recent programs and initiatives, especially dynamic pricing such as critical peak pricing and real time pricing. There is a widespread conceptual support for exposing electricity customers to price that reflect actual market conditions and associated prices
>
> ....

> In a recently published comprehensive review of RTP[32] programs offered to commercial and industrial customers, a surprisingly high fraction of RTP customers appear to not be very price sensitive
>
> ....
>
> Experience with dynamic pricing has been limited mostly to large commercial and industrial customers. There are, however, pioneering effort with residential dynamic pricing in a few states, including California, Illinois, Florida, Washington and New York. Some of the initial results are promising, but is still mostly too early to assess the full impacts of these programs. These programs should reveal a great deal about new residential customers respond to time-differentiated rates that reflect wholesale market prices and conditions" [33]

3.2.4 Realized Savings: Price Flexibility

The studies and pilot projects results carried out thus far throughout the world call for the greatest caution regarding the formulation of hypothesis or objectives, whether it is energy savings or even peak reduction. As it will be shown in the following section, the massive deployments of advanced meters with the objective of supply management — whether they are in the installation phase or set to be announced — rest mainly on the guiding principle that customers will react to prices.

The extent of customer reaction is expressed in price flexibility, the load variation percentage for a good compared to the price variation percentage of that good.

Price flexibility of electricity demand can more particularly be qualified in the context of dynamic pricing:

[33] York D. and Kushler M, Exploring the relationship between demand response and energy efficiency: A review of experience and discussion of key issues. American Council for an Energy-Efficient Economy, March 2005. http://www.aceee.org/pubs/u052full.pdf

> "The demand for electricity by time-of-use is inelastic in the short run, with most values for the own price flexibility of peak-period energy usage falling between –0.1 and –0.3; • Price flexibilities vary with climate and with appliance holdings. Specifically, the flexibility value is greater in hotter climates than in cooler ones and higher the greater the saturation of electric appliances. It is significantly higher for households with central air conditioning in hot climates than for typical households in cool climates; [34]
>
> • Dynamic pricing tariffs show much larger changes in usage than do traditional TOU rates, especially when combined with enabling technology such as two-way communication and programmable/controllable thermostats;
>
> • Price flexibilities for residential customers are significantly larger than for small to medium commercial and industrial customers." [35]

Moreover, among the factors that influence household price flexibilities in the context of Time of Use Pricing there are;

- peak/off-peak price ratio;
- characteristics of electrical household appliances;
- the temperature effect;
- demographic characteristics;
- voluntary participation vs. mandatory participation;
- price signal communication. [36]

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[34]Our comment: that explains, such as the following section will show, that in the jurisdictions where the state imposes smart meters, it is the air-conditioning loads which one wishes to eliminate at peak. This also explains the different results of reduction in summer and winter noted in California.

[35] Essential services commission, Installing Interval meters for electricity customers – Costs and benefits. Position Paper, November 2002 http://www.esc.vic.gov.au/apps/page/user/pdf/PositionPaperESC_IMRO_3_Nov02.pdf

[36] Maree Langmore and Gavin Dufty, Domestic electricity demand flexibilities, Issues for the Victorian Energy Market, June 2004, http://www.vinnies.org.au/files/VIC.2004%20June %20-%20Domestic%20Electricity%20Demand%20Flexibilities.pdf

4 FOREIGN EXPERIMENTS RELATED TO DYNAMIC PRICING

4.1 Ontario

In July 2004, the Ontario's Energy Minister asked the Energy Board to develop a plan for the installation of advanced meters that would offer customers the information they need to manage their electricity load.

The government's objective is that 800,000 meters be initially installed by December 31, 2007; by December 31, 2010, Ontario's 5.2 million customers must be equipped with an advanced meter.

In its final report released in January 2005[37], the Board recommends the installation of bidirectional meters that will record, via radio waves, each customer's electricity consumption on an hourly basis and allow to send him the consumption information on a daily basis. The total deployment cost of the meters, including installation and communication system is estimated at $1.25 billion, thus approximately $250 per installed meter. The net monthly cost for each residential customer is estimated at $3.50 ($2.47 for the total net cost in capital and $1.03 in additional net operational costs). In the Québec context, this cost alone would represent, for the average customer, a rate increase between 3% and 4%.

[37] Ontario Energy Board, Smart Meter Implementation Plan, Report of the Board To the Minister, January 26, 2005 http://www.oeb.gov.on.ca/documents/press_release_sm_implementationplan _ 260105.pdf

Initially, the Ontario Energy Board linked advanced meters with the possibility of avoiding the construction of 1 250 MW of generation equipment.

> "The objective of the policy is to help consumers control their electricity bills though conservation and demand response. Smart metering systems are also a key tool to enable another Ministry objective of 5% savings in energy use in Ontario by 2007." [38]

In the final report however, no objective in the reduction of the demand specific to advanced meters is specified.

In addition, recent conclusions from the energy effectiveness working group, set up by the government of Ontario, put a damper on the fast deployment of the advanced meters.

> "The Team was briefed about the implementation plan for smart meters, and agreed on the need for further study of smart meters, as well as the issue of individual or sub metering in multi-unit residential buildings." [39]

However, if the government goes ahead with the meters deployment [40], these should ultimately allow the application of Time of Use Pricing of the CCP type and get a peak demand reduction.

> "Customers will be able to control their consumption through moving use to off-peak periods (running the dishwasher at night) or lowering energy use during peak periods (setting the air conditioning a few degrees warmer during the afternoon). Customers will be able do this themselves, by using automatic control devices that they purchase and

[38] Ontario Energy Board, Smart Meter Implementation Plan, Report of the Board To the Minister, Appendices, January 26, 2005, page 5. http://www.oeb.gov.on.ca/documents/press_release_sm_appendices_260105.pdf

[39] Report of the conservation Action Team, Building a Conservation Culture, May 2005 http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.actionteam_report2005

[40] Certain Ontario distributors did not wait for the government's decision to undertake pilot smart meters projects .

> install themselves, or via a contract with an energy services company to control devices automatically based on price or demand level." [41]

During the transitional period, the regulated price in Ontario since April 1st, 2005, announced by the government, is of TUP type as described in table 2. These prices are based on a set of parameters: hourly price forecast on the electricity market, customer's consumption profile, price electricity provided by the OPG (price fixed by the government), price for the contracts signed between former Ontario Hydro and the independent producers as well as all the supply agreements signed by the Ontario Power Authority. Time of Use Pricing should not be available before 2006 or 2007.

The prices in Table 2 do not seem to be calibrated to mitigate the impacts on customer invoices (contrary to what was done in California, as shown hereafter) considering the following comment, drawn from the Ontario Energy Board final report on advanced meter installation:

> "Higher peak winter prices can have significant cost impacts on those customers who rely on electric heat and have limited ability to shift demand. Conservation programs may focus on support for mitigating technologies like thermal storage, heat pumps or conversion to natural gas heating." [42]

In other words, as the Board cannot ensure neutral rates to customers who use electricity heating, it recommends to these customers to mitigate the impact from the

[41] Ontario Energy Board, Smart Meter Implementation Plan, Report of the Board to the Minister, January 26, 2005 http://www.oeb.gov.on.ca/documents/press_release_sm_implementationplan _ 260105.pdf

[42] Ontario Energy Board, Smart Meter Implementation Plan, Report of the Board to the Minister, January 26, 2005 http://www.oeb.gov.on.ca/documents/press_release_sm_implementationplan _ 260105.pdf

peak period rates increase with a reduction in consumption.

TABLE 2
TIME OF USE PRICING–ONTARIO 1st APRIL 2005
(SUPPLY PRICE ONLY)

Days OF The WEEK		PERIOD	PRICE
Weekends and holidays		Off peak	2.9 ¢/kWh
Days of week – Be (1st May – Oct. 31.)	7 am – 11 am	Average peak	6.4 ¢/kWh
	11 amt – 5 pm	Peak	9.3 ¢/kWh
	5 pm – 10 pm	Average peak	6.4 ¢/kWh
	10 pm – 7 am	Off peak	2.9 ¢/kWh
Days of week – Winter (1st Nov – April 30)	7 am – 11 am	Peak	9.3 ¢/kWh
	11 am – 5 pm	Average peak	6.4 ¢/kWh
	5 pm – 8 pm	Peak	9.3 ¢/kWh
	8 pm – 10 pm	Average peak	6.4 ¢/kWh
	10 pm – 7 am	Off peak	2.9 ¢/kWh

The TUP structure in table 2 follows Ontario's load profile that peaks just about at the same level in winter as in summer; the summer peak being caused by air-conditioning while the winter peak by electric heating (in Ontario, 15% of households heat with electricity and 65% air-condition during summer[43]). Nevertheless, expressed in number of hours, the summer peak is definitely more critical.

> " Based on the average for 1999-2002, the table indicates how many hours in an average year that demand could be expected to exceed certain levels. The breakdown by time of year, clearly indicates that the highest demand situations occur in the summer and are of relatively short duration. For instance, demand would only be expected to exceed 24,000 MW, in an average year, for approximately 28 hours, all of which would be expected to occur in the summer. Similarly, demand would be expected to exceed 23,000 MW for

[43] Conversly, in Quebec 26 % of households air-condition their house in the summer and 68 % heat mainly with electricity. Sources: Canada Statistics. Inquiry into the expenditure of households 2002. Catalogue 62F0041.

approximately 71 hours, of which only 4 hours would be expected to occur in the winter." [44]

4.2 California

Carried out over a two year period following the energy problems California experienced in 2001, the *StateWide Pricing Pilot* (SPP) in California is most likely the most documented and most relevant study related to the problems of advanced meters and the impacts of dynamic pricing on consumption[45]. From 2003 to 2004, three types of dynamic pricings were tested on various consumer samples. The rate structures and the tested price levels had to be consistent with the three following criteria:

- To be neutral for the average customer over a one year period by assuming no change in the customer behaviour (with the new rate structure, an average customer that does not modify its load profile will anyway receive an invoice equivalent to the one he would have received as if he were under the normal rate);
- To do not have an impact higher than +/- 5% on the small and large-scale consumers by assuming no change in behaviour;
- To allow customers to reduce their annual invoice by 10% if they reduce their peak demand by 30%.

Based on the rate paid by an average customer, three types of price were tested: a TUP and two types of CCP (see table 3), one with a fixed number of hours per day when the

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[44] Hydro One, Electricity demand in Ontario, Submitted to the Ontario Energy Board regarding RP-2003-0144, November 2003 http://www.oeb.gov.on.ca/documents/directive_dsm_HydroOne211103.pdf

[45] Charles River Associates, Impact Evaluation of the California Statewide Pricing Pilot, March 2005 http://www.energy.ca.gov/demandresponse/documents/group3_final_reports/2005-03-24_SPP_FINAL_REP.PDF

peak price applies (5 hours per day) and the other with a variable number of peak hours (1 to 5 hours). In the first case, warning of a critical day is made the day before while in the second, the warning is made on the very same day. Associated with the CCP, there were 15 critical days, namely 12 days in summer and 3 days in winter. Although California is a network that peaks in summer[46], critical days could also be used to reduce the demand in case of network technical problems .

TABLE 3
DESCRIPTION OF THE SPP'S CCP

	Critical days per year	Period of peak hours	Peak hours per day	Critical day warning
TPC (fixed)	15	2 pm to 7 pm	5 hours	Day before
TPC (variable)	15	2 pm to 7 pm	from 1 to 5 hours	The very same day

4.2.1 Reduction in Summer

The following table summarizes the major results. A significant peak reduction is noted on all the cases, the best results being associated with a variable CCP offered to a sample of customers who had already been equipped with programmable thermostats to control their air-conditioning. [47]

It is noted however that there are significant differences between the peak and off-peak prices, variations going up to 600%. Moreover, as was mentioned in section 3.2, although a significant peak reduction was noted for the three rates tested, it however

[46] California ISO, Five year Assessment (2004-2008) http://www.caiso.com/docs/0900a6080/28/5b/0900a6080285b79.pdf

[47]Air-conditioning is the responsible use of the Californian peak: "Residential Air Conditioning is responsible for approximately 7.500 MW of peak electrical load". See http://www.californiaenergyefficiency.com/whitepapers.html

appears that no significant energy saving was recorded. The participants only shifted their consumption from a peak period to an off-peak period.

TABLE 4
CALIFORNIA PILOT PROJECT MAIN RESULTS (REDUCTION IN SUMMER)

	Period	Price ¢/kWh		Peak reduction Average impact in summer
Fixed TUP	Critical days	Peak	**59**	
		Off peak	9	-13.1%
	Normal days	Peak	**22**	
		Off peak	9	-4.7%
RTP	All days	Peak	**22**	-5.9 % in 2003
		Off peak	10	-0.6 % in 2004
Variable CCP (sample without thermostats but with offer of free and optional installation of a management tool; installation in 2003)	Critical days	Peak	**65**	
		Off peak	10	-15.,8 % in 2004
	Normal days	Peak	24	
		Off peak	10	-6.7% in 2004
Variable CCP (sample with programmable thermostats a priori)	Critical days	Peak	**65**	
		Off peak	10	-27.2%
	Normal days	Peak	**24**	
		Off peak	10	-4.5%

Let's recall, as an indication, that DT rate (residential bi-energy) allows for a customer load reduction of more than 50% while avoiding a recovery phenomenon.

4.2.2 Reduction in Winter

Although California experiences a summer demand peak, SPP also evaluated the demand reduction for winter. The reduction was less significant than in summer.

> "The winter average peak-period price was $0.61/kWh and the off-peak price was $0.11/kWh. As seen, the average

> critical day, peak-period impact hovers around 4 percent, notably less than the average summer impact of around 14 percent. The peak period impact on normal weekdays was less than 2 percent for the state as a whole."

Moreover, analysis of results, based on a linear regression, indicates that in winter the variance related to space heating is insignificant whereas in summer the variance related to air-conditioning is highly significant.

4.2.3 Coming Steps

During the 2005 summer, while working on the SPP, California's large electricity distributors (Southern California Edison, San Diego Gas and Electric, and Pacific Gas and Electric) intend to study the impact of better invoicing information as an additional tool to increase the impact of dynamic peak pricing.

The installation of advanced meters intended initially for remote meter reading (along with the savings that it entails) is however in the plans for the three distributors and if California Public Utilities Commission gives its agreement, 15 million mechanical meters (electricity and gas) will be replaced in California between 2006 and 2011. [48]

4.3 Analysis

4.3.1 Peak Reduction

The two cases of dynamic pricing presented here are similar in that the demand peaks are caused by air-conditioning use and that the demand for this use can more easily be reduced during the peak, even shifted. The Californian results seem to indicate as well that customers are less inclined to give up heating than air-conditioning. Without

[48] EEnergy Informer, "California Utilities Seek Regulatory Approval for AMI Rollout", August 2005, page 5.

transposing these results to a winter peak context, we must ask ourselves where are the possibilities of reducing a heating load significantly, especially when the peak periods can extend over several hours —even days —and taking into account also the recovery phenomenon . In fact, reduction of this use can only be guaranteed if there is a backup heating system. [49]

4.3.2 Peak / off-peak Price

In SPP's most convincing case, the difference between the peak and off-peak prices is significant, nearly six times higher, which contributes to explain the importance of the peak reduction.

Such a gap is difficult to establish given the importance to preserve rate neutrality. Indeed, demand management rate must be neutral compared to its reference rate, that is to say that if the average consumer does not change its consumption profile, his electricity bill must be the same as if it had been invoiced at the reference rate.

This neutrality objective aims at, on the one hand not to increase the customer bill who does not reduce part of his load and on the other hand not to penalize a customer who, for one reason or another, could not shed his load on peak. In the two situations, it is a matter of respecting the guiding pricing principles : equity between customers and cost reflection.

Rate neutrality through calibration allows, among other things, to prevent that those participating in an dynamic pricing option are mainly customers who will realize a profit

[49] As an indication, at Connecticut Light & Power, the TUP is not recommended for those customers that heat with electricity. See http://www.clp.com/esupplier/factors.asp. and http://www.clp.com/clpcommon/PDFs/online/business/bill/rates/rate7.PDF. See also at EDF where the Tempo TUP option is recommended for customers who have an alternative source of heating http://particuliers.edf.fr/rubrique112.html.

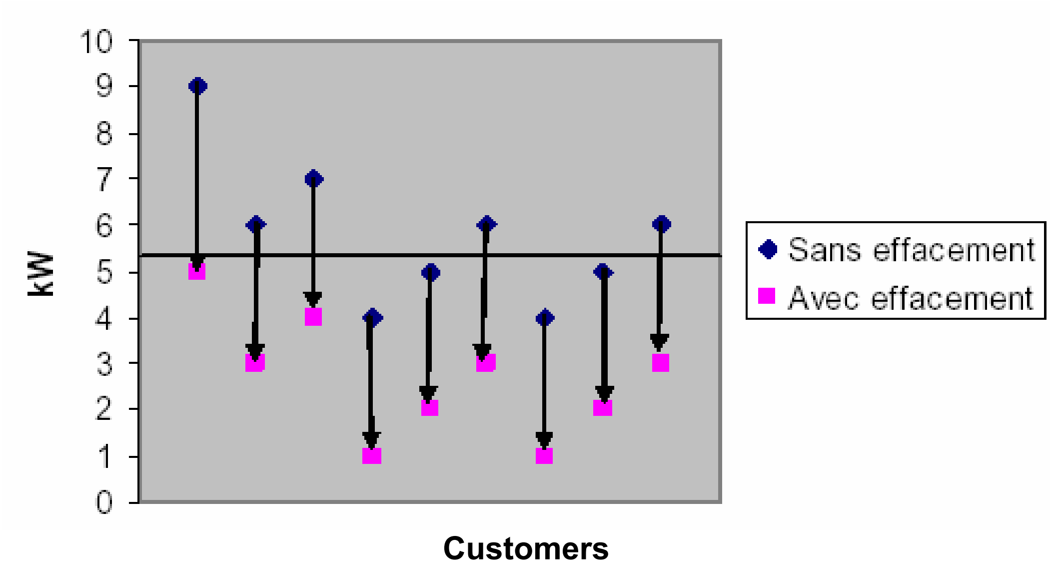
without modifying their load profile in any way. [50] Table 5 illustrates how the calibration logic works. Initially, 9 customers have on average a 5.5 kW power demand before any dynamic pricing. An average demand after reduction must be defined to gauge the new rate. This average demand must be fixed so that after reduction, the majority of customers will be under this threshold. [51]

In the illustration, 4 customers have a priori an under the average demand. They will benefit from the new rate without changing behaviour. Five customers have a demand deemed higher than the average. By reacting to the price signal and by reducing part of their demand, they go under the average demand and can achieve a benefit on their bill. On the other hand, if they do not modify their behaviour, that is to say if they do not reduce their peak load, the average customer must receive the same bill as if it had been on the regular rate.

[50] See on this subject: Hydro One Networks & Hydro One Brampton, Electricity Demand in Ontario, Submitted to the Ontario Energy Board regarding RP-2003-0144, November 2003, page 8 http://www.oeb.gov.on.ca/documents/directive_dsm_HydroOne211103.pdf "These customers, who could benefit significantly from an hourly miss structure, are likely to be disproportionately represented in any interval meter pilot for which customers were enrolled on a voluntary basis. However, since these customers usage pattern already matches the target demand curve, they would be considered free riders."

[51] Within the framework of the SPP, it was necessary that the large and small customers have a rate impact being located within +/- 5 %.

TABLE 5
ILLUSTRATION OF CALIBRATION



Sans effacement = without obliteration
Avec effacement = with obliteration

Puget Sound Energy's (PSE) experience with dynamic pricing in the state of Washington also explains the importance of calibration and rate neutrality.

At the end of 2000, PSE announced the installation of advanced meters to its 1.3 million customers. These meters were to initially allow a greater efficiency in its distribution and customer services activities and ultimately to allow the establishment of a TUP.

> "Making its distribution system faster, more efficient and less costly to operate, Puget Sound Energy is developing and integrating new technologies that are a natural extension of its utility business. The company has linked technologies, using an extensive wireless automated meter reading network and a suite of customer information systems, to provide faster service and new conveniences including real-time two-way data communication between customers and the utility." [52]

[52] See official statement of PSE: http://www.pse.com/news/2000/pr20000927a.html

In spring 2001, PSE set up a TUP pilot project approved by Washington Utilities and Transportation Commission (WUTC). Eighteen months later, the first results of the pilot project are available.

> "In October 2002, PSE mailed to TOU participants the first quarterly bill comparison report required by its June 2002 rate case settlement. The report compared each customer's bill under TOU with what the bill would have been if the customer had been on the standard rate for July-September 2002. The reports revealed that ninety-four percent (94%) of participants paid more on TOU than they would have otherwise, on average about 80 cents per month; most saved a few cents on TOU energy charges, but those savings were overwhelmed by the $1.00 incremental cost of TOU meter reading." [53]

The outcry raised by these results is due to PSE's TUP. In November 2002, the WUTC agreed with PSE's proposal to end the pilot project one year early. [54]

This failure may very well come from a calibration error in the TUP or that customers did not sufficiently reduce their consumption to benefit from the new rate.

It is obvious that very strict markers for the insurance of a rate neutrality must be established. The calibration exercise consists of, on the one hand, identifying which part of the basic uses an average customer can reduce during the peak and, on the other hand, at which price to remunerate this reduction. This exercise will be made more complicated, in the presence of electric heating, by the phenomenon of the cross effects that is to say that the reduction of most of the peak loads could increase the needs for heating. That is the case, amongst other things, for the loads associated with interior lighting, the water-heater and the refrigerator.

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[53] See on this subject http://www.atg.wa.gov/utility/tou.html

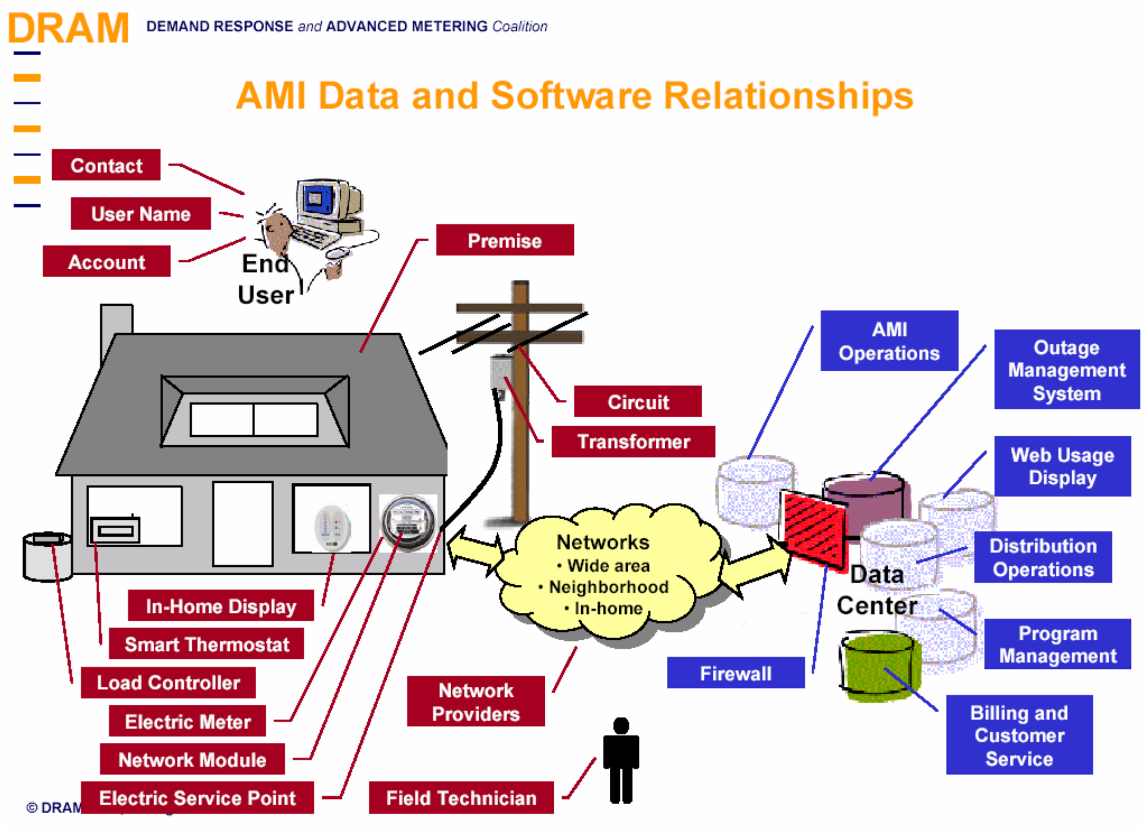
[54] See http://www.wutc.wa.gov/rms2.nsf/0/b9å104ë207628988256c73000â0bd?OpenDocument

5 FINDINGS

The Distributor will continue to follow other experiments relating to advanced meters. Given the progress of these experiments, it is premature to draw conclusions at this time but some general findings can be derived :

- the peak displacement is better documented than energy saving;
- the costs savings are associated with significant peak/off-peak price ratios;
- reduction in winter seems to be less significant than in summer;
- in spite of the promising benefits of demand management, no spontaneous initiative on behalf of the electricity distributors seems to exist to proceed with the massive deployment of advanced meters dedicated mainly to peak management.

APPENDIX A: ADVANCED METER AND INFORMATION SYSTEM



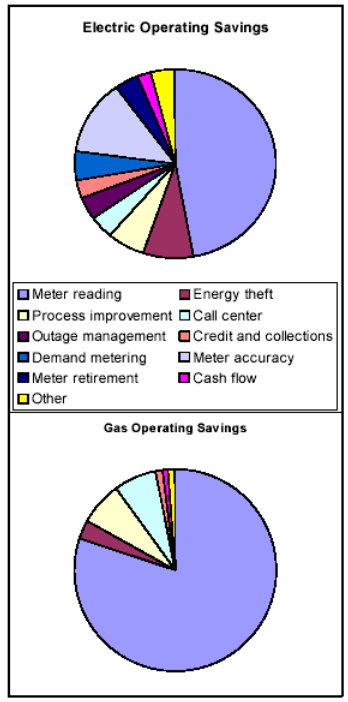
Drawn from King, C, "Smart metering infrastructure, Overview of system features and capabilities "Oregon PUC smart metering workshop, January 2005. http://www.puc.state.or.us/elecnat/010605/king.pdf

APPENDIX B: BENEFITS ASSOCIATED WITH ADVANCED METERS

Benefits – Utility Operations

Puget Sound Energy Example

Source	Share of benefits	
	Electric	Gas
Meter reading	47%	80%
Energy theft	8%	3%
Process improvement	6%	7%
Call center	4%	7%
Outage management	4%	0%
Credit and collections	3%	1%
Demand metering	5%	0%
Meter accuracy	13%	0%
Meter retirement	4%	0%
Cash flow	2%	1%
Other	4%	1%
TOTAL	100%	100%



PSE Payback: Operations Only = 9 years
Operations w/TOU = 5 years

Drawn from: King, C, "Smart metering infrastructure, Overview of system features and capabilities" Oregon PUC smart metering workshop, January 2005. http://www.puc.state.or.us/elecnat/010605/king.pdf