EDA

The Voice Of Ontario's Electricity Distributors

June 26, 2007

Board Secretary
Ontario Energy Board
PO Box 2319
2300 Yonge Street
Suite 2700
Toronto, ON M4P 1E4

Via email to BoardSec@oeb.gov.on.ca and by courier

Dear Board Secretary:

Re: EB-2006-0268: Comparison of Distributor Costs – Consultation on Consultant's Report

The Electricity Distributors Association ("EDA") is the voice of Ontario's electricity distributors.

Enclosed is the EDA response to the report on "Benchmarking the Costs of Ontario Power Distributors" by Pacific Economics Group (PEG) dated April 25, 2007. The EDA response was prepared by Adonis Yatchew, Ph.D. with some input received from EDA members.

One of the main concerns expressed by members has been the inconsistency of the data that has been collected and used in the PEG study and the need to improve the quality and quantity of the data. Members were concerned that cost drivers involving service quality and differing customer services were not adequately addressed in the PEG study because most of the required data has not been collected or not collected on a consistent and comparable basis. Members also noted that significant differences in the way distributors carry out their responsibilities, such as outsourcing most services or leasing space and equipment, were not addressed. The EDA members note that for many years a concern has been expressed that more consistency on the accounting practices and the collection of service quality measures was needed. Members recognize for the purposes of cost comparison the focus should initially be on improving the consistency of all US of A accounts as they impact comparability of OMA and capital costs, and service measures that impact overall costs. The EDA believes the Ontario Energy Board should lead an initiative to work with distributors to develop guidelines for consistent reporting of key accounts, service quality, and capitalization policies.

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The EDA believes the next step in the cost comparison initiative is further consultation to discuss how the studies can be improved to allow greater confidence in using the cost comparison results and a new key initiative to improve the quality and quantity of the data required for an improved cost comparison study.

Yours truly,

Richard Zebrowski
Vice President, Policy and Corporate Affairs

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Encl.

REVIEW OF

"BENCHMARKING THE COSTS OF ONTARIO POWER DISTRIBUTORS
PACIFIC ECONOMICS GROUP, APRIL 25 2007"

PREPARED FOR

THE ELECTRICITY DISTRIBUTORS ASSOCIATION

by

Adonis Yatchew, Ph.D.

June 26, 2007

Executive Summary

Background

1. The Ontario Energy Board regulates approximately 80 electricity distribution utilities. Over the past several years, the Board has begun to explore the use of statistical benchmarking as a tool for assessing distributor costs and thereby informing the regulatory process.

2. The Ontario Energy Board is presently engaged in a staged consultation process with respect to the comparison of Ontario distributor costs (EB 2006-0268). As part of the process, Board Staff engaged the Pacific Economics Group, LLC (PEG). The PEG report entitled "Benchmarking the Costs of Ontario Power Distributors" became publicly available April 27, 2007. The purpose of the present document is to provide an independent assessment of the PEG report.

The Pacific Economics Group Report

3. The PEG report begins with a review of alternative approaches to benchmarking. It then proceeds to briefly describe the use of benchmarking by regulators in several other jurisdictions. This is followed by a discussion of power distribution industry characteristics and factors that drive distribution costs.

4. Considerable attention is devoted to a discussion of the data that are available on Ontario electricity distributors. The PEG report concludes that Ontario is a leader in the development of electricity distributor benchmarking data. Moreover, it finds that the data are sufficient for the application of econometric techniques.

5. The PEG report also identifies some important data shortcomings. Significant or serious data deficiencies are identified in a number of areas including capital costs, labour expense reporting, power deliveries between distributors and power sales to customer classes. Notwithstanding the data deficiencies identified in the PEG report, the authors conclude that the "OEB data are solid enough to provide the foundations for the continued use of benchmarking in Ontario power distributor regulation" but that it is "best for now to confine benchmarking to total OM&A expenses" (PEG report, page 40-41).

6. The authors then proceed to estimate several models relating OM&A expenditures to various cost drivers including: number of retail customers; retail delivery

volume; total circuit kilometers of distribution line; the price of labour and materials; forestation; the proportion of distribution plant that is underground; and indicator variables for utilities located on the Canadian Shield or that have non-contiguous service territories.

7. Quantitative results are provided for two models: the “double-log” and the “translog” models, both of which have been widely used in econometric praxis. The models are found to have very high explanatory power: the "R^2" which measures the proportion of total variation in the data that is explained by the models is approximately 98%, which would suggest that the overwhelming majority of OM&A costs can be explained by observable factors that have been included in the model.

8. Based on these model estimates, the authors then calculate performance scores. These scores exhibit substantial variation: firms with the most favorable performance statistics have costs which are 30% or more below the level predicted by the models; firms with the least favorable performance statistics have costs which exceed predicted levels by 40% or more.

9. Based on their analyses, the authors conclude that “benchmarking can and should play a role in the upcoming rate EDR applications for Ontario power distributors”. However, due to data deficiencies, “benchmarking should be limited to the identification of companies that --- thanks to favorable scores --- merit expedited processing of rate applications and those that --- due to poor scores --- should be scheduled for especially thorough prudence reviews” (PEG report, page vi).

Assessment

10. The high explanatory power of the models estimated by PEG would suggest that a great deal is known about distributor costs and that costs can be predicted with a very high degree of accuracy given data on a relatively small number of distributor characteristics. However, this conclusion would be inaccurate. Differences in costs per customer are of greater practical interest since they are reflected in bills paid by consumers. If one uses “OM&A costs per customer” as the dependent variable (instead of total OM&A costs as in the PEG report) we expect the explanatory power of the variables currently in the models to drop dramatically from 98% to approximately 40%-60%. While this implies that a substantial portion of the variation in costs per customer can be explained by the

models that have been put forth, there are likely important cost drivers still missing from the models.

11. One of the most important shortcomings of the analysis in the PEG report – one that has been underscored by the authors -- is the exclusion of capital costs from the modeling process. Cost models in the peer-reviewed literature typically include capital costs and inclusion of these variables could materially alter the efficiency and productivity assessments put forth in the report.

12. A number of other potentially important variables are not included in the OM&A cost models including:
    i. average age of distribution plant -- past analyses have found that aging distribution plant requires increased OM&A expenditures;
    ii. service quality – differences in service offerings, service quality and reliability can materially affect costs;
    iii. voltage levels – for historic reasons, some distributors possess systems with a variety of voltage levels; this can have a significant impact on OM&A costs;
    iv. customer mix – distributor costs can be affected by the particular mixture of residential, commercial and industrial customers that it serves.

    Moreover, differences in capitalization policies and allocation of costs associated with ownership of transformer stations can also have substantial impacts on performance scores.

13. The PEG report suggests that "economies of scale are available over a wide range of output in Ontario" (PEG report, page 52). This conclusion is premature. The reported estimate of .938 for the scale effect (page 52) implies that if an average firm increases output by 10% its OM&A costs increase by somewhat less -- 9.38%. However, insufficient information is provided as to the accuracy of this estimated scale effect. Our preliminary assessment suggests a 95% confidence interval for this scale effect would encompass positive scale economies, negative scale economies and constant returns to scale. Any scale effects that can be teased out from these data merit a more careful statistical analysis.

14. Evidently additional models were estimated which incorporated equations on input factor shares. The results of these procedures need to be reported so that they can be compared to the single equation model estimates that have been provided.

Conclusions and Recommendations

15. To the extent that capital-related variables are absent from the analysis, the cost models that are estimated in the PEG report do not represent standard practice in the economics literature. In an industry where costs are dominated by capital-related expenditures, this would seem to be a perilous approach. On the other hand, the calibration and measurement of capital-related variables is difficult and data limitations should not paralyze the regulatory process.

16. As a result of difficulties associated with calibrating capital costs, some other jurisdictions have adopted a bifurcated approach where operating costs are assessed and examined separately from capital costs. However, this focus on OM&A costs can lead to a skewing of incentives within the regulatory process: distributors will have the incentive to increase capital costs in order to reduce OM&A costs. This in turn may lead to over-capitalization, under-spending on OM&A and sub-optimal decisions with respect to own/lease alternatives. The impacts of and remedies for this potential bias need careful examination. It is important that efforts at calibrating capital-related expenditures be given proper attention.

17. The PEG report raises numerous data-related issues that need to be addressed. Resolution of these will in all likelihood improve the ability of the models to explain the per-customer OM&A costs incurred by utilities. Age of capital stock, service quality, differing voltage service levels and customer mix are but a few of the cost drivers that need more careful examination. There is a real potential that in some instances performance scores would change materially upon the estimation of a more comprehensive model based on data that have been measured and collected on a consistent basis. Empirical work using earlier Ontario distributor data suggests that inclusion of a variable which measures the age of capital stock can influence performance scores for some utilities by more than 10%.

18. The “wage” variable used in the PEG study is a proxy index based on Canadian census data from 2001. To the extent that a proxy provides only an approximation to an important explanatory variable, productivity scores can be materially affected. Substantially more detail needs to be provided on how the index was computed. Moreover, actual remuneration data from company records should be tested as an alternative measure of the wage variable. Simulations suggest that mismeasurement of the wage variable can affect performance scores for some utilities by more than 5%.

19. Further model specification and validation analyses need to be undertaken and reported. While the “double log” and “translog” specifications that have been estimated have a long and venerable history in the economics literature, much progress has been made since their inception. Additional evidence on the validity of the estimated models needs to be provided, both in the single and multiple equation settings.

20. Insufficient information was provided in a number of areas to permit proper assessment of the appropriateness of the procedures. Among these were the “p-value” computations used to determine the 12 utilities which – according to the models – were found to be “significantly inferior performers”.

21. Recognizing the various limitations of the present modeling exercise, the authors of the PEG report have proposed that the results be used at this point solely for screening purposes. In particular, firms with unfavorable scores would face an especially thorough regulatory review. However, given the likelihood that the models that have been put forth are at this point deficient in a number of important ways, an efficient mechanism needs to be put in place so that utilities with unfavorable scores can address cost issues before the Board without the expenditure of excessive regulatory resources both on the part of the Board and the utility. Moreover, individual utilities should be given a full opportunity to explain and justify their costs and to independently assess the models and empirical work which have been used to determine their performance scores.

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1 Introduction

The Ontario Energy Board regulates approximately 80 electricity distribution utilities. Over the past several years, the Board has begun to explore the use of statistical benchmarking as a tool for assessing distributor costs.

A systematic data-based approach is particularly appealing in Ontario for at least three reasons.

> First, there are significant regulatory costs associated with the regulation of the relatively large number of distribution utilities (though it should be noted that historically there were many more). Statistical analysis can contribute to improving efficiency of regulation.
>
> Second, the presence of many distributors within a single jurisdiction should enhance the validity of the statistical results if the regulator and distributors take steps to further improve data consistency and comparability.
>
> Third, the presence of many distributors should enhance the effectiveness of regulation. Arguably, Ontario distributors have engaged in a form of yardstick competition for many years. The current benchmarking process builds on this form of regulatory model.

The Ontario Energy Board is presently engaging in a staged consultation process (EB 2006-0268) which is concerned with the comparison of Ontario distributor costs. As part of the process, Board Staff engaged the Pacific Economics Group, LLC (PEG). The PEG report entitled "Benchmarking the Costs of Ontario Power Distributors" became publicly available April 27, 2007.

The purpose of the present document is to provide a review of the PEG Report.

2 Benchmarking Tools

A. Methodologies for Benchmarking Costs of Production

A number of techniques have been developed that can be used for cost benchmarking. We will briefly discuss data envelopment analysis, stochastic frontier estimation, index approaches and cost function estimation.

Data envelopment analysis is a non-statistical technique that attempts to identify the most efficient firms amongst similar companies or "peers". It enjoys the advantage of requiring minimal assumptions about the functional form used for modeling costs. A major disadvantage is that it is often difficult to establish a sufficiently similar group of peers. Moreover, by restricting attention to peers it fails to incorporate relevant and valuable information about firms that are similar in some ways yet different in others.

Stochastic frontier estimation is a statistical approach that also attempts to identify the most efficient firms. Varying business conditions can be accommodated more easily within this framework. However, modeling is often strongly dependent upon functional form assumptions.

Both data envelopment analysis and stochastic frontier estimation can be crudely characterized as approaches that attempt to identify "best practices". While in certain circumstances these techniques can inform the regulatory process, they suffer from significant drawbacks. Perhaps most importantly, they are more susceptible to "outliers" -- that is, firms in the data-set with unusually favorable business conditions -- which can lead to spurious conclusions about efficiency. Moreover, best practices are far more difficult to estimate accurately from statistical data than average performance. Indeed, the rationale underpinning incentive regulation is founded on the idea that the regulator *cannot* estimate minimum costs especially accurately.

Index measures (such as cost per customer, costs per kwh, output per employee) are widely used as indicators of performance. However, they too require peer groups within which performance can be compared. Moreover, in order to arrive at an overall efficiency measure, it is necessary to combine the various indices using, for example, a weighting scheme. Selection of appropriate weights can be challenging.

The PEG report focuses primary attention on econometric modeling of cost functions. Cost function estimation has a long and venerable history in the economics and econometrics literature. Cost functions have been estimated for numerous industries using data from various countries. The approach readily permits inclusion of varying business conditions, so long as they can be quantified and recorded on a comparable basis. Moreover, regression analysis, which is the statistical technique used in this approach, is widely understood, at least in its simpler incarnations. Thus we are in agreement with the PEG report that econometric cost function estimation is the most suitable benchmarking technique in the present setting.

B. Capital As a Key Component of Production Costs

Theoretical work on cost functions emphasizes the interrelated nature of decisions about inputs. Inputs into the production process at a minimum, include capital, labour and materials as well as energy. In determining cost-minimizing combinations of inputs, the firm engages in trade-offs between one or another factor. For example, higher OM&A expenditures may be reflected by lower capital costs.

Empirical work on cost functions typically involves a careful analysis of the prices (and quantities) of labour, capital and materials. For the electricity distribution industry, cost functions have been estimated using data from Norway, Switzerland, the U.K., Japan, New Zealand, the U.S. and Canada. Papers published in peer-reviewed journals on electricity distribution cost functions have typically included both operating and capital costs. Indeed, two of the authors of the PEG Report recently published a paper on electricity distribution costs in the U.S. The models in that paper incorporated both capital and operating costs. [1]

While there are circumstances in which it may be appropriate to separately model various cost components – for example, having separate equations for operating costs and capital costs – important variables entering into one equation would also be relevant in other equations for the simple reason that expenditure decisions across cost categories are generally inter-related.

For example, consider the separation of total costs into operating (OM&A) costs and capital costs. Expenditures on the operation and maintenance of capital assets depend on the characteristics of those assets, such as their age. Older capital stock may require higher levels of maintenance. Decisions on refurbishment or replacement of capital assets in turn depend on continued and potentially ever-increasing expenditures on maintenance which in turn depend on the cost of labour and materials.

For the electricity distribution industry, which is highly capital-intensive, the exclusion of capital related variables is particularly problematic. Thus absence of important capital related variables from the analysis contained in the PEG report constitutes an important limitation of the models.

C. Econometric Modeling Considerations

One of the foremost advantages of regression modeling, and indeed one of the reasons that its use in applied settings is so common, is its capacity to incorporate data on apparently dissimilar objects of interest within a single framework. While peer group analysis limits comparison to firms that are similar in most essential respects, regression modeling permits one to infer the effects of differences in characteristics on outcomes.

[1] See "Econometric Benchmarking of Cost Performance: The Case of U.S. Power Distributors", by Mark Newton Lowry, Lullit Getachew and David Hovde, *The Energy Journal*, 2005, vol. 26, no. 3, pp. 75-92.

However, the validity of the empirical work ultimately depends on the quality of the data. In Ontario, where there are many distribution utilities within a single jurisdiction, costs are more amenable to numerical and statistical analysis so long as the measurement of relevant variables and factors is conducted in a similar fashion across utilities.

Utility operating environments and business conditions can vary widely and there are numerous factors which can influence costs. From a modeling point of view, one would like to be able to measure as many of these as possible if one is to conduct a fair assessment of costs. The absence or omission of variables affecting costs can seriously impair the validity of the conclusions.

Model specification also plays a central role in cost estimation. It is important that the estimated models enjoy sufficient flexibility to capture interesting and relevant features of the data. Specifications that are overly simplistic may overlook interactions or nonlinearities that are present in cost structures. Moreover, the validity of the specifications that are ultimately used for regulatory purposes need to be assessed using statistical testing procedures.

3 Pacific Economics Group Report

A. Overview

The PEG report begins with a review of alternative approaches to benchmarking. It then proceeds to briefly describe the use of benchmarking by regulators in several other jurisdictions. The report also discusses characteristics of the power distribution industry and factors that drive distribution costs.

Considerable attention is devoted in the report to the data that are available on Ontario electricity distributors. These data are obtained from documents which distributors file annually with the Ontario Energy Board. The report finds that Ontario is a leader in the development of electricity distributor benchmarking data and that the data are of sufficient quality to justify the application of econometric techniques.

The PEG report also identifies some important data shortcomings. In particular, the report finds that the "formidable advantages of OEB data are offset by noteworthy limitations that materially limit their usefulness. Good benchmarking is possible only if these limitations are recognized and the data are used cautiously" (PEG report, page 39).

Significant or serious data deficiencies are identified in a number of areas:

i. capital cost data are found to be of insufficient quality for ratemaking decisions;
ii. there are inconsistencies in labour expense reporting which undermine comparability across utilities; (for example labour costs associated with customer care are often allocated to the administrative category;)
iii. insufficient data are available on power deliveries by distributors to other distributors; this is important because – absent such data – the level of output for these utilities is understated to the extent that additional infrastructure is required to support the deliveries;

iv. there are insufficient data on deliveries to various customer classes, thus hampering analysis of the effects of differing service mixes on costs.

B. Statistical Analysis Restricted to OM&A Costs

Notwithstanding the data deficiencies identified in the PEG report, the authors conclude that the "OEB data are solid enough to provide the foundations for the continued use of benchmarking in Ontario power distributor regulation" but that it is "best for now to confine benchmarking to total OM&A expenses" (PEG report, page 40-41).

The authors then proceed to estimate several models relating OM&A expenditures to various cost drivers:

i. number of retail customers
ii. retail delivery volume
iii. total circuit kms of distribution line
iv. the price of labour
v. forestation
vi. the proportion of distribution plant that is underground
vii. an indicator variable for utilities located on the Canadian Shield
viii. an indicator variable for utilities with non-contiguous service territories.

The PEG report summarizes the estimation results for the "double-log" and "translog" models, both of which have been widely used in applied econometric work. The models are found to have very high explanatory power: the R^2 which measures the proportion of total variation in the data that is explained by the models is approximately 98% which would suggest that the overwhelming majority of costs can be explained by observable factors that have been included in the model.

Using the model estimates, the authors then calculate performance indices which are found to exhibit broad variation. Firms with the most favorable performance statistics have costs which are 30% or more below the level predicted by the models. Firms with the least favorable performance statistics have costs which exceed predicted levels by more than 40%.

Based on their analysis, the PEG report concludes that "benchmarking can and should play a role in the upcoming rate EDR applications for Ontario power distributors". However, due to data deficiencies, "benchmarking should be limited to the identification of companies that --- thanks to favorable scores --- merit expedited processing of rate applications and those that --- due to poor scores --- should be scheduled for especially thorough prudence reviews" (PEG report, page vi).

C. Data Issues

C.1 Overview

One of the most important shortcomings of the analysis in the PEG report – one that has been underscored by the authors -- is the exclusion of capital costs from the modeling process. Their empirical work attempts to explain OM&A costs, not total costs (which would include capital costs). Inclusion of capital cost data could materially alter the efficiency and productivity assessments put forth in the report.

In addition, a number of potentially important variables are not included in the OM&A cost models that have been estimated. Among them:

i. average age of distribution plant -- past analyses have found that aging distribution plant requires increased OM&A expenditures;
ii. service quality – differences in service offerings, service quality and reliability can materially affect costs;

iii. voltage levels – for historic reasons, some distributors possess systems with a variety of voltage levels which tend to increase their OM&A costs;

iv. customer mix – a utility whose customers are comprised almost exclusively of small residential and commercial customers can be expected to have higher OM&A costs than a utility whose load is dominated by large users.

Moreover, differences in capitalization policies and allocation of costs associated with ownership of transformer stations can also have substantial impacts on performance scores.

In some cases, a utility may be sufficiently different from others in Ontario to seriously limit its potential for inclusion in the econometric modeling exercise. In such cases extra-provincial benchmarking may be required.

C.2 Price of Labour

Input prices are an important cost driver. In order to incorporate the effects of difference in input prices across utilities, the authors used Statistics Canada data to develop a composite labour and materials price index. For purposes of developing the labour component, 2001 Census data were used to identify income and educational attainment levels for the service territories of each utility. The analysis of the labour index provided in the report raises several concerns.

First, the description of the procedures for developing input price data are not sufficiently detailed to permit independent assessment from a methodological point of view. Far more detail would be required, either in the form of computer code used to produce the data or as a detailed algorithm delineating the steps taken. If the authors used standard techniques, then references to the literature should be provided.[2] Reproducibility by independent investigators lies at the heart of good research.

Second, the authors assert that "Results of our labour price index calculations appear in Table 2. It can be seen that the variation in input prices was considerable." (PEG report, page 47). In fact, Table 2 does not contain labour price index information. Instead, Table 2 documents the results of the econometric estimation of the "double log" model.

Third, the authors also indicate that "Further details of our price index calculations are provided in the Appendix" (PEG report, page 47). While the appendices that were provided contain information about output quantity indexes, unit cost indexes and productivity indexes, few details on the calculation of input price indexes were provided.

Fourth, the use of labour indices as proxies for wage data introduces the potential for further biases in modeling. This deficiency is known as the "errors-in-variables" problem. If data on an explanatory variable are sufficiently noisy, then not only would the corresponding coefficient estimator be biased, but efficiency assessments can also be impaired just as in the case of an important omitted cost driver. Exploratory simulations conducted using earlier Ontario distributor data suggest that mismeasurement of the wage variable can affect performance scores for some utilities by more than 5%.

Fifth, while company wage data may have its own shortcomings, at a minimum it should be explored as an alternative measure. Such data have been used successfully in past estimation of distributor costs.

[2] At pages 80-81 of the PEG report, a number of references are provided. Few of these are explicitly cited in the report. Nor do any of these appear to address issues related to calculation of the labour price index used in the report.

C.3 Service Quality

Quality of service and differences of service offerings can have important impacts on distributor costs. Differences in service quality may be reflected in measurable variables such as frequency of interruption, average customer interruption times and customer inquiry wait times.[3] Incorporation of these variables may also improve the explanatory power of the models of per-customer costs thus helping to explain cost differences amongst utilities. It is important to emphasize that service quality data be collected on a consistent basis across utilities.

In a study of U.K. distributors, it was found that firms which have strong cost efficiency scores do not necessarily deliver high service quality. Moreover, performance scores arising out of models which focus on costs are not highly correlated with those which incorporate service quality.[4] Although the study, which uses data envelopment procedures, relies upon a small sample it provides support for the proposition that service quality needs to be considered as a factor in the cost benchmarking process.

C.4 Capitalization Policies

In some cases a utility may find it advantageous to lease an asset rather than purchase and own it. For example, a utility may choose to lease office, garage and inventory space; office and computer equipment; and vehicles. In this case, the associated fees -- which include depreciation -- would be captured in operating costs. On the other hand, a utility that owns the asset would be able to depreciate its costs directly.

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[3] In this connection, it is important to emphasize that data on these variables should be collected on a rigorous and consistent basis across the population of utilities.

[4] See "Benchmarking and Incentive Regulation of Quality of Service: An Application to the UK Electricity Distribution Networks", by Dimitrios Giannakis, Tooraj Jamasb and Michael Pollitt, *Energy Policy*, 2005, Vol. 33, Issue 17, pages 2256-2271.

From the point of view of the empirical researcher, the latter firm would appear to be more efficient because its operating costs are lower.[5]

There may also be significant differences in the capitalization policies used by distribution companies that may account for some of the differences in OM&A costs. It is our understanding that utilities filed their capitalization policies with the Board in 2006 but we are unaware of any comparative assessment that may have been performed.

C.5 Voltage Systems and Transformer Station Costs

It is our understanding that

i. some Ontario distributors have as many as six distribution and sub-transmission voltage levels in their system and that this generally results in higher costs than would be the case if the distributor had only one or two voltage levels;

ii. a distributor with a lower distribution voltage would have more distribution plant for the same amount of load than a utility with a higher distribution voltage; this too would generally lead to higher costs;

iii. a distributor may or may not have substation costs included in OM&A depending on their legacy systems and sub-transmission supply.

Such differences could lead to inequities in the comparison of costs.

[5] Veridian Connections Inc. provides a case in point. Preliminary estimates provided by Veridian staff suggest that if Veridian owned rather than leased office space, office equipment and vehicles, OM&A costs would be at least 5% and perhaps as much as 9% lower.

Utilities that own transformer stations will incur additional OM&A (and capital) costs. This would tend to skew cost comparisons in favour of utilities that do not own transformer stations and rely on the transmitter for this service. One approach to improving cost comparisons would be to remove transformer related costs when attempting to benchmark OM&A costs.

D. Assessment of Statistical Results

D.1 High Explanatory Power

A statistic commonly reported when estimating regression models is the "goodness-of-fit" or R^2 value which measures the proportion of variation in the data that can be explained by the variables in the model. An R^2 value of .98 reported in the PEG analyses[6] would suggest that a great deal is known about distributor costs and that they can be predicted with a very high degree of accuracy given data on a relatively small number of distributor characteristics. However, the high R^2 is somewhat deceptive -- a model of distributor OM&A costs which includes only the number of retail customers as an explanatory variable achieves an R^2 of about .97. That is 97% of variation in OM&A costs across distributors can be explained solely by their "size" as measured by the number of customers each serves. Figure 1 illustrates the results of estimation of this simplified model.

On the other hand, differences in costs per customer are of greater practical interest since they are reflected in bills paid by customers. If one instead uses "costs per customer" as the dependent variable then we expect that the models estimated in the report would have much lower explanatory power, in the range of 40%-60%.

While this still implies that a substantial portion of the variation in costs per customer can be explained by the models that have been put forth, there is substantial variation that remains unexplained by the variables that have been included.

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[6] More precisely, the authors provide values for $\overline{R}^2$, a related statistic (PEG report Table 2, page 48 and Table 3, page 50). If sample size is reasonably large relative to the number of explanatory variables – as is the case in the present study -- the two statistics are very similar.

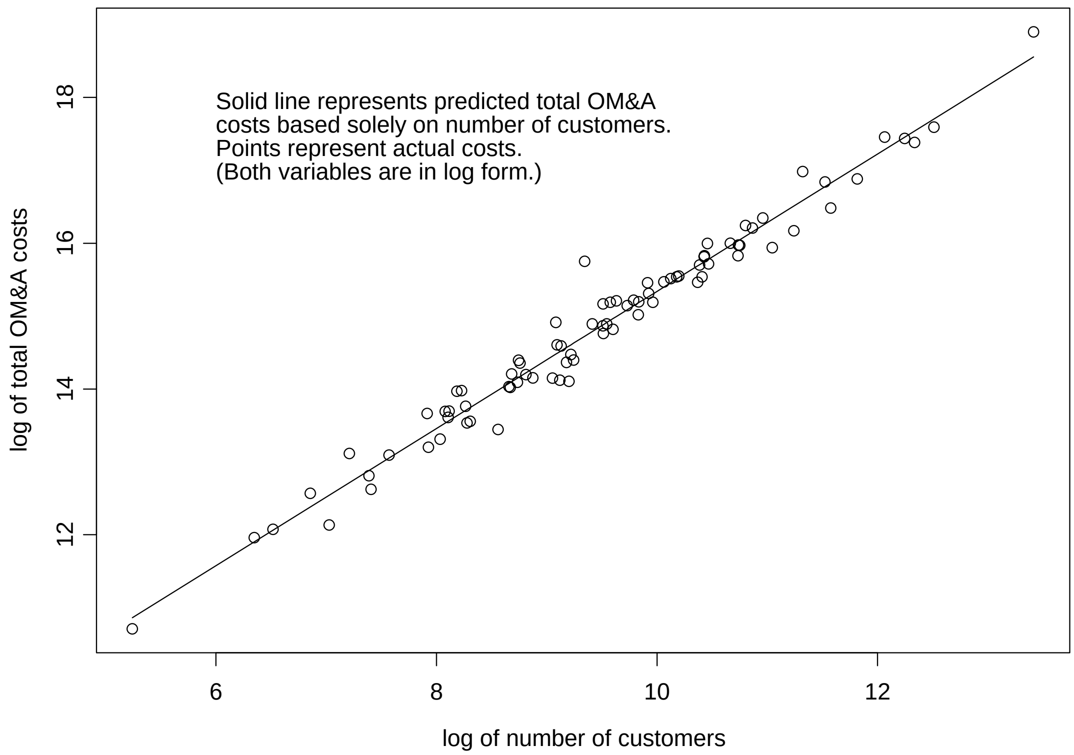

Figure 1

D.2 Performance Scores

The PEG report calculates model based performance scores as the ratio of actual OM&A costs to those predicted by the model. At the outset it should be emphasized that these scores are dependent on the explanatory variables in the model and the specifications that have been implemented. Modifications to either may result in material changes in the scores themselves and thus they need to be used judiciously.

The scores that have been calculated exhibit considerable variation: from 30% below predicted costs to 40% or more above predicted costs. While such a broad range might appear to be inconsistent with the very high explanatory power of the PEG models, they become much less puzzling once one realizes that on a "cost-per-customer" basis, the explanatory power of the variables in the models is much lower.

The PEG report then proceeds to conduct statistical tests of distributor efficiency. The authors state

> "The p-values reported in Table 5 indicate the results of the tests. For any distributor with a favorable appraisal and a p value between 0 and 0.10, the hypothesis of average performance can be rejected and we may conclude that the company was a *significantly superior* performer. Any distributor with an unfavorable appraisal and a p-value between 0 and 0.10 was, by analogous reasoning, a *significantly inferior* performer. Only 10 distributors were found to be significantly superior and 12 were significantly inferior in the translog model." PEG report, page 54.

However, the information provided in the report (for example, at pages 12-13), is insufficient to permit assessment of the testing methodology that was implemented.[7, 8]

D.3 Economies of Scale

The PEG report suggests "that economies of scale are available over a wide range of output in Ontario" (page 52). This conclusion is premature. The reported estimate of .938 for the scale effect (page 52) implies that if an average firm increases output by 10% its OM&A costs increase by somewhat less -- 9.38%. However, no information is provided as to the accuracy of this estimated scale effect. Our preliminary assessment, based on the data available to us, suggests a 95% confidence interval for this scale effect would encompass positive scale economies, negative scale economies and constant returns to scale. Any scale effects that can be teased out from these data merit a more careful statistical analysis.

Moreover, the overall approach in the PEG report is not ideally suited for analysis of scale economies: first, the empirical work focuses on OM&A rather than total costs; second, superior models are available for analyzing such effects.

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[7] At a minimum, if standard procedures were used, then references to the relevant papers on efficiency testing should be provided.

[8] The p-values are actually reported in Table 4 rather than Table 5. Moreover, for the translog model, there appear to be 18 utilities that are significantly superior performers according to the stated criterion, rather than 10 as given in the PEG report.

Whether there are substantial unexploited scale and other economies present in the Ontario electricity industry is beyond the scope of this analysis. In our view, the most appropriate approach to this issue would be to ensure that utilities are in a position to benefit from downstream cost savings for a significant period of time if they are to willingly undertake the upfront costs and risks of a merger. We note that this issue has been raised in the Board Staff discussion paper "On Rate-Making Policies Associated With Distributor Consolidation", March 5, 2007.

D.4 Multiple Equation Models

The authors of the report discuss the estimation of multiple equation models in the context of cost modeling. In the conventional case where total costs are a function of say capital, labour and materials, data on the quantities (or cost shares) of these inputs can be very useful in estimation of the cost function itself. Indeed the authors state that

> "A rigorous multiple equation approach to cost modeling that includes share equations is generally preferable to the single equation approach. The chief advantage results from the fact that economic theory suggests that the parameters of the cost function and share equations are linked. More data can thus be used in the estimation of cost model parameters. This increases the prospects for developing a cost benchmarking model that accurately reflects the effects of external business conditions. The chief downside of multiple equation models is their greater complexity." (PEG report, page 9.)

In fact, in certain instances, data on factor inputs can dramatically improve the precision of estimation of the cost function itself. This is particularly the case for classes of models which strive to achieve greater degrees of flexibility and accuracy of approximation.[9]

Evidently, multiple equation models were developed and estimated using distributor data, (PEG report, pages 50, 53-54). The authors report that these models had

[9] See, e.g., "Nonparametric Estimation When Data on Derivatives are Available" by Peter Hall and Adonis Yatchew, *Annals of Statistics*, 2007, Vol. 35, No. 1, 300–323. The ideas in that paper were motivated in part by cost function estimation.

"explanatory power similar to the single equation models" and that they were capable of recognizing additional cost drivers including the number of transformers possessed by a distributor, value of plant and the share of residential and general service customers (pages 53-54).

The authors, however, comment that

> "A disquieting feature of the multiple equation models was the greater prevalence of 'extreme' performance appraisals, which we define as appraisals in which actual cost differed from predicted cost by more that 50%. On balance, we believe that the advantages of multiple equation models do not outweigh the downside of their greater complexity at this time. The benefit-cost balance should improve when more years of data are available to estimate model parameters and there is more reliable information available regarding the breakdown of cost by input group." (page 54).[10]

Unfortunately, little additional information is provided about the multiple equation models that were estimated, the parameter estimates, the precision with which they were estimated and the performance appraisals that were conducted. In our view, three steps need to be undertaken in connection with multi-equation estimation:

i. The results need to be reported in addition to the single equation model estimates that have been provided.

ii. Assessments of the cost models should be conducted using the data from the other equation(s). These would include tests of specification and commonality of parameters.

iii. Assessments of the quality of the data used in the various equations need to be performed and the results reported.

[10] The finding of greater prevalence of extreme performance appraisals in multiple equation models is perhaps less surprising than might first appear. Estimation of a single equation cost function model using variants of least squares procedures will cause the "predicted" values to fit the observed or "actual" values as closely as possible.

If instead one now estimates a multiple equation model, least squares procedures will attempt to fit data for all equations – not just the cost equation -- as closely as possible. As long as parameters are shared across equations, the capacity for the cost equation model to track the actual cost data is reduced.

If the Board Staff are to be encouraged to make greater use of econometric modeling tools, additional assurance of their validity and of the validity of the data being used would be helpful.

E. Sensitivity of Performance Scores to Omitted Cost Drivers

E.1 Background

In any critical assessment of a cost modeling exercise, one could, with modest effort, compile an extensive list of variables or cost drivers that may be relevant, but which have not been incorporated in the model. However, what is ultimately pertinent is whether the data and the benchmarking exercise are of sufficient quality for the purpose to which they are applied.

The omission of relevant variables can bias the estimates of the effects of included variables or cost drivers. However, this will not necessarily invalidate the cost estimates that are predicted by the model. For example, if an omitted variable is sufficiently strongly correlated with others that are included, then the impacts on performance scores will be minor. Variables that have been included will act as proxies or surrogates for the omitted variable.

On the other hand, there is no *a priori* reason to believe that the effects of omitted variables are sufficiently well approximated by those that are included. In our view, there is a real potential that performance scores would in some instances change materially upon the estimation of a more comprehensive model based on data that have been measured and collected on a consistent basis.

E.2 Effects of Omitting Age of Distribution Plant

To illustrate the point, we return to a cost driver which has been noted to have a material impact on OM&A costs in the past – the age of distribution plant or alternatively their remaining life. Models contained in the PEG report do not incorporate this variable evidently because relevant data were not available. Thus, we cannot assess the potential impact of its omission using the 2002-2005 utility data.

However, we can demonstrate the impacts of its omission by referring to data on Ontario distributing utilities which were collected during the 1990's. A range of models using those data have been estimated.[11] For present purposes we have re-estimated a basic version of that model focusing on OM&A costs. In particular, the model that we have implemented is:

$$\begin{aligned} omapercust &= \beta_0 + \beta_1 cust + \beta_2 cust^2 + \beta_3 wage + \beta_4 pcap \\ &\quad + \beta_5 PUC + \beta_6 kwh + \beta_7 life + \beta_8 lf + \beta_9 kmwire + \varepsilon \end{aligned} \qquad (1)$$

where the variables are as follows:

omapercust	log of OM&A costs per customer
cust	log of the number of customers
wage	log of a benchmark utility wage rate
pcap	log of the capital price variable
PUC	a binary variable which equals one for public utility commissions
kwh	log of kilowatt-hours per customer
life	log of remaining average life of plant
lf	log of the load factor
kmwire	log of kilometers of distribution wire per customer.

[11] See "Scale Economies in Electricity Distribution: A Semiparametric Analysis", by A. Yatchew, *Journal of Applied Econometrics*, 2000, 15, 187-210.

The estimation results are summarized in Table 1. Keeping in mind the simple specification and that the dependent variable is OM&A costs per customer, the explanatory power of the model is reasonable with an R^2 of 55.7%.[12] Moreover, the coefficient reflecting the remaining lifetime of plant is both statistically significant and material in magnitude.

We re-estimated the model, this time omitting the variable "*life*". The results are contained in Table 2. Although the change in other coefficients is moderate, the quality of the model fit deteriorates from 55.7% to 39.4%.

Moreover, there were significant impacts on performance scores, which were calculated using the same approach used in the PEG report as the ratio of actual OM&A costs to those predicted by the model.[13] Of the 81 utilities in the sample, 26 experienced an increase, that is a deterioration, in the scores of 5% or more when the remaining life of plant was excluded from the model; 15 exhibited an increase of 10% or more. For example:

- York Hydro, (one of the predecessors of today's Toronto Hydro), had a performance score of 1.17 when the model in equation (1) above was estimated. Exclusion of the "remaining life of plant" from the model resulted in a deterioration of the score to 1.43.

- Toronto Hydro, which at that time had amongst the highest costs per customer in the Province, would have also been adversely affected if one were to fail to consider the age of its distribution assets – its score would have increased from 1.76 to 1.93. Although since that time, for a number of reasons including efficiency gains and amalgamation, unit

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[12] An additively separable specification which captures some of the inherent nonlinearities in the data yielded an R^2 of over 65%.

[13] See PEG report, Section 6.6 pages 54-57 and Table 4.

costs at Toronto Hydro have improved, omission of age related effects is still likely to adversely impact its performance scores.

- The score for Kingston Hydro deteriorated from 1.19 to 1.33 and for Peterborough Hydro from .79 to .93.

- A number of small utilities also exhibited substantial deterioration in their performance scores.

Table 1: Econometric Model of OM&A Costs Per Customer

Explanatory Variable	Parameter Estimate	Standard Error	t-Statistic
cust	-1.043	0.195	-5.351
$cust^2$	0.049	0.010	4.810
wage	1.062	0.370	2.873
pcap	0.422	0.083	5.112
PUC	-0.088	0.043	-2.033
kwh	0.044	0.096	0.461
life	-0.676	0.133	-5.097
lf	1.284	0.481	2.670
kmwire	0.301	0.097	3.111

R^2=0.557, Number of utilities = 81, Sample period 1993-1995.

Table 2: Econometric Model of OM&A Costs Per Customer Excluding the Variable Measuring Remaining Average Life of Plant

Explanatory Variable	Parameter Estimate	Standard Error	t-Statistic
cust	-1.044	0.226	-4.614
$cust^2$	0.049	0.012	4.085
wage	1.100	0.429	2.564
pcap	0.332	0.094	3.547
PUC	-0.064	0.050	-1.285
kwh	0.037	0.111	0.337
life	-	-	-
lf	1.282	0.558	2.296
kmwire	0.204	0.110	1.847

R^2=0.394, Number of utilities = 81, Sample period 1993-1995.

4 Conclusions

A. The Continuing Need to Address Data Issues

Although the PEG report is entitled "Benchmarking the Costs of Ontario Power Distributors" only OM&A costs are incorporated in the empirical analyses. Indeed, the cost models that are estimated do not represent common practice in the economics literature because they exclude capital variables from the analysis. In an industry where costs are dominated by capital-related expenditures, this would seem to be a perilous approach. On the other hand, the calibration and measurement of capital-related variables is difficult and data limitations should not paralyze the regulatory process.

The report raises numerous data-related issues that need to be addressed. Resolution of these will in all likelihood improve the ability of the models to explain the per-customer OM&A costs incurred by utilities. Age of capital stock, service quality, differing voltage service levels and customer mix are but a few of the variables that need more careful examination. It is also essential to ensure that data are collected on a consistent basis across utilities. Utilities and the Ontario Energy Board need to continue to address these issues collectively.

The "wage" variable used in the PEG study is a proxy index based on Canadian census data from 2001. Substantially more detail needs to be provided on how the index was computed. Moreover, actual remuneration data from company records should be tested as an alternative measure of the wage variable.

B. Model Specification and Validation Issues

Further model specification and validation analysis needs to be undertaken and reported. While the "double log" and "translog" specifications that have been estimated have a long and venerable history in the economics literature, much progress has been made since their inception. [14] (The "double log" was proposed in the early part of the 20th century and the translog model first appeared in the early 1970's.) Additional evidence on the validity of the estimated models needs to be provided, both in the single and multiple equation settings.

Moreover, it is important that utilities be able to independently assess and test the models which have been used to determine the efficiency scores which trigger a more onerous regulatory review.

C. Regulatory Implications of Proposed Approach

As a result of difficulties associated with calibrating capital costs, some other jurisdictions have adopted a bifurcated approach where operating costs are assessed and examined separately from capital costs. However, this focus on OM&A costs can lead to a skewing of incentives within the regulatory process: distributors will have the incentive to increase capital costs in order to reduce OM&A costs. This in turn may lead to over-capitalization, sub-optimal decisions with respect to lend/lease alternatives and under-spending on OM&A. The impacts of and remedies for this potential bias need careful examination. It is important that efforts at calibrating capital-related expenditures be given proper attention.

Nevertheless, the econometric approach being advanced in the PEG report is superior to the index-based approaches (also suggested by PEG) and to methods that rely heavily on peer group comparisons. Econometric modeling permits incorporation of data on similar as well as dissimilar utilities into a common framework. The present exercise

[14] The authors reference a 1983 paper which supports their contention that the translog model is "by some accounts the most reliable of several available flexible forms", (report page 71). Since that time, new and much more flexible regression modeling has emerged. Moreover, some papers in the subsequent literature find significant limitations arising from the translog form.

should underscore the need for further improvements in data collection and consistency as well as in modeling.

Recognizing the various limitations of the present modeling exercise, the authors of the PEG report have proposed that the results be used at this point solely for screening purposes. In particular, firms with unfavorable scores would face an especially thorough regulatory review. However, given the likelihood that the models that have been put forth are at this point deficient in a number of important ways, an efficient mechanism needs to be put in place so that utilities with unfavorable scores can address cost issues before the Board without the expenditure of excessive regulatory resources both on the part of the Board and the utility.

APPENDIX

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OTHER PROFESSIONAL ACTIVITIES:
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Joint Editor (with Len Waverman) The Energy Journal (1995-1996)

Member, Editorial Board, Foundations and Trends in Econometrics
Editor (with Yves Smeers) 1997, Distributed Generation, special issue of the Energy Journal
Advisory Editor, Economics Letters (1985-1997)
Member, Advisory Board, *Eurasia Foundation*, 1995-2007

AWARDS AND DISTINCTIONS:
Teaching award: 1987 SAC APUS Teaching Award, University of Toronto
Top grade in Ontario, Royal Conservatory of Music, Toronto, Grade X Piano exam, 1969.

DEGREES:
Ph.D. Harvard University, Economics - 1980
M.A., University of Toronto, Economics - 1975
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Completed all practical exams for an A.R.C.T. in performance, piano, Royal Conservatory of Music, Toronto – 1972.

ACADEMIC EXPERIENCE:

2005	Visiting Fellow, ARC Center of Excellence for Mathematics and Statistics of Complex Systems, Mathematical Sciences Institute, Australian National University
2004-present	Professor of Economics, University of Toronto
2001	Visiting Fellow, School of Mathematical Sciences, Australian National University
1986 to 2004	Associate Professor, Economics, University of Toronto

1989, 1990, 1991	Visiting Research Associate, Harvard University
1986	Visiting Fellow Commoner, Trinity College, Cambridge U.K.
1980 to 1986	Assistant Professor, Economics, University of Toronto
1984	Visiting Research Associate, National Bureau of Economic Research, Cambridge, Massachusetts
1982 to 1984	Visiting Assistant Professor, University of Chicago
1976	Lecturer, University of Toronto, Scarborough College

REFEREED PUBLICATIONS:

Pesando, J., and Yatchew, A., 1977, "Real vs. Nominal Interest Rates and the Demand for Consumer Durables in Canada", Journal of Money, Credit, and Banking, 428-436.

Yatchew, A., 1981, "Further Evidence on 'Estimation of a Disequilibrium Aggregate Labor Market'", Review of Economics and Statistics, 142-144.

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BOOK

Yatchew, A., 2003, Semiparametric Regression for the Applied Econometrician, 213 pages, Themes in Modern Econometrics, Cambridge University Press.

OTHER PAPERS / STUDIES

Yatchew, A. 1995, "The Distribution of Electricity on Ontario: Restructuring Issues, Costs and Regulation",Ontario Hydro at the Millenium, University of Toronto Press, 327-342,353-354.

Yatchew, A. 1995, "Comments on The Regulation of Trade in Electricity: A Canadian Perspective",Ontario Hydro at the Millenium, University of Toronto Press, 165-7.

Yatchew, A. 2001: “Incentive Regulation of Distributing Utilities Using Yardstick Competition”, Electricity Journal, Jan/Feb, 56-60.

Littlechild, S. and A. Yatchew, 2002: “Hydro One Transmission and Distribution: Should They Remain Combined or be Separated”, www.chass.utoronto.ca/~yatchew .

WORKING PAPERS

Yatchew, A., 1999, “Differencing Methods in Nonparametric Regression: Simple Techniques for the Applied Econometrician, 86 manuscript pages.

RECENT RESEARCH GRANTS

2007-2010 SSHRC grant “Nonparametric and semiparametric estimation when data on derivatives are available”.
2004-2007 SSHRC grant "Semiparametric demand modeling and testing".
2003-2004: Grant to develop interactive web-based teaching software for undergraduate statistics at the University of Toronto.
2001-2004: SSHRC grant, “Efficient estimation of semiparametric equivalence scales”

SUPERVISION OF GRADUATE STUDENTS DURING THE LAST FIVE YEARS

1. Brian McCaig -- Ph.D. student, Economics Department. I am a member of thesis committee. Brian co-authored a paper with me which he delivered at conferences in Germany and the United Kingdom. That paper has now been accepted for publication.

2. Laurie Ricciuto – Ph.D. student in the Department of Nutritional Sciences, Faculty of Medicine, University of Toronto. I was a member of her thesis committee. She successfully defended her thesis in August, 2006.

3. Angela No – Ph.D. student, Economics Department. I was a member of her thesis committee. Angela co-authored a paper with me which appeared in Econometrica. She has just begun teaching at Carnegie-Mellon. She defended her thesis in 2004.

4. Yiguo Sun – I supervised her Ph.D. thesis which she completed in 2002. Yiguo Sun co-authored a paper with me and Catherine Deri on estimation of equivalence scales which appeared in the Journal of Business and Economic Statistics in 2003. She is currently teaching at the University of Guelph.

5. Catherine Deri – co-authored a paper with me and Yiguo Sun on estimation of equivalence scales which appeared in the Journal of Business and Economic Statistics in 2003. She has just begun teaching at the University of Ottawa.

6. Toby Daglish, Ph.D. student in finance. I suggested a topic and then supervised a paper which he wrote for one of my graduate econometrics courses. The paper has recently been published in the Journal of Financial Econometrics.

7. Marie Rekkas, Ph.D. student, Economics Department. I was a member of her Ph.D. thesis committee. She has just begun teaching at Simon Fraser University.

8. Each year I supervise 20-25 papers Ph.D. research papers (pre-thesis stage).

COURSES TAUGHT DURING THE LAST FIVE YEARS

ECO 2400F(Ph.D): Econometrics I.
ECO 2401S(Ph.D): Econometrics II
ECO 2403S (Ph.D): Special Topics in Econometrics
ECO 2404S (Ph.D): Empirical Applications of Economic Theory

OTHER PROFESSIONAL EXPERIENCE:

Member, Board of Directors, *EnerConnect*, 1998-2006

Electrical Utilities:

> (2007) Filed evidence before the Market Surveillance Panel in Ontario on appropriate monitoring of spot markets.
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> (2006) Filed evidence before the New Brunswick Board of Commissioners of Public Utilities on cost-sharing of joint-use power poles.
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> (2005) Prepared analysis on cost-sharing of power poles by cable companies. The analysis was part of the basis for a settlement proceeding in Ontario.
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> (2004) Prepared analysis on cost-sharing of power poles by cable companies. The document was filed before the Ontario Energy Board.
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> (2003) Testified before the Ontario Energy Board on distributor service area amendments.
>
> (2003) Testified before the New Brunswick Board of Commissioners of Public Utilities on performance based regulation, benchmarking and rate of return issues
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> (1993-1998) Prepared major studies for the Municipal Electric Association on restructuring of the electric utility industry in Ontario
>
> (1991-1992) Research Director for the Municipal Electric Association in their intervention before the Environmental Assessment Board in connection with Ontario Hydro's 25 year Demand/Supply Plan
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> (1992) Prepared testimony on forecasts of electricity demand for Ontario -- Environmental Assessment Board Hearing
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> (1982-1995) consultant to the Municipal Electric Association at the Ontario Hydro Rate Hearings before the Ontario Energy Board

Airlines: (1989) prepared technical analysis of the effects of booking system biases in a major U.S. litigation.

Banking Industry: (1997) Prepared analysis of securities lending for Canada Trust

Bell Mobility: (1991- 1994) prepared short term market assessment and forecasts for cellular telephone sales

Competition / Antitrust: (1990) prepared statistical analysis in connection with a legal proceeding on anti-competitive behavior relating to the supply of paper forms; (1989) prepared analysis in connection with the Imperial Oil/Texaco merger deliberations before the Federal Competition Tribunal

Film Industry: (1981), one of three co-investigators in study for Federal Government of tax incentives to the Canadian film industry

Information Technology: (1994) prepared cost allocation analyses.

Probability Analysis: (2004, 2005, 2006) prepared odds of winning prizes in promotions by international fast-food chain.

Minerals: (1985), performed econometric analysis of zinc, copper, potash markets as part of a larger study for Cominco

Natural Gas: (1985), coauthored a major background study for the Federal Government/Province of Alberta energy price negotiations; (2005), prepared statistical and economic analyses in litigation proceeding.

Oil Pipelines: (1987, 1992) coauthored studies on pipeline cost allocation.

Parking Authority of Toronto: (1985), designed data sampling scheme for Parking Authority of Toronto - to be used for monitoring flows into parking lots and as a broad audit check

Toronto Transit Commission: (1988, 1989, 1991), various studies on subjects such as subway reliability measures, evaluation criteria for resource allocation, statistical procedures in relation to count data