POLITIQUE D'AJOUTS AU RÉSEAU

Témoignage du Dr Ren Orans et du Dr C.K. Woo
Transmission Rate Design

for Hydro-Québec TransÉnergie (HQT)

Direct Testimony of

Dr. Ren Orans and Dr. C.K. Woo

Energy and Environmental Economics, Inc. (E3)

101 Montgomery Street, Suite 1600

San Francisco California 94104
1. Introduction and overview

This testimony is jointly prepared by:

- Dr. Ren Orans, Managing Partner of Energy and Environmental Economics, Inc. (E3)
- Dr. C.K. Woo, Senior Partner of E3.

Our business address is 101 Montgomery Street, Suite 1600, San Francisco, California, 94104, USA.

We have been retained by Hydro-Québec TransÉnergie (HQT) to evaluate an alternative treatment (“Alternative Treatment” hereafter) described in the Régie’s decision D-2007-141 of HQT’s network upgrade cost related to Hydro-Québec Distribution’s (HQT) interconnection of a 990-MW wind farm to serve HQD’s load obligation.

Our evaluation draws on our qualifications and experience described below:

**Dr. Ren Orans**

With over 20 years of experience in the electric utility business, Dr. Orans has worked extensively in transmission pricing, wholesale and retail rate design, electricity market reform, integrated resource planning, and transmission and distribution (T&D) planning. He has testified before state and provincial regulators on transmission pricing, electricity market reform, and asset valuation. Over the past ten years, his work has focused on transmission pricing and planning for electric utilities in North America. He received his Ph.D. in Civil Engineering from Stanford University and his B.A. in Economics from
University California, Berkeley. His curriculum vitae provided in the appendix further details his qualifications and experience.

Dr. Orans has testified in Québec and other Canadian provinces on transmission rate design and related matters:

- On behalf of Hydro-Québec (HQ) before the Régie in HQT’s 2001 wholesale transmission tariff and 2005 Open Access Transmission Tariff (OATT) application.
- On behalf of British Columbia Transmission Corporation (BCTC) before the British Columbia Utilities Commission (BCUC) in BCTC’s 2004 open access transmission tariff (OATT) application.
- On behalf of Ontario Power Generation (OPG) in Ontario Hydro Network’s 2000 transmission rate application.
- On behalf of BC Hydro before the BCUC in BC Hydro’s 2008 Residential Rate Application, 1996 and 1997 initial wholesale transmission service rate applications before both the FERC and the BCUC and 1995 participation in the BCUC’s Electricity Market Restructure Review.

**Dr. C.K. Woo**

With over 20 years of experience in the electricity industry, Dr. Woo has published extensively on electricity economics, applied microeconomics, and applied finance. Recognized by *Who’s Who in America*, he is an associate editor of *Energy* and a guest editor of a 2006 special issue on *Electricity Market Reform and Deregulation*. He is also a member of the editorial board of *The Energy Journal* and a guest editor for a 1988
special issue on *Electricity Reliability*. He holds a Ph.D. (Economics) from University of California, Davis, a M.A. (Economics) from Queen’s University, and a B.Comm. (Economics) from Concordia University. His curriculum vitae provided in the appendix further details his qualifications and experience.

Dr. Woo’s prior experience of providing testimony on rate-related matters includes:

- On behalf of Southern Water Company (SWC), he filed rebuttal testimony with the California Public Utilities Commission (CPUC) regarding SWC’s procurement cost prudence.¹

- On behalf of Upper Canada Energy Alliance, he filed comments and testified in 1999 before the Ontario Energy Board (OEB) regarding OEB Staff’s *Draft Electric Distribution Rate Handbook*.

- On behalf of Pacific Gas and Electric Company (PG&E), he filed rebuttal testimony and testified in 1996 before the CPUC on the use of customer outage cost in generation marginal cost estimation.²

- On behalf of BC Hydro, he filed direct testimony and testified in 1996 before the British Columbia Utilities Commission (BCUC) on *Industrial Service Options*.³

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To be detailed in the remainder of our testimony below, our evaluation yields the following findings:

- HQT’s current OATT approved by the Régie in decisions D-2008-019, D-2008-027, D-2008-036 and D-2008-045 offers open and comparable transmission access to all eligible customers requesting interconnection, without differentiation by interconnection customer characteristics, generation technology or capacity factor.

- The Alternative Treatment in D-2007-141 is a significant departure from HQT’s OATT because (a) it is based on an agreement between HQD and Hydro-Québec Production (HQP), of which HQT is not a party; and (b) it assigns HQD’s share of the network upgrade cost by reason of a specific technology (wind) and a specific peak capacity factor (35%, which is the agreement’s guaranteed capacity at HQT’s system peak divided by the wind farm’s installed capacity).

- The Alternative Treatment is inconsistent with the industry standard practice that an OATT’s upgrade cost treatment for generation interconnection does not vary by interconnection customer characteristics, generation technology or capacity factor.

- The Alternative Treatment can cause differential transmission access by technology type.

- The Alternative Treatment can present implementation complications because of technological diversity among renewable resources (e.g., biomass vs. hydro).
While we are fully aware that the Régie has the full jurisdiction to determine just and reasonable rate levels for both HQD and HQT, the above findings lead us to recommend the Régie (a) not use the Alternative Treatment for the 990-MW wind farm interconnection cost; and (b) not modify HQT’s OATT based on the Alternative Treatment.

2. HQT’s OATT offers open and comparable transmission access

In general, HQT’s OATT is based on the 1996 FERC Order 888 pro forma tariff commonly used by North American jurisdictions. An important goal of an OATT is to provide open and comparable transmission to all eligible customers. Thus, “an open access tariff that is not unduly discriminatory or anticompetitive should offer third parties access on the same or comparable basis, and under the same or comparable terms and conditions, as the transmission provider's uses of its system.” (Order 888, p.37).

To achieve open and comparable access, HQT’s OATT does not differentiate network upgrade cost treatment by interconnection customer characteristics, generation technology or capacity factor. The cost treatment in HQT’s OATT (p.186) is that “[a]ny Network Upgrade to the Transmission System required to meet the need for Transmission Service under Parts II, III and IV herein, including generating station connections under Section 12A, shall be paid for by the Transmission Provider and incorporated into its rate

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base for cost recovery purposes … .” The same OATT (p.196) provides that $574/kW is the maximum amount to be borne by HQT for the connection of generating stations to Transmission and Distribution System.

When compared to the OATTs in other jurisdictions, the cost treatment in HQT’s OATT helps foster the province’s generation development, including renewable resources. This is because the amount borne by HQT reduces the upfront payment of an interconnection customer, thus easing the customer’s financing burden.

3. The Alternative Treatment is a significant departure from HQT’s OATT

The Alternative Treatment is that only 35% of the 990-MW wind farm’s interconnection cost would be eligible for the maximum amount borne by HQT; this is notwithstanding that HQD made the interconnection request in accordance with HQT’s OATT. Decision D-2007-141 reasoned that the 35% factor reflects the wind farm’s winter guaranteed capacity at HQD’s single coincident peak (1-CP) (p.25).

The Alternative Treatment is technology- and capacity-factor-specific; and it is therefore a significant departure from HQT’s current OATT approved by the Régie’s decisions D-2008-019, D-2008-027, D-2008-036 and D-2008-045. This departure can be illustrated using the following example:

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5 See Tables 1A-1D below.
Example. Suppose a point-to-point (PTP) customer makes a 990-MW wind-farm interconnection request and signs a 20-year contract with HQT for long-term firm service based on HQT’s OATT. There is no provision in HQT’s OATT that would subject the PTP customer to the Alternative Treatment for setting the amount to be borne by HQT. If the Alternative Treatment were to be used for the PTP customer, HQT’s OATT would have to be revised accordingly. As will be shown in Section 6 below, however, the Alternative Treatment can present implementation complications for HQT.

To the extent that the Régie had accepted transmission access under HQT’s current OATT being open and comparable, the Alternative Treatment is discriminatory and inconsistent with the goal of open and comparable transmission access, as will be demonstrated in the remainder of our testimony below.

4. The Alternative Treatment is inconsistent with the industry standard practice

We recognize that network upgrade cost treatment can vary by transmission provider, as demonstrated by the OATT examples shown in Tables 1A – 1D below. These OATT examples encompass:

- Canadian providers in Tables 1A and 1B and US providers in Tables 1C and 1D;
- Providers in Tables 1A and 1C that use OATTs based on the FERC pro forma tariff and those in Tables 1B and 1D that do not; and
• Hydro- (e.g., British Columbia, Washington and Oregon) and thermal-generation dominated regions (e.g., Alberta, Ontario, New York, New England, and PJM).

The OATT examples indicate that some transmission providers (e.g., Nova Scotia Power in Table 1A) require an interconnection customer to make an upfront payment for the entire network upgrade cost, and other providers do not (e.g., AESO in Table 1B). However, they also indicate that each transmission provider’s cost treatment is identically applied to all of its eligible customers requesting generation interconnection. None of the OATTs differentiate network cost treatment by identity (e.g., affiliate vs. non-affiliate of the transmission provider), generation type (e.g., renewable vs. non-renewable) or capacity factor (high vs. low). As a result, none of the OATTs has a cost treatment that depends on an interconnection customer’s agreement for renewable energy.

The cost treatments in Tables 1A-1D generally follow FERC Order 2003-C (pp.3-4) that requires the transmission provider reimburse an interconnection customer for its upfront payments for network upgrades by means of credit against the customer’s transmission bills over a maximum period of 20 years. In justifying this policy, FERC Order 2003 (p.139) states that “the Commission's crediting policy helps to ensure that the Interconnection Customer's interconnection is treated comparably to the interconnections that a non-independent Transmission Provider completes for its own Generating

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6 AESO's OATT offers demand transmission service (DTS) to loads and supply transmission service (STS) to generators, see [http://www.aeso.ca/downloads/AESO_2006_Terms_and_Conditions_2006-01-01.pdf](http://www.aeso.ca/downloads/AESO_2006_Terms_and_Conditions_2006-01-01.pdf). DTS customers are eligible for AESO's local investment allowance that would reduce their interconnection costs. STS customers are not eligible for AESO's local investment allowance. As only STS customers, not DTS customers, request generation interconnection, the AESO's treatment is applied identically to all STS customers requesting generation interconnection.
Facilities. The Transmission Provider has traditionally rolled into its transmission rates the cost of Network Upgrades required for its own interconnections, and the Commission's crediting policy ensures that Network Upgrades constructed for others are treated the same way."

Consistent with standard industry practice, HQT’s OATT provides open and comparable transmission access. As a result, the cost treatment in HQT’s OATT does not vary by customer characteristics, technology or capacity factor.

In contrast, the Alternative Treatment is based on an agreement between HQD and HQP, with specific terms and with reference to a particular technology and a particular peak capacity factor. Hence, the Alternative Treatment is inconsistent with the industry practice and the goal of open and comparable transmission access.
## Table 1A
Treatment of network upgrade cost for generation interconnection by Canadian transmission providers that use OATTs based on the FERC *pro forma* tariff

<table>
<thead>
<tr>
<th>Transmission provider (Province)</th>
<th>Description</th>
<th>Does the treatment vary by customer characteristics, generation type or capacity factor?</th>
</tr>
</thead>
</table>
| BCTC (British Columbia)         | Transmission customer provides security for the network upgrade; balance of security is reduced by an amount equal to the customer’s payment for transmission service.  
7 BCTC Open Access Transmission Tariff, Effective March 1, 2006, p. 59 and Attachment K, p. 3 | No                                                                                       |
| Manitoba Hydro (Manitoba)       | Transmission customer is responsible for costs of new facilities and receives credit where such facilities are jointly planned with the Transmission Provider.  
8 Manitoba Hydro Open Access Transmission Tariff, Effective June 1, 2008, pp. 65, 76 | No                                                                                       |
| New Brunswick Power (New Brunswick) | “If the additional transmission tariff revenues associated with the increased use of the transmission system are less than the increase in the Transmission System revenue requirement, the Transmission Customer will make a contribution to capital of an amount that will allow the Transmission Provider to continue to collect the full revenue requirement.”  
9 New Brunswick Power Open Access Transmission Tariff effective May 1, 2005, Attachment K, pp. 335, 336 | No                                                                                       |
| Nova Scotia Power (Nova Scotia) | “…the Transmission Customer shall be responsible for such costs as determined by the Transmission Provider.” The customer shall receive credit “…where such facilities are jointly planned and installed.”  
| SaskPower (Saskatchewan)        | “the Transmission Customer shall be responsible for such costs to the extent consistent with law and policy governing the Transmission Provider”  
11 SaskPower Open Access Transmission Tariff, Effective Jan 1, 2006, p. 62 | No                                                                                       |
### Table 1B
Treatment of network upgrade cost for generation interconnection by Canadian transmission providers that use OATTs not based on the FERC *pro forma* tariff

<table>
<thead>
<tr>
<th>Transmission provider (Province)</th>
<th>Description</th>
<th>Does the treatment vary by customer characteristics, generation type or capacity factor?</th>
</tr>
</thead>
</table>
| AESO (Alberta)                  | AESO offers: (a) supply transmission service (STS) to generators that pay upfront all “supply related costs” for generation interconnection; and (b) demand transmission service (DTS) to loads (e.g., an industrial firm) that pay upfront “demand related costs” for load interconnection, net of maximum local investment allowance: $125,000 per year plus $5,000/MW/year.

A STS customer is not eligible for the local investment allowance; and the customer is required to pay a system contribution, which is refunded over a 10-year period. |
| No                              |                                                        |
| IESO (Ontario)                  | “For a single generator customer, a transmitter shall attribute to that generator customer the cost of any required modification to a transmitter-owned connection facility required to serve the rated peak output of the generation facilities.” |
| No                              | “Where more than one generator customer triggers the need for a modification to a transmitter-owned connection facility, a transmitter shall attribute the cost of the modification to those generator customers …” |

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Table 1C
Treatment of network upgrade cost for generation interconnection by US transmission providers that use OATTs based on the FERC pro forma tariff

<table>
<thead>
<tr>
<th>Transmission provider (States)</th>
<th>Description</th>
<th>Does the treatment vary by customer characteristics, generation type or capacity factor?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonneville Power Administration (Oregon)</td>
<td>Unless the transmission provider decides otherwise, network upgrades shall be “solely funded by the Interconnection Customer.” Interconnection customer is entitled to a cash repayment, with interest, “as payments are made under the Transmission Provider’s tariff for transmission services...” Full reimbursement shall not extend beyond 20 years.</td>
<td>No</td>
</tr>
<tr>
<td>PacifiCorp (Washington, Oregon)</td>
<td>“…the Transmission Customer shall be responsible for such costs to the extent consistent with Commission policy.”</td>
<td>No</td>
</tr>
<tr>
<td>Southern Companies: Alabama Power, Georgia Power, Gulf Power, Mississippi Power (Alabama, Georgia, Florida, Mississippi)</td>
<td>“…the Transmission Customer shall be responsible for such costs to the extent consistent with Commission policy.”</td>
<td>No</td>
</tr>
</tbody>
</table>

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16 Bonneville Power Administration, Open Access Transmission Tariff, Attachment L, effective May 1, 2005, pp.260, 261
17 PacifiCorp FERC Electric Tariff Seventh Revised Volume No. 11 Pro Forma Open Access Transmission Tariff, effective July 13, 2007, p.105. In Order 2003-C, the FERC affirmed that full reimbursement for an interconnection customer’s upfront payment shall not extend beyond 20 years.
<table>
<thead>
<tr>
<th>Transmission provider (States)</th>
<th>Description</th>
<th>Does treatment vary by customer characteristics, generation type or capacity factor?</th>
</tr>
</thead>
<tbody>
<tr>
<td>MISO (Mid-west states in Northern US)</td>
<td>Network upgrades are initially funded by the interconnection customer, but these costs are repaid. Upgrades resulting from interconnection requests are included in subsequent Midwest ISO Transmission Expansion Plans and are subject to regional cost sharing. 19</td>
<td>No</td>
</tr>
<tr>
<td>NYISO (New York)</td>
<td>“…the Transmission Customer shall be responsible for such costs to the extent consistent with Commission policy.” 20</td>
<td>No</td>
</tr>
<tr>
<td>ISO-NE (New England)</td>
<td>Generator owners are responsible for all costs, unless they are determined to “provide benefits to the system as a whole as well as to particular parties,” in which case they are regionally shared to Transmission Customers. 21</td>
<td>No</td>
</tr>
<tr>
<td>PJM (Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia.)</td>
<td>“[A]n Interconnection Customer shall agree to reimburse the Transmission Provider (for the benefit of the affected Transmission Owners) for the costs . . . of constructing Attachment Facilities, Local Upgrades, and Network Upgrades necessary to accommodate its Interconnection Request to the extent that the Transmission Owner, as Interconnected Transmission Owner, is responsible for building such facilities.” 22</td>
<td>No.</td>
</tr>
</tbody>
</table>

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22 PJM Open Access Transmission Tariff, Original Sheet 224X.
5. The Alternative Treatment can cause differential transmission access by technology type

The Alternative Treatment can cause differential access because the amount of network upgrade cost to be borne by HQT will vary by technology type, as illustrated by the following examples.

The first example compares natural-gas generation and renewable generation. Suppose a customer, for reliability reasons, installs a new combustion turbine (CT) with high fuel cost. Though seldom run, the new CT’s capacity available at HQT’s system peak is equal to the installed capacity. Under the Alternative Treatment, the new CT would qualify for 100% of the $574/kW maximum to be borne by HQT, more than the percentage for renewable energy (e.g., solar or wind) that has a peak capacity factor less than 100%.

The second example compares biomass generation and wind energy. Biomass generation has an average capacity factor of 80%, as shown in Table 2 below. This high average capacity factor indicates that biomass energy is likely to have a peak capacity factor closer to 80% than the 35% factor used by Alternative Treatment for the 990-MW wind farm. Thus, biomass generation would, under the Alternative Treatment, qualify for more of the $574/kW maximum to be borne by HQT than the wind farm.

23 Different from the peak capacity factor used by the Alternative Treatment, an average capacity is a generation unit’s average MW output over 8760 hours per year divided by the unit’s installed capacity.
The final example compares hydro without storage and hydro with storage. A hydro unit without storage can have a low peak capacity factor if river flow is low at the time of the system peak. However, a hydro unit with storage can have a peak capacity factor close to 100% because the unit is likely operated at full capacity at the time of system peak. Under the Alternative Treatment, the hydro unit without storage would qualify for less of the $574/kW maximum to be borne by HQT than the hydro unit with storage.

6. The Alternative Treatment can present implementation complications

The Alternative Treatment can present implementation complications because it is specific to a particular generation technology and a particular peak capacity factor. As renewable energy generation can have varying capacity factors by technology type (e.g., biomass vs. hydro), the Alternative Treatment opens up the possibility that the amount of network upgrade costs to be borne by HQT for future interconnection requests may have to be done on a case-by-case basis.

To see this point, consider Table 2 that presents technology-specific average capacity factors used by our firm to model greenhouse gas emissions in the Western Electricity Coordinating Council (WECC) for the California Public Utilities Commission. Irrespective of a renewable generation unit’s average or peak capacity factor, however, the MW size of the unit’s interconnection should match an interconnection customer’s

24 http://www.ethree.com/cpuc_ghg_model.html
request. If the customer requests a 100-MW interconnection for a 100-MW generation unit, a transmission provider should provide a 100-MW interconnection in accordance with its OATT.

Even though Table 2 is admittedly not Quebec-specific and the average capacity factors are not the same as a peak capacity factor, it serves as an example to show that there is significant variance in capacity factor within a given technology such as hydro, as well as across technologies (e.g., biomass vs. hydro).

<table>
<thead>
<tr>
<th>Technology type</th>
<th>Capacity factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>12% - 65%</td>
</tr>
<tr>
<td>Concentrating solar power</td>
<td>37%-40%</td>
</tr>
<tr>
<td>Biomass</td>
<td>80%</td>
</tr>
<tr>
<td>Geothermal</td>
<td>90%</td>
</tr>
</tbody>
</table>

Notes:
(a) An average capacity is a generation unit’s average MW output over 8760 hours per year divided by the unit’s installed capacity.
(b) Average capacity factor data were downloaded on July 10, 2008 from the following sources:

As shown by Table 2, biomass and geothermal generation have higher capacity factors than hydro and solar generation. To the extent that average and peak capacity factors correlate, the Alternative Treatment will cause the network upgrade cost to be borne by HQT to differ by renewable energy type. This can make the Alternative Treatment’s implementation difficult, as it may need a case-by-case assessment of the performance of a specific renewable generation unit.
7. Conclusion

Since HQT is a transmission provider not subject to FERC jurisdiction, the Régie has the full jurisdiction to determine just and reasonable rate levels for both HQD and HQT. However, the Régie has also adopted the goal of providing open and comparable transmission access when approving HQT’s OATT based on the FERC *pro forma* tariff.

Our evaluation presented above indicates that the Alternative Treatment described in D-2007-141 is inconsistent with open and comparable transmission access. This leads us to recommend the Régie (a) not use the Alternative Treatment for the 990-MW wind farm interconnection cost; and (b) not modify HQT’s OATT based on the Alternative Treatment.
Appendix

Curriculum vitae of Dr. Ren Orans

Curriculum vitae of Dr. C.K. Woo
Dr. Orans founded the consulting firm Energy and Environmental Economics (E3) in 1993. The firm specializes in energy economics and has nationally recognized experts in the fields of electricity pricing, integrated resource planning and regulatory theory and finance. Dr. Orans heads the electricity pricing practice for E3.

ENERGY & ENVIRONMENTAL ECONOMICS, INC.
Managing Partner
1993-Present

- Dr. Orans’s work in utility pricing and planning is centered on the design and use of area-and time-specific costs for electric utilities. The first successful application was conducted for Pacific Gas and Electric Company in their 1993 General Rate Case. Using costs developed by Dr. Orans, PG&E became the first electric utility to use area and time specific costing in its ratemaking process. This seminal work led to detailed area costing applications in pricing, marketing and planning for Wisconsin Electric Company, Niagara Mohawk Power Company, Public Service of Indiana, Kansas City Power and Light, Central and Southwest Utilities, Philadelphia Electric Company, Tennessee Valley Authority and Ontario Hydro. This work has been formalized in Dr. Orans’ Dissertation, Area-Specific Costing for Electric Utilities, A Case Study of Transmission and Distribution Costs (1989) and a more recent NARUC report revising the California Standard Practice Guidelines for Evaluating DSM programs (2000).

- Dr. Orans’s expertise in utility planning is complemented by his practical working experience at Pacific Gas and Electric Company (PG&E), where he was responsible for designing their electric utility rates between 1981 and 1985. He has relied on this background, along with his published papers to provide expert testimony on transmission pricing on behalf of BC Hydro (1996, 1997 and 2004, 2005), Ontario Power Generation (2000) and Hydro Quebec (2001, 2006). Dr. Orans has also testified in stranded asset cases before the British Columbia Utilities Commission and the Texas PUC on behalf of BC Hydro and Central Power and Light, respectively. Dr. Orans was also PG&E’s expert witness for avoided generation costs in their most recent rate case (2005) and is currently sponsoring testimony on electric rate design for both Hawaiian Electric Company and Lower Valley Energy. He is also currently (2007) sponsoring testimony on behalf of the CALISO on the economics of SDG&E’s proposed Sunrise project.

DEPARTMENT OF ENERGY
NATIONAL RENEWABLE ENERGY LABORATORY
ELECTRIC POWER RESEARCH INSTITUTE
Lead Consultant
1992-1993

- Developed new models to evaluate small-scale generation and DSM placed optimally in utility transmission and distribution systems.
PACIFIC GAS & ELECTRIC COMPANY
San Francisco, CA
Research and Development Department
1989-1991

- Developed an economic evaluation method for distributed generation alternatives. The new approach shows that targeted, circuit-specific, localized generation packages or targeted DSM can in some cases be less costly than larger generation alternatives.

- Developed the evaluation methodology that led to PG&E’s installation of a 500KW photovoltaic (PV) facility at their Kerman substation. This is the only PV plant ever designed to defer the need for distribution capacity.

ELECTRIC POWER RESEARCH INSTITUTE
Palo Alto, CA
Consultant
1988-1992

- Developed the first formal economic model capable of integrating DSM into a transmission and distribution plan; the case study plan was used by PG&E for a $16 million pilot project that was featured on national television.

DEPARTMENT OF ENERGY
Washington, DC
Lead Consultant
1989-1990

- Collaborated on a cooperative research and development project with the People’s Republic of China. The final product was a book on lessons learned from electric utility costing and planning in the United States.

PACIFIC GAS & ELECTRIC COMPANY
San Francisco, CA
Corporate Planning Department
1989-1992

- Lead consultant on a joint EPRI and PG&E research project to develop geographic differences in PG&E’s cost-of-service for use in the evaluation of capital projects.

- Developed shared savings DSM incentive mechanisms for utilities in California.

PACIFIC GAS & ELECTRIC COMPANY
San Francisco, CA
Rate Department Economist
1981-1985

- Responsible for the technical quality of testimony for all electric rate design filings.

- Responsible for research on customers’ behavioral response to conservation and load management programs. The research led to the design and implementation of the first and largest residential time-of-use program in California and a variety of innovative pricing and DSM programs.
Education

Stanford University
Ph.D., Civil Engineering
Palo Alto, CA

Stanford University
M.S., Civil Engineering
Palo Alto, CA

University of California
B.S., Economics
Berkeley, CA

Citizenship

United States

Refereed Papers


**Research Reports**


8. Orans, R., Feinstein, C. et. al. (1993), Distributed Utility Valuation Study, submitted to the Electric Power Research Institute, the National Renewable Energy Laboratory, and PG&E.


Conference Papers


Dr. C.K. Woo specializes in public utility economics, applied microeconomics, and applied finance. With over 20 years of experience in the electricity industry, he has testified and prepared expert testimony for use in regulatory and legal proceedings in California, British Columbia and Ontario. He has also filed declaration for and testified in arbitration in connection to contract dispute. Dr. Woo's current research includes electricity deregulation, procurement, risk management, demand response and rationing, avoided cost estimation, integrated resource planning, value of service reliability, deregulation, and transmission pricing.

ENERGY & ENVIRONMENTAL ECONOMICS, INC.
San Francisco, CA
Senior Partner
1993 – Present

CITY UNIVERSITY OF HONG KONG
Hong Kong, China
Associate Professor, Department of Economics and Finance
1991 – 1993
Dr. Woo analyzed the economic impacts of supply shortage on consumers, resulting in a series of publications on water and electricity rationing. He also performed specification tests of econometric models of stock returns. As a consultant, he performed marginal costing, demand-side-management evaluation and reliability planning which led to several publications on local integrated resource planning and T&D costing.

ANALYSIS GROUP, INC.
San Francisco, CA
Senior Associate
1987 – 1991
Dr. Woo was responsible for applied microeconomics, outage cost estimation, reliability planning, and electricity pricing. He was the primary consultant to several utilities for outage cost estimation and reliability differentiation. His extensive publications in these two areas are widely cited by other researchers. He also performed economic analysis of mergers and acquisition with a primary focus on the anti-trust aspect of market power, with the resulting findings filed with both state and federal courts.
Dr. Woo revamped PG&E’s research on outage cost estimation whose findings appear in a special issue of *The Energy Journal* focusing on electricity reliability. He also participated in PG&E’s preparation of the General Rate Cases.

Dr. Woo was responsible for demand estimation and load forecasting. The results from his study guided SMUD’s resource planning.

Dr. Woo was responsible for time-of-use (TOU) demand analysis and TOU pricing mandated by the CPUC. This work resulted in a performance award from PG&E and several publications.

Mr. Woo was the primary author of the life cycle costing model used by the CEC to analyze solar energy and other DSM measures. He testified before the CPUC on the economics of solar financing.

**Education**

**UNIVERSITY OF CALIFORNIA**

Ph.D. in Economics

Thesis: The non-parametric approach to production analysis: a case study on a regulated electric utility.

**QUEEN’S UNIVERSITY**

M.A. in Economics

**CONCORDIA UNIVERSITY**

B. Comm. in Economics

**Citizenship**

United States
Research

Special issues


Refereed Publications

Electricity Deregulation


Electricity Procurement


Electricity Risk Management


Demand Response and Capacity Rationing


Electricity Pricing and Rate Design


### Integrated Resource Planning


Value of Service Reliability


Applied Microeconomics


Applied Finance


Book Reviews


**Invited lectures**


**Testimony**


Research Reports


Conference Papers


