PEG Commentary on Hydro-Québec's *MRI* Evidence

Mark Newton Lowry, PhD

President

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Pacific Economics Group Research LLC

44 East Mifflin, Suite 601
Madison, Wisconsin USA 53703
608.257.1522 608.257.1540 Fax

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1. Introduction

Pacific Economics Group Research LLC ("PEG") and the Brattle Group prepared power transmission productivity and benchmarking studies in Phase 2 of Régie de l'énergie proceeding R-4058-2018. The Régie requested these studies to help it determine the X Factor and Stretch Factor parameters of the revenue cap index in the *mécanisme de réglementation incitatif* ("*MRI*") that it approved for Hydro-Québec Transmission ("HQT" or "the Company"). These studies were to consider capital cost efficiency as well as total cost efficiency and trends in *productivité multifactorielle* ("*PMF*"). Consideration of these studies was postponed until the Company filed its *demande tarifaire* for the last two years of the *MRI.* HQT's *dossier* in this matter, filed in July, included Brattle's February report and used it to support their X factor and stretch factor proposals. The Company also commented on the propriety of adding a *compte d'ecarts et reportes* ("*CER*") for capital cost to *MRIs*.

PEG's study was requested by the Association Québécoise des Consommateurs Industriels d'Électrité ("AQCIE") and the Conseil de l'Industrie Forestière du Québec ("CIFQ"). These parties have retained PEG to file comments on Brattle's evidence. We have also been asked to comment on the issue of a *CER* for HQT's capital cost. These are the requested comments.

The plan for our commentary is as follows. In the next section we provide some pertinent background information. In Section 3 we provide an overview of the Brattle and PEG studies. There follows in Section 4 a discussion of our concerns about Brattle's empirical work. Section 5 discusses other aspects of Brattle's work, while Section 6 considers the *CER* issue. There are brief concluding remarks.

2. Background

Highlights of the *MRI* Proceeding

The Régie decided in D-2018-001 to establish an *MRI* for HQT. In this mechanism, a *formule d'indexation* escalates the component of HQT's allowed revenue which compensates the Company for its *charges nettes d'exploitation* ("*CNE*").[1] Capital costs continue to be addressed by cost of service regulation. The X factor and S factor terms of the formula were set provisionally by a process of *jugement* in proceeding R-4058-2018. However, productivity studies were ordered to take place during the term of the *MRI.* In Phase 2 of R-4058-2018, the Régie in D-2020-028 established guidelines for these studies and directed that parties also file statistical benchmarking studies of the Company's cost. The requested studies could provide the basis for X and S in the last year of the *MRI*.

In February 2021, PEG and the Brattle Group submitted reports on their productivity and benchmarking studies. HQT then requested that consideration of the studies be delayed until its *demande tarifaire* for the final two years of the *MRI* (2021-22). Their *dossier* in this case was filed on 30 July. Brattle's February report was included, without apparent amendment or update, along with working papers. HQT made X and S factor recommendations in its *dossier*.

HQT requested confidentiality for key portions of Brattle's working papers. PEG received Brattle's confidential papers on Thursday 7 October. We submitted *demandes de renseignements* ("*DDRs*") concerning Brattle's work on 14 October. Unredacted responses to all questions were received on Thursday 28 October.

Related Ontario Proceedings

In proceeding R-4011-2017, Hydro-Québec Distribution witness Jim Coyne of Concentric Energy Advisors highlighted the research and testimony of Steven Fenrick, a witness for Hydro One Networks in an Ontario Energy Board proceeding to determine an *MRI* for Hydro One's distribution services.[2] Mr.

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[1] In the United States, these costs are called operation and maintenance ("O&M") expenses or "opex".

[2] Concentric Energy Advisors (2018), "Performance Based Regulation: Recommended X Factor," filed in Régie de l'énergie Docket R-4011-2017 as HQD-20, document 2, pp. 11-13.

Fenrick has also provided research and testimony for Hydro One in three proceedings that have considered *MRIs* for that Company's transmission services.[3] In each of these proceedings, he used Federal Energy Regulatory Commission ("FERC") Form 1 data on the operations of U.S. electric utilities to calculate their transmission productivity trends and to develop an econometric benchmarking model for the total transmission cost of Hydro One. The benchmarking addressed Hydro One's proposed future cost during the proposed *MRI* as well as the company's recent historical cost. The most recent of these proceedings (EB-2021-0110) is still in progress. Since Mr. Fenrick is, like Brattle, a witness for a large power transmitter serving a broad region of eastern Canada, his methodological choices and research results in the current Ontario proceeding are relevant to this proceeding. In the only completed power transmission *MRI* proceeding where the Board specified a *PMF* growth target, it chose a base *PMF* growth target of 0% for Hydro One Sault Ste. Marie.[4]

The *CER* Issue

In HQT's last *demande tarifaire*, the Régie expressed concern about persistent differences between the authorized and actual values of the Company's rate base over the last few years.[5] The Régie noted that these differences, which generally favor HQT, can result from differences between planned and actual values of plant commissioned and from differences between planned and actual monthly distributions. Even though the Régie is only concerned about differences of the second kind, they invited comments on the establishment of a *CER* for the Company's depreciation and return on rate base in the next *demande tarifaire*. HQT discussed this issue as well in its July *dossier*.

[3] Steven A. Fenrick and Erik S. Sonju (2018), "Transmission Study for Hydro One Networks Inc.: Recommended CIR Parameters and Productivity Comparisons," Exhibit D-1-1, Attachment 1 in OEB Case EB-2018-0218, May 23; Steven A. Fenrick and Erik S. Sonju (2019), "Transmission Study for Hydro One Networks: Recommended CIR Parameters and Productivity Comparisons," filed as Exhibit A-4-1, Attachment 1 in OEB Case EB-2019-0082, January 24; and Steve Fenrick (2021), Clearspring Energy Advisors, "Benchmarking and Productivity Research for Hydro One Networks' Joint Rate Application," Exhibit A-4-1, Attachment 1 in OEB Case EB-2021-0110, July 30.

[4] OEB "Decision and Order EB-2018-0218, "Hydro One Sault Ste. Marie LP," June 20, 2019, p. 19.

[5] D-2020-041, p. 106-110, paragraphs 389-403.

3. Overview of the Brattle and PEG Studies

PEG's study used FERC Form 1 data to calculate the *CNE*, capital, and multifactor productivity trends of a large group of U.S. power transmitters. We additionally used econometric methods to benchmark the Company's recent historical *CNE*, capital cost, and total cost. The scope of Brattle's research for HQT was similar. The scope of Mr. Fenrick's recent study differed chiefly in his not developing econometric capital cost or *CNE* benchmarking models.

Productivity Results

Table 1 compares PEG's productivity trend calculations to those from Brattle's featured "base case" runs over each consultant's full sample period and the last fifteen years.

Table 1

Summary of Productivity Results[6]

	Multifactor		**CNE**		**Capital**	
Consultant	Brattle	PEG	Brattle	PEG	Brattle	PEG
Capital Cost Specification	OHS	GD			OHS	GD
Full Sample Period	-1.04%	-0.62%	-3.38%	-0.68%	-0.05%	-0.46%
Last 15 Years (2005-2019)	-1.69%	-2.26%	-3.09%	-1.74%	-0.97%	-2.16%

It can be seen that, while Brattle's *capital* productivity trend was much less negative than PEG's over both sample periods, and especially so in the last fifteen years, Brattle's *CNE* productivity trend was much more negative over both sample periods. Brattle's multifactor productivity trend was considerably more negative than PEG's for the full sample period, but it was considerably less negative over the last 15 years.

Informed by their productivity research, each consultant discussed the appropriate X factor that would apply only to the Company's *CNE* revenue.

- Brattle proposed to base X on the **-3.38%** *CNE* productivity trend that it calculated for its full sample period.

[6] *Pièce* B-0012, p. VI-53 and C-AQCIE-CIFQ-0009, pp. 83-84.

- PEG stated that the Régie has a choice between **0%** (the choice of the Ontario Energy Board), **-0.68**% (the *CNE* productivity trend we calculated over our full sample period), and **-1.74**% (the *CNE* productivity trend we calculated over the most recent fifteen years of our sample period).

The following recommendations were made by the consultants in the event that the *formule d'indexation* for a succeeding *MRI* applies to capital cost as well as *CNE.*

- Brattle stated that the X factor should depend on the inflation measure. They recommend **-1.04%** if the inflation measure is a power transmission input price index and **-2.82%** if the Canadian *indice implicite de prix du produit intérieur brut* ("*IIPPIB*") is instead used as the sole inflation measure.[7]

- PEG stated that the Régie should choose between **0%, -0.62%, and -2.26%** as an X factor depending on how much supplemental capital revenue the Régie intends to provide, in this and future *MRIs*. We did not, like Brattle, comment on how our numbers would change if the *IIPPIB* were the inflation measure in the *formule d'indexation*.

Benchmarking Results

Table 2 reports econometric benchmarking results that the two consultants reported for the last three years of the sample period, which in both studies was 2017-2019.

Table 2

Summary of Cost Benchmarking Results (2017-2019)[8]

Consultant	Total Cost	Capital Cost	*CNE* (O&M)
Brattle	-4%	8%	-41%
PEG	67%	55%	121%

It can be seen that the results of the two consultants differ markedly. Brattle's benchmarking results are much more favorable to HQT than PEG's results. The difference between the results is especially large for *CNE.*

[7] This index is called the gross domestic product implicit price index in English.

[8] *Pièce* B-0012, pp. VI-65, 68, 71 and C-AQCIE-CIFQ-0009, pp. 93-94.

Informed by their research Brattle, citing precedents in other jurisdictions on the relationship of benchmarking scores to stretch factors, proposed an S factor in the **0.10%** to **0.30%** range. We advocated an S factor of at least **0.60%**, based on our benchmarking work, and also argued for an adder in the [0.10%, 0.30%] range to address the fact that most U.S. utilities in the productivity and benchmarking studies operated under formula rates for their transmission services.

HQT's Proposal

In its July *dossier*, HQT stated that

> *"le Transporteur s'en remet aux recommandations de son expert en proposant, sur la base des conclusions de l'étude réalisée par celui-ci, les Facteurs X et S utilisés dans la formule d'indexation aux fins de l'établissement des revenus requis de l'année 2022. Ainsi, il retient un Facteur X 13 de **-3,38 %** ainsi qu'un Facteur S de **+0,1 %** appliqués à la formule d'indexation*."[9]

Common Methods

Brattle used research methods in their study that were similar in many respects to those in PEG's study. Like PEG, Brattle . . .

- calculated capital cost using a monetary method such that capital cost was the product of a capital service price index and a capital quantity index constructed using a perpetual inventory equation;
- assumed a 46-year average service life for transmission assets in their capital cost calculations;[10]
- used the Régie's approved rate of return on capital to calculate HQT's capital cost;
- reported that capital cost accounted for the lion's share of the total cost considered;
- excluded pension and benefit expenses from the productivity and benchmarking work;
- used an Employment Cost Index for the utilities sector of the economy as the labor price index and the Gross Domestic Product Price Index as the material and service price index for U.S. utilities*;*
- used regional Handy Whitman indexes of power transmission construction costs to deflate reported values of U.S. utility plant;

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[9] *Pièce* B-0004, HQT-1, Document 1, p. 7.

[10] The rationale is that this is HQT's average service life.

- used the gross domestic product implicit price index for final domestic demand as the price deflator for HQT's material and service expenses;
- used multidimensional output indexes in their productivity calculations which featured two scale variables (peak demand and line length) that had weights reflecting the estimated relative cost elasticities for these variables;
- massaged some data to make them more plausible;[11]
- used input price and quantity indexes of Tornqvist form;
- calculated industry productivity trends as *size*-weighted (rather than *even*-weighted) averages of trends for individual companies;
- estimated model parameters using a "panel" data set consisting of multiple observations on the operations of dozens of utilities;
- used *real* cost (Cost/Input Prices) as the dependent variables in their econometric research;
- used transmission line length, ratcheted peak demand, average substation capacity, substations per line mile, and an overhead/underground variable as external business conditions in their econometric models; and
- calculated percentage differences between actual costs and the corresponding econometric benchmarks logarithmically.

Unobjectionable Differences

Brattle's study differed from PEG's in several ways that we find unobjectionable but worthy of discussion.

[11] Brattle states on page VI-44 of their February report that "we made changes to the underlying data when we concluded that the data were obviously a typo."

One-Hoss Shay vs. Geometric Decay

Brattle used a one-hoss shay specification to calculate capital cost in their base case runs but presented some productivity results using geometric decay. PEG (like Mr. Fenrick)[12] used geometric decay exclusively.

In response to AQCIE-CIFQ-PEG question 4.3, Dr. Ros indicated that geometric decay was used in two of the four prior studies in which he participated. The two studies in which geometric decay was used addressed the productivity of telecommunications utilities. He noted in his response that

> "At the time of the studies, telecommunications assets included local distribution facilities (copper and fiber lines, poles, conduit, switching stations) and long-distance facilities (transmission lines). Many of these assets have the capital service characteristics exemplified by one hoss shay. Factors that led to selection of one hoss shay vs. geometric decay in the telecommunications studies were data availability, inflationary considerations and its effects on accounting data and precedence of previous Commission studies."[13]

We discussed alternative capital cost specifications at some length on pages 38-52 of our February report. Here are some highlights of this discussion.

- We documented that, while geometric decay and cost of service specifications for capital cost have been the most widely used in X factor studies for *MRI* proceedings to date, the one-hoss shay specification is increasingly popular and has been recently favored by utility witnesses.[14]
- Geometric decay results are more sensitive than one-hoss shay results to capital spending ("capex"). If capex is surging in an industry, geometric decay can therefore yield a more negative multifactor productivity trend that can help to fund a capex surge and reduce the need for supplemental capex funding. However, it is difficult with available data to determine in such

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[12] Steve Fenrick, 2021, op. cit., pp. 15-16.

[13] *Pièce* B-0064, HQT-10, Document 3.1.1, p. 12.

[14] Brattle stated on page IV-35 in its February report that "the *One-Hoss Shay* and the *Geometric Decay* methodologies are the methodologies used most often in regulatory TFP studies." However, this has only recently been the case.

cases whether the industry's need for capex is the same as the need of a particular utility operating under an *MRI.*

- One-hoss shay results are particularly sensitive to the average service life assumed. For example, Brattle reports that when the average service life in its study is reduced from 46 to 44 years, the multifactor productivity trend of transmitters in its sample falls from -1.04% to -1.24%.[15]

- The recent popularity of one-hoss shay with utility witnesses is in our view due to flawed execution of the approach by Christensen Associates and Brattle in power distribution *MRI* proceedings. These flaws biased results in favor of their clients. The main flaw was to use an average service life that was far below that which was prevalent during the focus period of their studies.

  One way to test this theory is to consider the difference in capital productivity trends, using one-hoss shay and geometric decay, when the average service life is more appropriate for the focus period of the study. In their study for this proceeding, for instance, Brattle has used an average service life which was not well below that which is appropriate for their focus period. Brattle's productivity results using one-hoss shay and geometric decay are presented in Table 3 below. Brattle notes in its report that, "The use of *Geometric Decay* results in significantly slower TFP growth during all periods considered….These results are neither expected nor unexpected, as there is no theoretical reason why Geometric Decay results in faster or slower TFP growth compared to *One-Hoss Shay.*"[16]

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[15] *Pièce* B-0012, p.VI-54.

[16] *Pièce* B-0012, p. VI-54.

Table 3

How Capital Cost Specifications Affected Brattle's Productivity Results[17]

	Multifactor		**Capital**	
Consultant	Brattle		Brattle	
Capital Cost Specification	OHS	GD	OHS	GD
Full Sample Period	-1.04%	-1.82%	-0.05%	[redacted]
Last 15 Years	-1.69%	-2.91%	-0.97%	[redacted]

- An argument commonly ventured in support of one-hoss shay is that it better approximates the service flow of individual utility assets.

  Arguments against the notion of a constant service flow include the fact that *CNE* tends to rise as assets age and that one-hoss shay is usually applied to a cohort of assets with varied service lives.[18] For example, Brattle's calculations are based on the total plant additions and retirements of each utility in a given year. Hyperbolic decay is more consistent with these realities than is one-hoss shay, and is used by the U.S. government in sectoral productivity studies. While utility consultants should have the funding to explore the hyperbolic decay

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[17] *Pièce* B-0012, pp. VI-53, 54 and *Pièce* B-0013, Document de soutien 1.

[18] In response to AQCIE-CIFQ-PEG question 4.4 (B-0064), Dr. Ros conceded that it was reasonable to conclude that the cost of operating and maintaining transmission assets tended to rise as they age.

> "While we have not undertaken a study to confirm the proposition and each company is different, in general it is not unreasonable to assume that O&M increases with age."

In response to AQCIE-CIFQ-PEG question 4.2 (B-0064), Brattle described the process of organizing their plant data for use in a benchmarking or productivity study.

> "We utilize different FERC accounts for transmission plant that consists of assets such as station equipment, towers and fixtures, overhead conductors to name a few, all with the same asset life assumption of 46 years."

In other words, the same 46-year service life assumption is applied to all kinds of assets.

specification, we believe that they are discouraged from doing so by the favorable results that one-hoss shay has produced for power distributors using flawed methods.

Utility consultants who tout one-hoss shay for its more realistic approximation of capital service flows have, in recent Massachusetts proceedings, also championed the notion that the goal of X factor research should be to measure as accurately as possible the true productivity trend of the industry and not the trend in some alternative productivity metric designed to be more pertinent for ratemaking.[19] They have gone so far as to say that the costs included in an X factor study need not even match those that will be addressed by the revenue cap index. It shouldn't matter, for example, if a sizable portion of capex is separately addressed by a cost tracker.

Sample Period

The sample period has been an important issue in several recent *MRI* proceedings due to a tendency of productivity growth to decelerate for many utilities in recent years. Utility witnesses (including Mr. Fenrick) have generally touted 15 years as striking the right balance between a need to smooth volatile year-to-year productivity results and a need to reflect current business conditions. NERA used a much longer 1973-2009 sample period in the Alberta power distribution study in which Dr. Ros participated.

In our February report, we reported productivity trends for the 1996-2019 and the fifteen-year 2005-2019 periods and used a 2004-2019 sample period for our econometric research. Brattle, unusually amongst recent utility witnesses, used its full 25-year 1995-2019 period in its featured base case. This period produced a more negative *CNE* productivity trend but a more positive *PMF* trend. Brattle's econometric cost models were estimated with data for the 1994-2019 period.

Data Source

We gathered most of the U.S. transmission operating data used in our study directly from the FERC Form 1 reports of utilities. Brattle instead obtained their FERC Form 1 data from S&P Global

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[19] See, for example, Julia Frayer and Marie Fagan (2020), "Rebuttal Testimony," filed Exhibit ES-JF/MF-Rebuttal-1 in Massachusetts D.P.U. 19-120, p. 58.

Market Intelligence ("S&P Global" formerly SNL Financial). SNL Financial was a reputable commercial vendor that PEG used in the past. A disadvantage of SNL Financial was that they did not provide the older capital cost data that long-time practitioners prefer to use in utility *PMF* and total cost benchmarking studies. Hydro One witness Fenrick has used SNL Financial data in his studies for Hydro One and other utilities but has recently gone to considerable effort to gather older capital cost data.[20]

Capital Asset Price Index

To deflate the reported plant values of HQT, PEG took the average of the growth rates of a transmission construction cost index (adjusted for changing purchasing power parities between the U.S. and Canada) and Statistics Canada's implicit capital stock deflator for the utility sector of Québec. Brattle used an alternative custom capital asset price index.[21]

Sensitivity Analyses

Brattle is to be credited for presenting results of several sensitivity analyses in their report. For example, they presented productivity results using alternative capital cost specifications and average service lives as well as for alternative sample periods. We would also like to acknowledge that Brattle was reasonably responsive to the AQCIE-CIFQ-PEG *DDRs*.

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[20] Steve Fenrick, 2021, op. cit., pp. 15-16.

[21] *Pièce* B-0012, p. VII-057.

4. PEG Concerns with Brattle's Empirical Work

Brattle's research methods differed from PEG's in other respects that we find controversial. Many of these differences produced results that materially favored their client's interests. Methodological issues frequently arise when statistical research on utility cost is used in regulatory proceedings. Discussion of these issues is constructive, but only some issues have a material potential to impact rates. To ease review of the issues by the Régie, its staff, and intervenors, we accordingly group our discussion of the issues the order of their importance.

Major Concerns

We find the following aspects of Brattle's methodology to be particularly controversial.

Accounting for Structural Change

Having done several studies of productivity using U.S. transmission data over the years, we have learned a lot about their idiosyncrasies and discussed these at some length in our February report. The treatment of *CNE i*s especially important because this is a notable problem area and an X factor and stretch factor are currently needed only for the Company's *CNE* expenses.

Transmission *CNE* reported by U.S. utilities have been affected by structural changes in the U.S. transmission industry. Most notably, these changes have caused transmission dispatching, transmission by others expenses (FERC account 565), and miscellaneous transmission expenses to grow at an unusually rapid pace. In the case of transmission by others expenses, this is due in part to a marked increase by utilities in the use of other transmission systems that is not very relevant to the revenue requirement that the *CNE formule d'indexation* addresses. All three of these cost categories have also been affected by idiosyncratic reporting of costs incurred for the services of independent system operators and regional transmission organizations. There is thus a material risk that inclusion of these data in productivity and benchmarking studies will produce results that are not useful for ratemaking.

Due to these concerns, we excluded all three of these cost categories when calculating our multifactor and *CNE* productivity indexes. We included miscellaneous transmission expenses and dispatching in our econometric benchmarking since analogous costs of HQT could not be readily excluded from their data. However, we excluded from the econometric sample some companies for which these costs are conspicuously problematic. Mr. Fenrick threw out transmission by others expenses in his latest productivity and benchmarking studies for Hydro One, stating that

> "Subtracting "transmission of electricity by others" expenses (Uniform System of Accounts category 565, on page 321 of FERC Form 1) creates a more comparable cost definition to Hydro One and, if not removed, would yield an unfair advantage to Hydro One, since certain U.S. utilities would have inflated expenses without commensurate output values."[22]

In response to *demande des renseignements* (*DDR*) 6.1 from AQCIE-CIFQ-PEG, Brattle disputed the merit of studying the effect of structural change on transmission cost and productivity trends, stating that

> "In long run TFP studies in regulated industries … economic, regulatory and technological change is a normal feature of the industries and collectively drive long run TFP growth. While of interest from an academic perspective, embarking on such an endeavor in this proceeding is not advisable. During our study we did not embark on such analyses."

In response to *DDR* 6.2 from AQCIE-CIFQ-PEG, Brattle stated that

> "Perfection in the underlying database is not a requirement for a TFP study which focuses on growth rates and some amount of measurement error is standard in econometric analysis and, when part of the dependent variable, presents no challenge in estimation."[23]

We disagree with both statements, noting that the inclusion of these costs does affect productivity growth rates, biases productivity and benchmarking results in favor of HQT, and reduces the relevance of statistical cost research for ratemaking.

As for the specific matter of *CNE*, Brattle confirmed in response to *DDR* 6.3 from AQCIE-CIFQ-PEG that they did not exclude any *CNE* categories from their productivity or their benchmarking work. In response to *DDR* 6.3 from AQCIE-CIFQ-PEG, Brattle stated that "We used all transmission O&M accounts in our study, because they are transmission O&M expenses." In response to *DDR* 6.4 from AQCIE-CIFQ-PEG, Brattle specifically defended their decision to include transmission by others expenses, stating that

> "expenses included in account 565 represent legitimate transmission expenses incurred to provide service for tariff customers. These are relevant transmission O&M expenses to include in a transmission TFP and cost benchmarking study."[24]

Brattle's inclusion of these costs in their productivity calculations had a sizable negative impact on their productivity results, especially those for *CNE* productivity. Consider, for example, the following.

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[22] Steve Fenrick, 2021, op. cit., pp. 20 and 47.

[23] *Pièce* B-0064, HQT-10, Document 3.1.1, p. 18.

[24] *Pièce* B-0064, HQT-10, Document 3.1.1, p. 19.

- Brattle notes on page VI-50 of their report that "The fastest growing input quantity during the period was [materials, rents, and services], averaging 5.58%, followed by capital at 0.93% and labor at 0.69%."
- Brattle further stated, in their response to *DDR* 6.9 from AQCIE-CIFQ-PEG, that transmission by others expenses grew by 11.26%, miscellaneous transmission expenses grew by 13.13%, and load dispatching expenses grew by 10.02%.[25] Meanwhile, the growth of all other transmission *CNE* averaged only 5.12%.
- Over the last 15 years of their sample period, Brattle reports a *CNE* productivity trend of -3.09% (p. VI-53) whereas we report a trend of –1.74% on page 83 of our report and Mr. Fenrick's results suggest a *CNE* productivity trend of -0.78%.[26]
- When asked to calculate productivity trends excluding transmission by others in *DDR* 6.8 from AQCIE-CIFQ-PEG Brattle, using elasticity weights that reflected new econometric results when these costs were excluded, reported that for their full sample period the *CNE* productivity trend rose from -3.38% to -2.44% while the multifactor productivity trend rose from -1.04% to -0.78%, despite a drop in the output quantity trend from 0.89% to 0.74%.[27] Over the 2005-2019 sample period, the multifactor productivity trend rose from -1.69% to -1.52% while the *CNE* productivity trend rose from -3.09% to -2.79%.

Brattle's inclusion of these costs in their econometric study bloated the *CNE* of some U.S. utilities and caused the parameter estimate for the trend variable to be more positive. In Brattle's *CNE* model, the trend variable parameter estimate indicates that cost should increase by about 4% per year for reasons other than changes in the values of the model's business condition variables. In a response to *DDR* 6.7 from AQCIE-CIFQ-PEG Brattle stated that, for sampled U.S. utilities, "transmission of

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[25] *Pièce* B-0064, HQT-10, Document 3.1.1, p. 22.

[26] PEG calculated this result using data from Tables 11 and 12 of Mr. Fenrick's testimony. For the 2005-2019 period, using Mr. Fenrick's reported results PEG calculated an output quantity index trend of 0.70% and an OM&A quantity index trend of 1.49%.

[27] *Pièce* B-0064, HQT-10, Document 3.1.1, p. 19 and Piece B-0012, p. VI-53.

electricity by others represents approximately 35% of total transmission O&M expenses for our sample . . . For HQT, the account labeled "transmission purchases" represents 3% of total transmission O&M expenses."[28] Brattle also disclosed that miscellaneous transmission expenses accounted for 17.18% of the total while dispatching expenses accounted for 10.74%. These latter shares would be much larger if transmission by others expenses were removed.

In response to *DDR* 6.8 from AQCIE-CIFQ-PEG, Brattle reported the benchmarking results that resulted from just excluding transmission by others from their definition of transmission cost. Over the 2010-2019 period, HQT's average total cost benchmarking score went from -6.0% to -2.3% while the Company's *CNE* benchmarking score went from -35.2% to -26.8%. The changes in HQT's benchmarking scores are muted by the fixed effects estimation procedure Brattle uses, as discussed further below.

Exclusion of General Costs

Brattle discusses at some length in their February report the hazards of including a share of administrative and general expenses and the capital cost of general plant in productivity and benchmarking studies. PEG's view is that the management and allocation of general costs is a significant part of the management of total cost and should somehow be included in benchmarking studies of the costs of particular services. In ratemaking, these costs are typically apportioned to revenue requirements for unbundled transmission and distribution services using sensible rules of thumb. Like Hydro One witness Fenrick[29] we included sensible shares of administrative and general expenses and the cost of general plant in our featured productivity and benchmarking calculations. Christensen Associates has included administrative and general expenses in two recent X factor studies for Massachusetts proceedings after stoutly opposing the practice, using language similar to Brattle's, in prior proceedings.[30]

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[28] *Pièce* B-0064, HQT-10, Document 3.1.1, p. 19.

[29]Steve Fenrick, 2021, op. cit., pp. 20 and 47.

[30] See, for example Direct Testimony of Mark E. Meitzen and Nicholas A. Crowley as filed in Massachusetts D.P.U. 20-120, as Exhibit NG-MEM/NAC-1, Appendix A, p. 6-8 and Pre-filed Direct Testimony of Mark E. Meitzen as filed in Massachusetts D.P.U. 18-150, as Exhibit NG-MEM-1, pp.52-55.

Brattle did not include either of these general costs in their base case calculations. They did, however, conduct a sensitivity analysis and reported that multifactor productivity growth accelerated substantially when these costs are included, as shown in Table 4 below. This seems to have been due chiefly to the impact that inclusion of general plant had on capital quantity growth.[31]

Table 4

How Inclusion of Administrative and General Costs Affected Brattle's Multifactor Productivity Results[32]

	Multifactor		***CNE***	
Consultant	Brattle		Brattle	
	Base Case	Add General Costs	Base Case	Add General Costs
Full Sample Period	-1.04%	-0.32%	-3.38%	-3.49%
Last 15 Years	-1.69%	-0.97%	-3.09%	-3.57%

Output Variables

Peak load is widely considered to be an important driver of power transmission cost. We discussed the available sources of U.S. electric utility peak load data on pages 73-75 of our February report. We noted there that data are available on FERC Form 1 for "monthly transmission system peak load" and for "monthly peak load". Both of these data series make it possible to compute the highest (aka maximum) monthly peak load in a given year.

Transmission peak load is a closer match to the peak load reported by HQT but is not available before 2004. In the research we reported on in February, our resolution of this quandary was to use

[31]When they added a share of administrative and general expenses, as requested in *DDR* 7.1 from PEG, Brattle reported that

> The difference in PFP O&M when A&G and general plant are included is that PFP O&M decreases from -3.38% to -3.49%, a decrease of 11 basis points, see response to Régie 12.2.

[32] *Pièce* B-0012, pp. VI-53, 54, *DDR* 12.2 from the Régie.

monthly peak load in our productivity research (where a longer sample period was more essential) and transmission system peak load in our benchmarking research. Brattle used the monthly peak load data in their econometric work as well as their productivity work.[33] In Brattle's sample, the transmission system peak is about 11% higher on average from 2004-2019, and about 5%-8% higher on average for recent years. Brattle's use of the monthly peak in benchmarking therefore tends to help their client.

Another issue is whether to ratchet peak demand data. Maximum peak demand varies from year to year due to fluctuations in weather and other demand drivers. We believe that transmission systems are designed to serve the highest maximum peak demand that is likely to occur over a multiyear period. Thus, cost does not rise and fall with the year-to-year variations in actual peak load. Ratcheted peak demand is a reasonable proxy for the expected high end of likely monthly peak demands. We accordingly ratcheted peak demand in both our productivity and benchmarking work. In his latest work for Hydro One, Mr. Fenrick used a 10-year rolling average of peak demands for both his productivity and benchmarking work.[34] In his prior study he used ratcheted peak demand for both.[35]

Brattle ratcheted the peak demand data in their benchmarking work but not in their productivity work. In response to *DDR* 3.3 from AQCIE-CIFQ-PEG, Brattle reported that, when they recalculated productivity trends using ratcheted (monthly) peak demand, the multifactor productivity trend over the full sample period rose from -1.04% to -0.84%, while the *CNE* productivity trend rose from -3.38% to -3.20%. Over the 2005-2019 period, the multifactor productivity trend rose from -1.69% to -1.47% while the *CNE* productivity trend rose from -3.09% to -2.88%.

Econometric Model Estimation Procedure

We discussed the econometric approach to cost benchmarking on pages 28-33 and pages 100-101 of our February report, explaining that econometric cost models approximate the relationship between cost and external business conditions. These conditions are sometimes called cost "drivers". The parameters for each driver are estimated using a sample of historical data on the costs of utilities and the business conditions that they faced. Predictions of cost that are made when the model is fitted with a utility's values for the business condition variables are then used as benchmarks.

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[33] Hydro One witness Fenrick also used monthly peak in his benchmarking calculations. Steve Fenrick, 2021, op. cit., p. 13.

[34] Steve Fenrick, 2021, op. cit., pp. 13-14 and 47.

[35] Steven A. Fenrick and Erik S. Sonju, 2019, op. cit., pp. 24-25, 36.

The ability to draw conclusions about cost efficiency from econometric model predictions is increased to the extent that the number of observations in the sample is large and the values of cost and the business condition variables are varied. Panels of data on the operations of numerous utilities facing diverse business conditions are therefore typically used to estimate cost benchmarking models. Each panel consists of several years of data for the utility.

Various methods are available for estimating the values of econometric model parameters. These methods are sometimes called estimators. The choice between estimators can affect econometric parameter estimates and benchmarking results.

Criteria for choosing between the many estimators that are available include their bias (the extent to which the expected values of the parameter estimates that an estimator produces equal the true parameter values). An estimator that is increasingly unbiased as the sample size approaches infinity is said to be consistent. One source of possible bias and inconsistency is the exclusion of relevant business condition variables that are correlated with the values of variables that are included.

Another criterion for choosing between estimators is the tendency of parameter estimates to deviate from their expected values. It is preferable for estimates to be clustered close to the true value rather than being widely scattered around it. A tendency for an estimator to produce parameter estimates that cluster around the true value can in principle trump bias.

In Ontario *MRI* proceedings, Hydro One witness Fenrick has favored an ordinary least squares estimator.[36] The witness for Board Staff (PEG) has in these same proceedings favored a feasible generalized least squares estimator that corrected for autocorrelation and groupwise heteroskedasticity. In this proceeding, we elected to use an ordinary least squares estimator that is similar to Mr. Fenrick's in the hope of avoiding an arcane methodological controversy. Brattle reported econometric and benchmarking results using only fixed effects ("FE") and random effects ("RE") estimators in the report on their econometric research for HQT. Their three featured econometric benchmarking models were produced using a fixed-effects estimator.

[36] The specific ordinary least squares estimator that Mr. Fenrick uses features robust estimates of standard errors that take account of autocorrelation and heteroskedasticity in the data. Standard errors are needed to test the statistical significance of model parameters.

Estimators used in published econometric benchmarking studies have included ordinary least squares, feasible generalized least squares, stochastic frontier analysis, seemingly unrelated regressions, and maximum likelihood estimation. When asked in AQCIE-CIFQ PEG *DDR* 13.9 to cite examples of econometric benchmarking studies where fixed effects were used, Brattle stated that “we have not performed a literature search on the topic” but did cite an article that Dr. Ros published on telecommunications prices. However, this was not a benchmarking study, and focused instead on the effect of market concentration on prices.

A fixed effects estimator entails a two-step process. The first step transforms the panel data by subtracting each company’s mean value for cost and the various business condition variables (e.g., transmission line length) from the company’s corresponding yearly value. The transformed dataset consists of panels for each company which contain time series of the deviations of each variable from the company’s corresponding mean value. In the second step, ordinary least squares is used to estimate model parameters using the transformed data. The first-step data transformation is known as a “within transformation” since only the relationship between the within-company variation in cost and that of the business condition variables is used in modelling. The variation between companies in the values of the variables is ignored. When Brattle uses each of its three fixed-effects models to benchmark the corresponding historical costs of HQT, the Company’s average cost is part of the prediction. Their models therefore effectively predict how the Company’s cost varies from year to year around its average cost given the changes in the values of the business conditions it faced.

The random effects estimator also entails a two-step process. However, the first step in this case entails an adjustment to the mean values of variables before subtraction from the year-to-year values. Specifically, each mean value is multiplied by theta, which has a value between zero and one. Brattle’s total cost model estimated with random effects has theta values ranging from 0.861 to 0.901. Thus, between 86.07% and 90.1% of the mean is subtracted from each variable instead of the full value of the mean. Unsurprisingly, results using their random effects estimator are similar to their results using fixed effects.

Fixed effects estimators have some advantages in research using panel data. One is that they eliminate inconsistency that results from the exclusion from the model of time-invariant relevant variables[37] which are 1) relevant cost drivers and 2) correlated with the business condition variables that are included in the model. In a benchmarking application, a fixed effects model also holds the utility that is the subject of the benchmarking study harmless from the cost impact of any excluded time-invariant variables that are relevant drivers.[38] A fixed effects estimator can make sense in research where a) the focus is the impact of a certain (independent) variable on another (so-called dependent) variable[39], b) panel data are being used to estimate the parameter of the variable of interest in an econometric model, c) it is costly to control for the other independent variables that affect the dependent variable, d) some of these other independent variables are correlated with the variable of interest (since this can bias the estimate of its parameter), and e) there is sufficient within variation in the data.

Brattle's fixed effects estimators also have some notable disadvantages. Since they are using the estimators for benchmarking, one major problem is that the average level of HQT's cost during the sample period is taken as given. While this average reflects the cost impact of excluded relevant variables, it also reflects the average level of the company's cost inefficiency during the sample period.

Brattle's methodology would be more useful were the goal of the econometric research to predict HQT's cost. However, the goal of the exercise is instead to provide a benchmark that permits us to estimate the extent of the Company's cost efficiency. The benchmark should effectively be the cost that typical utility managers would incur if faced with Brattle's business conditions.

Another problem with fixed effects is that the cost impact of variables whose values are time-invariant (e.g., the extent of forestation in the service territory) cannot be modeled since subtracting the mean from the annual values will result in all zeroes. This explains why the Brattle models omit some time-variant variables found in the PEG and Fenrick models.

When used in cost research, a third problem with fixed effects is that a major source of variation in the data for an econometric cost study is between utilities and not within them. For example, in both the Brattle and PEG samples there is a marked difference between the costs and operating scale of utilities. However, costs and many cost drivers do not vary greatly from year to year. Fixed effects

[37] The extent of forestation is an example of a cost driver that ordinarily changes little from year to year.
[38] Fixed effects also holds the subject utility harmless from the average cost impact of any excluded time-varying variables that are relevant drivers.

[39] An example might be the impact of a medical trial or a piece of legislation.

ignores the valuable information contained in between variation when estimating model parameters. Moreover, parameter estimates are particularly sensitive to the data for companies in the sample whose values were more varied.

The amount of relevant data and variation used in an econometric model strongly affects the statistical significance and precision of the parameter estimates. Brattle acknowledges in response to AQCIE-CIFQ-PEG question 13.1 that

> "The standard error of a parameter is due to three factors—the variation in the independent variable, the standard error of the regression and the linear relationships among the independent variables. Holding the other factors constant, as the variation in the independent variable increases, so does its precision."

It is often difficult to estimate a good fixed effects model without a very large dataset with significant within-company variation.

The low significance of the parameter estimates in Brattle's fixed effects models is indicative of this problem. For example, using fixed effects, the statistical significance of the peak demand parameter was so low that Brattle chose to use its random effects estimator instead to produce cost elasticities for the output index. Brattle stated in response to AQCIE-CIFQ-PEG *DDR* 13.4 that

"For the cost elasticities [that are needed for the output index weights], we used some judgement in selecting the RE coefficients. For cost elasticities our main interest is in the parameters of the output variables, as we use the output parameters to determine the shares in the productivity study. Under FE only the transmission length output was significantly different than zero thus implying the use of only transmission length as an output in our productivity study."

Brattle also noted in response to AQCIE-CIFQ-PEG question 13.1 that

> "The FE estimator is consistent under both the null hypothesis of no correlation between the unobserved heterogeneity and the regressors and the alternative."

This is an interesting observation since Brattle would presumably not use fixed effects if the null hypothesis of no correlation could not be rejected, notwithstanding the consistency property of the estimator. They would not use it because fixed effects has disadvantages and consistency isn't the only estimator property that matters. We argue that these disadvantages merit consideration even if there is some correlation. Brattle acknowledges in response to AQCIE-CIFQ-PEG *DDR* 13.6 that a researcher sometimes needs to strike a balance between bias and precision when choosing estimators.

Brattle stated in response to AQCIE-CIFQ-PEG *DDR* 13.1 that

> "Fixed effects and random effects estimators are panel data estimators and it is best practice in econometrics and not in any way controversial to utilize panel data estimators with panel data… Not using a panel data estimator for the panel data at hand and instead utilizing pooled OLS is a mistake, as it is not using the proper tool for the job at hand, as reflected in the result of the Hausman test discussed in response to 13.11 below. The RE estimator is preferred to pooled OLS when the researcher fails to reject the null hypothesis of no correlation between the unobserved effects and the regressors."

We acknowledge that fixed effects and random effects estimators are expressly designed for use in panel data research and are sometimes defensible in such research. However, we do not believe that these estimators are "best practice" for this statistical cost benchmarking exercise. Relatedly, in an econometric cost benchmarking study, the Hausman test should not be the sole criterion for deciding whether to use a fixed-effects estimator in a cost benchmarking study.

Brattle states in response to AQCIE-CIFQ-PEG 13.2 that

> "the fixed effects model estimates a unique constant term for each firm in our sample, including HQT. These constant terms are used for prediction. The unique constant term is, by definition, the unobserved heterogeneity that represents all those unobserved, time-invariant factors that affect transmission costs and that differ across firms and is a crucial part of cost benchmarking. Ignoring this heterogeneity in a benchmarking exercise is a mistake and biases the results, as demonstrated through the Hausman test result in our sample. Moreover, while the FE estimator uses the panel-level variable's deviation from the panel-level means to estimate the parameters, the estimated slope coefficients are not unique to each company. The model produces overall slope coefficients estimated from all the transmission companies in our sample and makes predictions based on those common coefficients and the unique utility-specific constant term."

PEG notes the following in response.

- The "unique constant term" for HQT reflects the Company's average inefficiency as well as the cost impact of excluded time-invariant cost drivers. This corrupts Brattle's predictions as benchmarks of cost efficiency.
- While the "slope coefficients" are estimated using data for all the companies in the sample, the substantial variation in data between the companies is ignored in these calculations.

Input Price Specification

PEG (like Hydro One witness Fenrick)[40] carefully levelizes the labor and capital asset prices used in econometric cost research. This permits the levels of these prices to vary realistically between sampled utilities in each year of the sample period.

Brattle did not properly levelize the capital asset price indexes used in their benchmarking study.[41] All U.S. utilities were assumed to pay the same rates for construction in 2001. Brattle stated in response to AQCIE-CIFQ-PEG *DDR* 8.1 that

> "For capital, we use the price levels implicit in the Handy Whitman, which are available and differ based at the regional level South Atlantic, Pacific, Plateau, South Central, North Atlantic and North Central."

However, Handy Whitman indexes are designed to measure construction cost trends.

Brattle did not properly levelize the labor price for sampled U.S. utilities either.[42] They state in response to AQCIE-CIFQ-PEG *DDR* number 8.1 that

> "For labor level we use mean wage level estimates for 2019 published in the Occupational Employment Statistics (OES) by the US BLS.

However, our understanding of their working papers is that state-by-state wage data were not actually used in Brattle's calculations.

Instead, all U.S. utilities have the same labor price in all years. Even regional variation in labor price growth was ignored.[43] The values for Brattle's *CNE* price index do vary by small amounts between utilities but this is due to the company-specific weights given to the labor and M&S price subindexes.

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[40] Steve Fenrick, 2021, op. cit., pp. 14, 59.

[41] Table 7 in Brattle's February report makes no mention of any source for a capital price levelization.

[42] Our review of the working papers suggests that some attempt was made to adjust for price levels such as mapping U.S. companies to state level, industry-specific wage rates and using HQT dollars per employee. However, their indexing methodology made this moot once they set a benchmark value of 1.00 in 2001 for all the price indexes. An improvement would have been to set the 2019 value of the labor price for example to the state-level value and then use to trend index to calculate earlier values of the index. This would have preserved both the between company variation in price levels and trends over time.

[43] We regionalize the trends in our labor prices using regional employment cost indexes.

Benchmark Year Capital Stock

We explained on p. 39 of our February report that the calculation of a capital quantity index using a monetary method typically begins in a "benchmark year" in which either the reported gross or net values of utility assets are converted to a quantity by dividing them by an average of past values of an appropriate asset price index. PEG has long maintained that

- The benchmark-year calculation for a one-hoss shay capital quantity index should divide *gross* plant value by an appropriate average of past values of a construction cost index; and
- the denominator in this calculation should be an *arithmetic* average of past values of the construction cost index rather than the *triangularized* weighted average which makes more sense when geometric decay is the capital cost specification.[44]

Utility witnesses in recent North American *MRI* proceedings have denied both of these contentions, claiming that there is no settled theory regarding these matters. However, their choices have moved in our direction over time.

- The power distribution productivity study, coauthored by Dr. Ros, which NERA filed in Alberta combined one-hoss shay with a benchmark year calculation that featured net plant value in the numerator.[45] Two Brattle studies in Alberta *MRI* proceedings did the same.[46] However, Dr. Ros used gross plant value in the numerator in his study for HQT.
- In a recent Massachusetts proceeding London Economics ("LEI") witnesses for NSTAR Gas prepared a productivity and benchmarking study using one-hoss shay. They stated in their report that

[44] A triangularized weighting of a time series assigns recent years more weight.

[45] Jeff D. Makholm and Agustin J. Ros, "Total Factor Productivity Study for Use in AUC Proceeding 566 – Rate Regulation Initiative" filed in Alberta Utilities Commission Proceeding 566, p. 13.

[46] Dr. Ros was not involved in these two Brattle studies. He did not join Brattle until 2017, after both of Brattle's Alberta *PMF* studies were completed.

> "The best available information to construct a benchmark value is the *gross* book value of all capital assets and equipment, which is made up of assets of different vintages."[47]

- Subsequent to this LEI testimony, a Christensen Associates witness for National Grid in Massachusetts combined one-hoss shay with a benchmark year calculation that featured gross plant value in the numerator after previously using and defending net plant value in his research and testimony in several proceedings.[48]

Unfortunately Dr. Ros, like Christensen Associates in Massachusetts, used a triangularized weighted average of past values of the asset price index in the denominator of its benchmark year calculation.[49] This error produced an *under*statement of the initial capital stock that in turn produced an *over*statement of capital quantity growth and an *under*statement of capital and multifactor productivity growth.

Utility consultants are not united in their embrace of this "odd couple," however. In their work for NSTAR Gas, LEI instead combined gross book value with an arithmetic average of the asset price index values in its benchmark year adjustment. When asked why in an information request, they responded that

> "LEI selected its approach independent of what other experts may have used in other cases. LEI's approach for the benchmark year, real capital stock estimate [sic] is influenced by the observation of a steady stream of capital additions. Therefore, the use of an average of the asset price index is appropriate because LDCs are incurring capital additions annually."[50]

Input Price Differential

We discussed on pages 24-25 of our February report that an adjustment to the X factor of a revenue cap index may be warranted if a macroeconomic price index is used as the inflation measure of a revenue cap index instead of a proper industry input price index. In the United States (e.g., Massachusetts), where macroeconomic inflation measures are more common in rate and revenue cap indexes than they are in Canada, this adjustment has, on several occasions, taken the form of decomposing the X factor into a productivity differential (the difference between the productivity trends

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[47] Massachusetts D.P.U. 19-120, Exhibit ES-JF/MF-2, p. 34.

[48] Direct Testimony of Mark E. Meitzen and Nicholas A. Crowley as filed in Massachusetts D.P.U. 20-120, as Exhibit NG-MEM/NAC-1, Appendix A, p. 11.

[49] *Pièce* B-0012, p. IV-34, *Pièce* B-0013, and *Pièce* B-0019 (Document de soutien 3].

[50] Massachusetts D.P.U. 19-120, Information Request AG-9-7, part b.

of the industry and the economy) and an input price differential (the difference between the input price trends of the economy and the industry).

The use of capital service prices in the calculation of capital cost complicates adjustments of this kind because these prices tend to be volatile. The volatility stems from several sources. Assets are valued in current dollars, not historical dollars, and there is sometimes a capital gains term in the service price index. There are occasional surges in construction costs (due, for example, to surges in metal prices). For example, U.S. transmission construction costs surged around 2008.

One way to mitigate the problem of identifying a reasonable input price differential is to consider long sample periods when calculating X factors. Another volatility mitigation measure is to smooth the fluctuations in capital service price inflation. A third is to statistically test the hypothesis that the input price trends of the industry and the economy are similar. In such a test, the likelihood of rejecting the hypothesis is reduced to the extent that input prices are volatile.

In the power distribution X factor study by NERA that Dr. Ros coauthored, we noted above that a lengthy 1973-2009 sample period was used. One of the authors stated that, under certain circumstances, theory suggests that the X factor should reflect the sum of an input price differential and a productivity differential.[51] NERA performed a statistical test to see if the input price growth of the industry was different than that of the U.S. and Canadian economies and found that there was not a significant difference.

Even though the inflation measures the Régie has approved for Hydro-Québec's revenue cap indexes have averaged growth in multiple price indexes that include a labor price index, Brattle considered the X factor that would be warranted in the event that the *indice implicite de prix du produit intérieur brut* were the sole *formule d'indexation* inflation measure.[52] In this exercise, Brattle properly used their full 1994-2019 sample period to calculate their inflation adjustment but did not additionally smooth the capital price indexes or conduct a statistical test. We recommend that the Régie disregard Brattle's exercise.

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[51] Alberta Utilities Commission Proceeding 566, Exhibit 461.02, AUC-NERA-II-4 a). In Transcript volume 1, p. 142 from the first AUC proceeding, NERA author Jeff Makholm confirmed in oral testimony that these differentials only apply when you use a [macroeconomic] "output price index" [as the rate or revenue cap index inflation measure].

[52] PEG did not consider this because the Régie has effectively approved a simple input price indexes as the inflation measure for HQT's revenue cap index.

Other Serious Concerns

Brattle's work also differed from PEG's in other ways that were probably less important to the outcome but are methodologically substandard.

Econometric Model Specification

Statistical Significance of the Business Condition Variables

Like Hydro One witness Fenrick,[53] we typically limit the business condition variables in our benchmarking models to those with statistically significant and plausible parameter estimates. This guards against unreasonable model specifications and reduces the likelihood that there will be too many variables. In Brattle's three featured benchmarking models, there are numerous variables with statistically insignificant parameter estimates. This is due in part to their use of a fixed effects estimator, as discussed above. Remarkably, the parameter estimate for the important ratcheted peak demand variable was statistically insignificant in all three benchmarking models. Only two of nine variables were statistically significant in Brattle's *CNE* benchmarking model.

Second-Order Terms

We discussed the choice of a functional form for an econometric benchmarking model on pages 99-100 of our February report. We noted that the addition of quadratic terms (e.g., line km x line km) and interaction terms (e.g., line length x peak demand) to such models can better capture nonlinear relationships that may exist between cost and the business condition variables. The statistical significance of the parameters for these "second-order" terms is indicative of the extent of nonlinearity in the data. Since the precision of parameter estimates diminishes with the number of explanatory variables in an econometric model, however, these terms are typically used only for important cost drivers.

[53] Steve Fenrick, 2021, op. cit., pp. 24, and 35-36.

Our featured cost models, like that of Hydro One witness Fenrick,[54] contain quadratic and interaction terms for the output variables. The parameter estimates for these terms generally had high statistical significance. Brattle did not include second-order terms in their featured econometric models and commented in this regard that "these did not yield conclusive results."[55] However, we have already noted that the fixed effects estimator that Brattle uses in their base case run tends to produce weak statistical significance in cost studies.

Relevant Excluded Business Conditions

PEG used forestation, elevation, and construction challenge variables in the three featured cost models.[56] All of these variables had statistically significant parameter estimates in our models. Brattle could not use any of these variables in their models because the variables were time-invariant.

Benchmark Year for the Capital Cost Specification

We explained on page 39 of our February report that capital costs are more accurately estimated to the extent that the initial (benchmark) year for the calculation of capital quantities is far in the past. Brattle used 1988 as the first year for its capital quantity indexes. They confirmed in response to *DDR* 5.4 from AQCIE-CIFQ-PEG that this is one of the earliest benchmark years possible when relying solely on S&P Global utility cost data. We gather our own data and used 1964 as the benchmark year for the capital cost index. Hydro One witness Fenrick used SNL Financial data but went to the extra effort of gathering the older capital cost data needed for a 1948 benchmark year.[57] Brattle's more

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[54] Steve Fenrick, 2021, op. cit., pp. 24 and 35.

[55] *Pièce* B-0012, p. VII-62.

[56] PEG sought and received the permission of Mr. Fenrick's former employer, Power Systems Engineering, to use these variables. Brattle could have done the same.

[57] Steve Fenrick, 2021, op. cit., pp. 15-16. He states there that "the earlier the capital benchmark year is, the more actual plant addition data can be used to calculate the capital quantity and costs of each utility. Given the fact that PEG and Clearspring assume geometric decay, much of the capital quantity assumed in the capital benchmark year will have depreciated by the relevant years in the study. Despite our continued opinion that the capital benchmark year is a minor issue and that 1989 was a sufficient capital benchmark year, we have nonetheless collected all the necessary data to begin the capital benchmark year in 1947 for most of the U.S. utilities, and in 1959 for the rest that were missing data between 1947 and 1959. We have therefore used the actual transmission or distribution

recent benchmark year amplifies the effect of the inappropriate denominator in its benchmark year calculation.

Sampled Companies

The companies used in a productivity or benchmarking study typically have a modest effect on the results. Brattle used a sample of 74 transmitters in both their productivity and econometric research. Hydro One witness Fenrick used a sample of 50 utilities in his productivity research and 60 utilities in his benchmarking research.[58] We used a sample of 51 U.S. power transmitters in our productivity research and 46 in our econometric cost research.[59] Our sample is based on earlier work done to review the evidence of Mr. Fenrick in prior Hydro One *MRI* proceedings. In our work for AQCIE-CIFQ, we did not place a priority on expanding the sample to add other candidate companies with good data due to the potential cost and our conviction that it would not significantly alter the conclusions of our work.

While some of the extra Brattle companies may have sound data, others have problematic data. For example, several have implausible surges in miscellaneous transmission expenses. Others have problematic data for one or more business condition variables.

Another problem is that the Brattle sample includes companies with data that have not been corrected for the effect of mergers. The most salient example of this is Green Mountain Power. Simply put, the Green Mountain Power in 2019 is not the same company as the Green Mountain Power of 1995. The merger with Central Vermont Public Service almost tripled the scale of transmission of the combined company relative to the old Green Mountain Power. The main issue is that unless the older CVPS data on transmission plant, plant additions, and plant retirements are added to that of GMP, the calculated capital quantity of the company will not include the legacy CVPS assets. This will result in a distortion of the benchmarking and productivity results for the company. In the case of the Brattle one-hoss shay calculation, this contributed to the negative capital quantities in which some CVPS assets were retired and subtracted from a capital stock that did not include them. Other examples of mergers not

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plant addition data for the U.S. sample for the years 1948 to 2019 in the perpetual inventory capital method to calculate capital quantities and costs. This is over 70 years' worth of actual plant addition data."

[58] Steve Fenrick, 2021, op. cit. p. 20.

[59] Several utilities were excluded from our econometric research due to suspect data on miscellaneous transmission expenses. This cost category was excluded from our productivity calculations.

properly addressed by Brattle include Georgia Power (Savannah) and NSTAR (Boston Edison, Cambridge, Commonwealth). PEG does not believe that the correction of these data or the exclusion of these companies would have a major impact on the results of the work, but it is nonetheless worth noting.

Benchmarking Sample Period

Brattle reported benchmarking results for the 2010-19 sample period whereas it is customary in North American statistical benchmarking reports for *MRI* proceedings to focus on the three most recent historical years of the period. In Ontario, projected future costs or revenue requirements are also routinely benchmarked in rate rebasings.

Substation Data

Brattle's substation data were not sufficiently cleaned and this resulted in major measurement errors.

Alternative Productivity Runs Using Brattle Data

It is possible to upgrade Brattle's research using the working papers provided. We consider three here. The first upgrade is to use the correct denominator for deflating gross plant value in the benchmark year capital quantity calculation. This will affect capital and multifactor productivity but not *CNE* productivity. The second set of upgrades is to exclude some categories of U.S. transmission *CNE* *e*xpenses from the study. Specifically, we excluded transmission by others expenses, miscellaneous transmission expenses, and the costs in FERC Accounts 561.1 to 561.8. FERC account 561 was formerly called "dispatching". The third upgrade is to use ratcheted peak demand in the output index.

Tables 5-10 and Figures 1 and 2 below present productivity trends, for periods featured in the Brattle report, with steps taken individually followed by a full year-by-year presentation of the results if all changes are made. *CNE,* capital, and multifactor productivity trends are considered.

Inspecting the results, it can be seen that the combined effect of all of these upgrades is to raise the multifactor transmission productivity trend for Brattle's featured 1995-2019 sample period from -1.04% to +0.09%.[60] The *CNE* productivity trend rose from -3.38% to -1.00%. Over the 15-year 2005-

[60] The MFP trend associated with just changing the benchmark year price is -0.72%. The MFP trend associated with just removing transmission by others O&M is -0.64% which had the largest effect on the results.

2019 sample period, the transmission *PMF* trend rose from -1.69% to -0.72% while the *CNE* productivity trend rose from -3.09% to -2.16%.

Table 5

Productivity Trends with an Improved Benchmark Year Capital Quantity

(growth rates)

Year	Output Index	Input Index	Productivity Indexes		
			Multifactor	*CNE*	Capital
1995-2019 (full sample period)	**0.89%**	**1.61%**	**-0.72%**	**-3.38%**	**0.13%**
2000-2019 (last 20 years)	**0.75%**	**1.87%**	**-1.12%**	**-3.28%**	**-0.34%**
2005-2019 (last 15 years)	**0.71%**	**2.01%**	**-1.30%**	**-3.09%**	**-0.61%**
2010-2019 (last 10 years)	**0.74%**	**2.27%**	**-1.54%**	**-3.13%**	**-0.97%**

Table 6

Productivity Trends Excluding Transmission by Others Expenses

(growth rates)

Year	Output Index	Input Index	Productivity Indexes		
			Multifactor	*CNE*	Capital
1995-2019 (full sample period)	**0.89%**	**1.53%**	**-0.64%**	**-2.32%**	**-0.05%**
2000-2019 (last 20 years)	**0.75%**	**1.90%**	**-1.15%**	**-2.55%**	**-0.64%**
2005-2019 (last 15 years)	**0.71%**	**2.09%**	**-1.39%**	**-2.63%**	**-0.97%**
2010-2019 (last 10 years)	**0.74%**	**2.44%**	**-1.70%**	**-1.99%**	**-1.43%**

Table 7

Productivity Trends Excluding Transmission by Others and Miscellaneous Expenses

(growth rates)

Year	Output Index	Input Index	Productivity Indexes		
			Multifactor	*CNE*	Capital
1995-2019 (full sample period)	**0.89%**	**1.36%**	**-0.47%**	**-1.92%**	**-0.05%**
2000-2019 (last 20 years)	**0.75%**	**1.82%**	**-1.07%**	**-2.48%**	**-0.64%**
2005-2019 (last 15 years)	**0.71%**	**2.21%**	**-1.50%**	**-3.29%**	**-0.97%**
2010-2019 (last 10 years)	**0.74%**	**2.55%**	**-1.82%**	**-2.41%**	**-1.43%**

Table 8

Productivity Trends Excluding Transmission by Others, Miscellaneous, and Dispatch-Related Transmission Expenses[61]

(growth rates)

Year	Output Index	Input Index	Productivity Indexes		
			Multifactor	*CNE*	Capital
1995-2019 (full sample period)	**0.89%**	**1.22%**	**-0.34%**	**-1.21%**	**-0.05%**
2000-2019 (last 20 years)	**0.75%**	**1.68%**	**-0.94%**	**-1.76%**	**-0.64%**
2005-2019 (last 15 years)	**0.71%**	**2.04%**	**-1.33%**	**-2.40%**	**-0.97%**
2010-2019 (last 10 years)	**0.74%**	**2.46%**	**-1.72%**	**-1.87%**	**-1.43%**

Table 9

Productivity Trends All Three *CNE* Exclusions and Improved Benchmark Year Capital Quantity

(growth rates)

Year	Output Index	Input Index	Productivity Indexes		
			Multifactor	*CNE*	Capital
1995-2019 (full sample period)	**0.89%**	**1.00%**	**-0.11%**	**-1.21%**	**0.13%**
2000-2019 (last 20 years)	**0.75%**	**1.36%**	**-0.61%**	**-1.76%**	**-0.34%**
2005-2019 (last 15 years)	**0.71%**	**1.65%**	**-0.94%**	**-2.40%**	**-0.61%**
2010-2019 (last 10 years)	**0.74%**	**2.00%**	**-1.27%**	**-1.87%**	**-0.97%**

[61] Dispatch-related expenses are those reported in FERC Form 1 accounts 561.1 to 561.8.

Table 10

Productivity Results with All Three *CNE* Exclusions, Improved Benchmark Year Capital Quantity, and Ratcheted Peak Demand

(growth rates)

			Productivity Indexes		
Year [A]	Output Index [B]	Input Index [C]	Multifactor [D]	*CNE* [E]	Capital [F]
1995	3.33%	0.21%	3.12%	1.62%	3.26%
1996	1.85%	-0.22%	2.08%	2.61%	2.10%
1997	-1.09%	-0.02%	-1.07%	-1.86%	-1.02%
1998	1.54%	-0.10%	1.64%	0.64%	2.01%
1999	2.40%	-2.11%	4.50%	2.64%	4.69%
2000	0.64%	0.00%	0.64%	-0.44%	0.85%
2001	0.85%	0.07%	0.78%	3.65%	0.56%
2002	1.58%	0.22%	1.36%	3.57%	1.07%
2003	1.36%	0.80%	0.57%	1.05%	0.50%
2004	0.87%	1.44%	-0.57%	-6.02%	0.21%
2005	2.12%	0.48%	1.65%	-2.33%	2.25%
2006	2.42%	1.49%	0.93%	-3.26%	1.49%
2007	1.00%	0.97%	0.03%	-3.56%	0.33%
2008	0.23%	1.16%	-0.94%	-5.68%	-0.44%
2009	0.08%	0.56%	-0.48%	0.10%	-0.46%
2010	0.68%	1.79%	-1.11%	-4.26%	-0.70%
2011	0.55%	0.14%	0.41%	-0.50%	0.56%
2012	1.07%	1.46%	-0.38%	-0.37%	-0.36%
2013	0.40%	2.33%	-1.92%	-2.87%	-1.82%
2014	0.81%	2.89%	-2.08%	-1.91%	-1.91%
2015	0.97%	1.92%	-0.95%	2.26%	-1.54%
2016	0.33%	1.93%	-1.60%	-2.19%	-1.47%
2017	2.06%	1.06%	1.01%	2.95%	0.80%
2018	0.14%	1.43%	-1.29%	-1.30%	-1.19%
2019	0.87%	4.88%	-4.00%	-9.54%	-1.33%
1995-2019 (full sample period)	**1.08%**	**0.99%**	**0.09%**	**-1.00%**	**0.34%**
2000-2019 (last 20 years)	**0.95%**	**1.35%**	**-0.40%**	**-1.53%**	**-0.13%**
2005-2019 (last 15 years)	**0.92%**	**1.63%**	**-0.72%**	**-2.16%**	**-0.39%**
2010-2019 (last 10 years)	**0.79%**	**1.98%**	**-1.19%**	**-1.77%**	**-0.90%**

Figure 1

Comparison of Brattle and PEG Multifactor Productivity Results

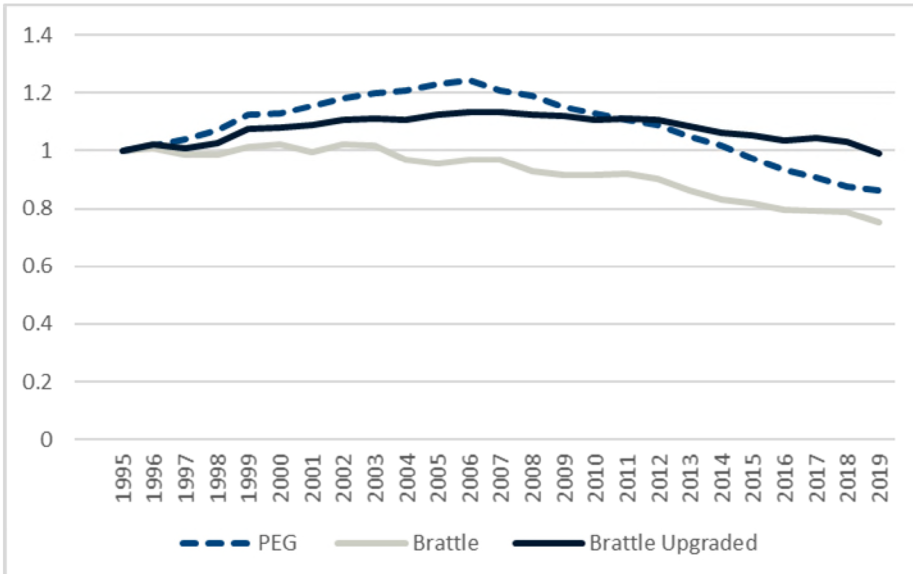
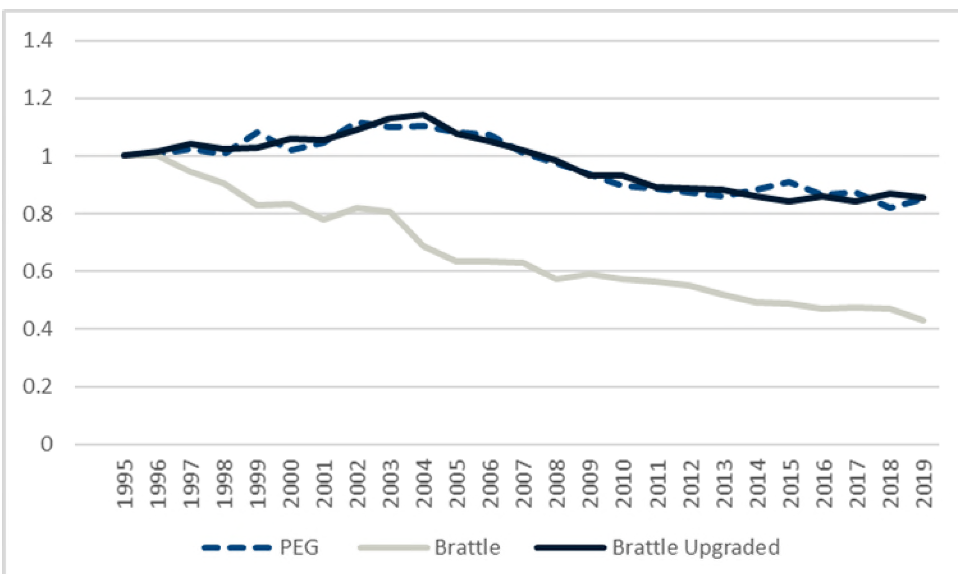


Figure 2

Comparison of Brattle and PEG *CNE* Productivity Results



Alternative Benchmarking Runs Using Brattle Data

It was possible for PEG to replicate Brattle's econometric work using the information that they provided. Starting from these replications, PEG made several upgrades to Brattle's econometric work which reflect the criticisms and concerns we stated above. The first step was to upgrade the benchmark year capital calculations to use an arithmetic average of historical prices to deflate gross plant instead of the inappropriate triangularized weighted average used by Brattle. The second step was to remove transmission by other expenses. The third step was to remove 6 companies from the sample which had implausibly large miscellaneous transmissio*n CNE* expenses (FERC Account 566).

For each of these upgrades, PEG reestimated the benchmarking models using Brattle's fixed effects estimator, their random effects estimator, and an OLS estimator. The result of this work is presented below for the total cost, *CNE* and capital models. Results for the three most recent historical years (2017-2019) of the sample period are most pertinent since these have the most bearing on the appropriate stretch factor for HQT.

Results are shown in Tables 11–13 and in Figures 3 and 4. It can be seen that the PEG upgrades tended to make HQT's benchmarking scores less favorable to the Company. The exception is the benchmark year calculation because this is more of an issue for productivity trends. Using the fixed effects and random effects estimators, the changes in the efficiency scores are not large. The OLS benchmarking scores were much more sensitive. Most strikingly, benchmarking scores were much more adverse for the Company using our OLS estimator.

Table 11

Summary of Alternative Econometric Benchmarking Results: Total Cost

Year	Full Sample									Remove 6 Companies with Bad Miscellaneous Transmission Expenses							
	Brattle			Upgraded Benchmark Year Adjustment [A]			[A] + Remove Transmission by Others Expenses			Brattle		Upgraded Benchmark Year Adjustment [A]			[A] + Remove Transmission by Others Expenses		
	FE	RE	OLS	FE	RE	OLS	FE	RE	OLS	FE	RE	FE	RE	OLS	FE	RE	OLS
2001	4.4%	6.2%	100.5%	5.1%	6.6%	102.8%	-1.0%	0.4%	74.5%	4.2%	6.3%	4.9%	6.6%	111.7%	-0.9%	0.7%	85.4%
2002	2.0%	4.2%	99.4%	2.0%	3.9%	101.2%	-2.8%	-0.8%	74.5%	1.8%	4.2%	1.8%	3.9%	109.6%	-2.8%	-0.7%	84.9%
2003	1.9%	3.4%	97.9%	1.8%	3.1%	99.6%	-2.1%	-1.0%	73.4%	1.8%	3.6%	1.7%	3.1%	108.0%	-2.0%	-0.7%	84.0%
2004	0.8%	1.9%	96.8%	0.7%	1.6%	98.5%	-2.5%	-1.9%	72.7%	0.8%	2.2%	0.6%	1.7%	107.1%	-2.2%	-1.5%	83.4%
2005	4.2%	6.0%	104.9%	4.2%	5.6%	106.7%	2.1%	3.3%	81.8%	4.1%	6.1%	4.0%	5.6%	114.3%	2.1%	3.5%	91.1%
2006	7.5%	9.8%	112.4%	6.8%	8.8%	113.7%	6.4%	8.1%	89.9%	7.2%	9.8%	6.5%	8.7%	120.5%	6.3%	8.2%	98.2%
2007	5.6%	7.1%	109.3%	5.0%	6.2%	110.7%	5.4%	6.2%	87.5%	5.3%	7.2%	4.7%	6.2%	117.6%	5.3%	6.4%	95.9%
2008	-0.2%	1.6%	102.3%	0.2%	1.7%	104.7%	-0.2%	1.0%	81.3%	-0.4%	1.8%	0.0%	1.8%	111.7%	-0.2%	1.2%	90.0%
2009	0.8%	3.0%	104.4%	1.6%	3.5%	107.2%	1.5%	3.1%	84.2%	0.7%	3.2%	1.4%	3.5%	114.1%	1.4%	3.2%	92.6%
2010	-2.4%	-0.1%	101.1%	-1.5%	0.4%	104.1%	-1.1%	0.5%	81.5%	-2.4%	0.1%	-1.5%	0.6%	110.9%	-1.1%	0.7%	90.0%
2011	-5.9%	-4.4%	96.6%	-4.8%	-3.8%	99.6%	-3.7%	-3.1%	77.4%	-5.9%	-4.1%	-4.9%	-3.5%	106.5%	-3.6%	-2.8%	86.0%
2012	-8.3%	-6.5%	94.7%	-6.8%	-5.3%	98.3%	-5.6%	-4.6%	76.5%	-8.3%	-6.2%	-6.8%	-5.1%	105.0%	-5.6%	-4.3%	84.8%
2013	-8.1%	-6.6%	93.2%	-6.8%	-5.6%	96.5%	-4.9%	-4.3%	75.8%	-8.0%	-6.1%	-6.7%	-5.2%	103.4%	-4.8%	-3.9%	84.4%
2014	-7.4%	-5.6%	95.0%	-6.4%	-4.9%	98.1%	-3.7%	-2.6%	78.2%	-7.3%	-5.2%	-6.2%	-4.5%	104.7%	-3.6%	-2.3%	86.5%
2015	-9.1%	-7.0%	92.9%	-8.0%	-6.2%	96.2%	-5.0%	-3.6%	77.0%	-8.9%	-6.5%	-7.7%	-5.8%	102.8%	-4.9%	-3.3%	85.3%
2016	-6.1%	-3.6%	96.2%	-4.9%	-2.8%	99.6%	-1.5%	0.3%	81.1%	-5.8%	-3.1%	-4.6%	-2.3%	106.1%	-1.5%	0.6%	89.4%
2017	-4.9%	-2.1%	98.1%	-4.2%	-1.8%	100.9%	0.2%	2.5%	83.8%	-4.6%	-1.6%	-4.0%	-1.4%	107.1%	0.3%	2.7%	91.8%
2018	-3.7%	-0.7%	99.2%	-3.4%	-0.6%	101.9%	1.7%	4.4%	85.9%	-3.4%	-0.2%	-3.0%	-0.1%	107.9%	1.7%	4.6%	93.7%
2019	-3.7%	-0.4%	98.7%	-3.2%	-0.2%	101.5%	2.2%	5.2%	86.2%	-3.3%	0.1%	-2.7%	0.3%	107.4%	2.2%	5.4%	94.0%
2001 - 2019	***-1.7%***	***0.3%***	***99.7%***	***-1.2%***	***0.5%***	***102.2%***	***-0.8%***	***0.7%***	***80.2%***	***-1.7%***	***0.6%***	***-1.2%***	***0.7%***	***109.3%***	***-0.7%***	***0.9%***	***89.0%***
2005 - 2019	***-2.8%***	***-0.6%***	***99.9%***	***-2.1%***	***-0.3%***	***102.6%***	***-0.4%***	***1.1%***	***81.9%***	***-2.7%***	***-0.3%***	***-2.1%***	***-0.1%***	***109.3%***	***-0.4%***	***1.3%***	***90.2%***
2010 - 2019	***-6.0%***	***-3.7%***	***96.6%***	***-5.0%***	***-3.1%***	***99.7%***	***-2.1%***	***-0.5%***	***80.3%***	***-5.8%***	***-3.3%***	***-4.8%***	***-2.7%***	***106.2%***	***-2.1%***	***-0.3%***	***88.6%***
2017 - 2019	**-4.1%**	**-1.1%**	**98.7%**	**-3.6%**	**-0.9%**	**101.4%**	**1.4%**	**4.0%**	**85.3%**	**-3.8%**	**-0.5%**	**-3.2%**	**-0.4%**	**107.5%**	**1.4%**	**4.2%**	**93.2%**

Table 12

Summary of Alternative Econometric Benchmarking Results: *CNE*

Year	Full Sample						Remove 6 Companies with Bad Miscellaneous Transmission Expenses				
	Brattle			Remove Transmission by Others Expenses			Brattle		Remove Bad Companies and Transmission by Others Expenses		
	FE Report	RE Report	OLS Brattle Data	FE Brattle Data	RE Brattle Data	OLS Brattle Data	FE Brattle Data	RE Brattle Data	FE Brattle Data	RE Brattle Data	OLS Brattle Data
2001	47.1%	49.1%	123.9%	37.3%	39.9%	74.5%	46.5%	49.0%	38.7%	42.0%	85.4%
2002	37.4%	39.8%	116.1%	28.5%	31.7%	74.5%	36.7%	39.4%	29.2%	33.3%	84.9%
2003	35.8%	37.7%	113.0%	28.0%	30.3%	73.4%	35.2%	37.5%	29.1%	32.1%	84.0%
2004	29.3%	31.0%	107.0%	24.1%	25.9%	72.7%	29.3%	31.4%	26.1%	28.5%	83.4%
2005	21.3%	23.6%	105.0%	19.9%	22.6%	81.8%	21.5%	24.2%	21.9%	25.2%	91.1%
2006	18.5%	21.5%	107.5%	21.2%	24.7%	89.9%	19.3%	22.5%	23.7%	27.9%	98.2%
2007	12.5%	15.0%	101.3%	16.3%	18.9%	87.5%	13.3%	16.2%	19.0%	22.1%	95.9%
2008	-5.8%	-3.2%	81.1%	-2.9%	0.0%	81.3%	-5.3%	-2.3%	-1.0%	2.6%	90.0%
2009	-6.4%	-3.4%	81.7%	-2.1%	1.4%	84.2%	-5.8%	-2.5%	-0.3%	3.9%	92.6%
2010	-12.6%	-9.5%	75.6%	-7.4%	-3.8%	81.5%	-11.9%	-8.5%	-5.6%	-1.4%	90.0%
2011	-21.0%	-18.4%	66.8%	-14.1%	-11.6%	77.4%	-20.0%	-17.1%	-11.8%	-8.7%	86.0%
2012	-33.3%	-30.4%	55.1%	-26.0%	-23.0%	76.5%	-32.5%	-29.3%	-24.4%	-20.7%	84.8%
2013	-36.7%	-34.1%	49.8%	-29.9%	-27.3%	75.8%	-36.2%	-33.3%	-28.7%	-25.4%	84.4%
2014	-37.6%	-34.7%	49.8%	-29.1%	-26.0%	78.2%	-36.9%	-33.7%	-28.0%	-24.2%	86.5%
2015	-44.5%	-41.4%	42.2%	-36.3%	-32.7%	77.0%	-44.0%	-40.6%	-35.7%	-31.3%	85.3%
2016	-41.8%	-38.4%	44.9%	-33.3%	-29.2%	81.1%	-41.4%	-37.8%	-33.1%	-28.2%	89.4%
2017	-40.7%	-37.0%	46.7%	-31.5%	-26.9%	83.8%	-40.5%	-36.6%	-31.8%	-26.4%	91.8%
2018	-38.3%	-34.4%	48.8%	-29.1%	-24.1%	85.9%	-38.3%	-34.3%	-30.1%	-24.1%	93.7%
2019	-45.0%	-41.0%	40.9%	-35.9%	-30.6%	86.2%	-45.3%	-41.1%	-37.6%	-31.2%	94.0%
2001 - 2019	***-8.5%***	***-5.7%***	***76.7%***	***-5.4%***	***-2.1%***	***80.2%***	***-8.2%***	***-5.1%***	***-4.2%***	***-0.2%***	***89.0%***
2005 - 2019	***-20.8%***	***-17.7%***	***66.5%***	***-14.7%***	***-11.2%***	***81.9%***	***-20.3%***	***-17.0%***	***-13.6%***	***-9.3%***	***90.2%***
2010 - 2019	***-35.2%***	***-31.9%***	***52.1%***	***-27.2%***	***-23.5%***	***80.3%***	***-34.7%***	***-31.2%***	***-26.7%***	***-22.2%***	***88.6%***
2017 - 2019	**-41.3%**	**-37.5%**	**45.5%**	**-32.1%**	**-27.2%**	**85.3%**	**-41.3%**	**-37.3%**	**-33.2%**	**-27.2%**	**93.2%**

Table 13

Summary of Alternative Econometric Benchmarking Results: Capital Cost

	Full Sample					
Year	**Brattle**			**Upgraded Benchmark Year Adjustment [A]**		
	FE Report	RE Report	OLS Brattle Data	FE Brattle Data	RE Brattle Data	OLS Brattle Data
2001	-12.9%	-11.1%	85.6%	-11.9%	-10.8%	66.1%
2002	-12.9%	-10.6%	87.0%	-12.1%	-10.5%	67.6%
2003	-12.1%	-10.7%	86.3%	-10.9%	-10.1%	67.1%
2004	-10.9%	-10.0%	87.2%	-9.9%	-9.6%	67.8%
2005	-3.4%	-1.9%	98.6%	-3.2%	-2.4%	78.6%
2006	2.8%	4.9%	108.0%	2.0%	3.4%	87.2%
2007	2.5%	3.6%	106.3%	2.0%	2.4%	85.7%
2008	-0.4%	1.0%	102.7%	-0.5%	0.3%	82.7%
2009	1.8%	3.7%	106.1%	1.6%	2.8%	86.0%
2010	-0.1%	1.9%	104.0%	-0.1%	1.1%	84.2%
2011	-1.6%	-0.8%	101.0%	-1.6%	-1.3%	81.2%
2012	-1.8%	-0.5%	101.7%	-1.7%	-1.0%	82.1%
2013	-0.7%	0.2%	101.5%	0.0%	0.3%	82.5%
2014	1.2%	2.4%	104.4%	1.7%	2.4%	85.4%
2015	0.7%	2.3%	104.0%	1.5%	2.6%	85.4%
2016	4.4%	6.5%	108.2%	5.4%	6.8%	89.9%
2017	6.3%	8.8%	110.9%	7.4%	9.2%	92.9%
2018	7.5%	10.5%	112.7%	8.8%	11.0%	95.0%
2019	9.1%	12.3%	113.9%	10.8%	13.2%	96.8%
2001 - 2019	***-1.1%***	***0.7%***	***101.6%***	***-0.6%***	***0.5%***	***82.3%***
2005 - 2019	***1.9%***	***3.7%***	***105.6%***	***2.3%***	***3.4%***	***86.4%***
2010 - 2019	***2.5%***	***4.4%***	***106.2%***	***3.2%***	***4.4%***	***87.5%***
2017 - 2019	**7.6%**	**10.5%**	**112.5%**	**9.0%**	**11.2%**	**94.9%**

Figure 3

Comparison of Brattle and PEG Benchmarking Results: Total Cost 2017-2019

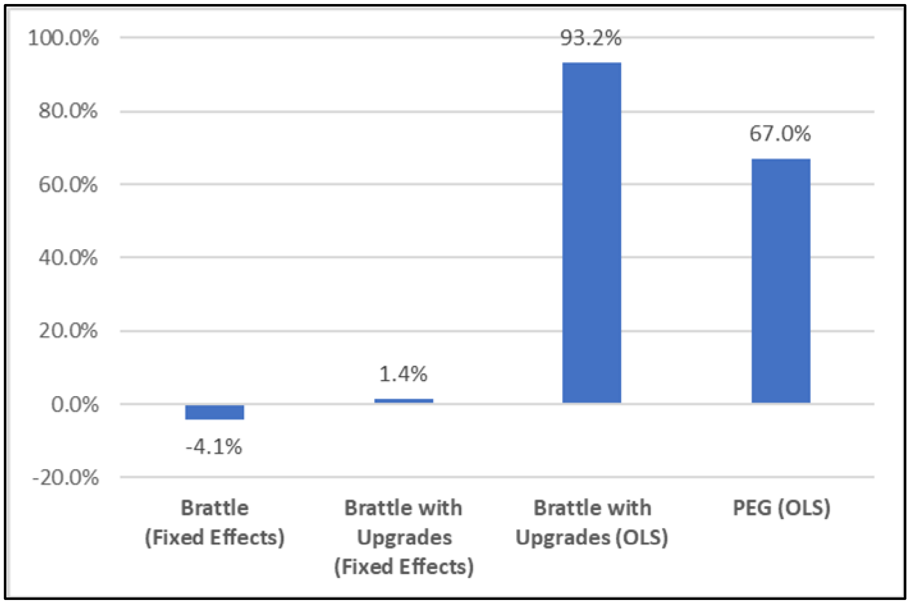
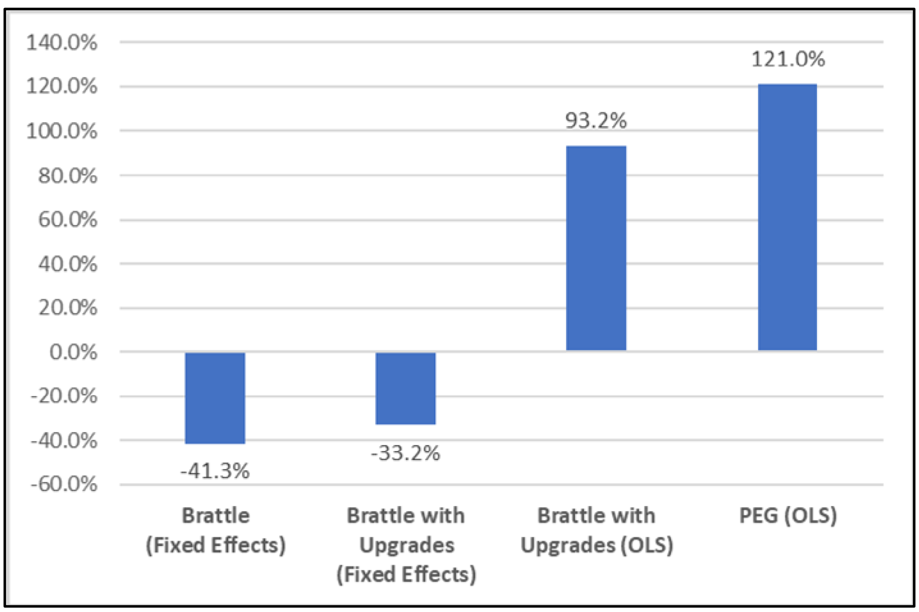


Figure 4

Comparison of Brattle and PEG Benchmarking Results: *CNE* 2017-2019



5. PEG Concerns with Other Aspects of Brattle's Work

Here are some reservations we have about Brattle's commentaries on other *MRI* issues.

Rationale for a Revenue Cap Index Design

We discussed the mathematical reasoning supporting the design of a revenue cap index in Section 3.2 of our February report. We showed there that such an index can be justified exclusively using mathematical cost theory. Our analysis indicates the appropriateness of using output indexes featuring drivers of cost that are weighted by estimates of the corresponding cost elasticities.

Brattle instead employs an alternative (and in our view confusing) two-step rationale for revenue cap indexes in their February report.[62] In the first step, a rationale for a *price* cap index (frequently encountered in the testimony of telecommunications economists) is detailed. In the second step, the implication for revenue growth is considered. According to their logic, the output quantity metric would ideally track growth in billing determinants and have revenue-share weights if there were multiple determinants. We believe that Brattle's discussion of this topic should be disregarded.

Stretch Factor

We have several concerns about Brattle's X factor discussion.

1. Brattle states on page III-23 of their February report that

> "the regulatory economic theory underpinning the stretch factor in a PBR formula is that given a significant change in the regulatory environment—in this case moving from cost-of-service regulation to PBR—the firm will have improved incentives to operate more efficiently *than it has had in the past*—on either the cost side, the demand side or both. It seems to us that if it were possible to measure, one would compare the *firm's* expected efficiency incentives post adoption of PBR plan to the efficiency incentives prior to the change to PBR."

They state further on page III-23 that

> "When initially moving from rate-of-return regulation to PBR, the change in regulatory structure can lead to efficiency gains by the regulated firm. The stretch factor provides customers with a "first cut" of the share of the increased productivity growth due to the initial incentive effects of PBR. Thus, a stretch factor should be more common in "first generation" PBR plans than in subsequent generation plans… Since HQT is already operating to some extent under the efficiency enhancing incentives of PBR, at least for O&M costs, there will likely be less "low hanging fruit" in subsequent plans, thus arguing for a lower stretch factor than would otherwise be the case."

[62] *Pièce* B-0012, pp. III-17 to III-20 and IV-32 to IV-32

We disagree with parts of both of these statements. The proper theoretical underpinning of a stretch factor is that the productivity growth of a utility should be more rapid to the extent that it is a) inefficient and b) operating under stronger performance incentives than those of the typical utility in the productivity growth sample that is used to set the X factor. Linking the stretch factor to efficiency has the additional benefit of strengthening the performance incentives of the subject utility.

Inefficiency is an empirical issue that can be addressed by statistical benchmarking. While the stretch factors warranted in subsequent plans may be lower than in the first, there are several reasons why this may not be the case. These include the following.

- Incentives in first-generation PBR plans are often not that strong.
- First-generation plans often last only a few years, limiting the time available for cost cutting even if incentives are strong.
- The utility might need higher capex in latter plans.
- Even in competitive markets strong incentives to contain cost do not guarantee good cost performance. Brattle notes, for example, in response to AQCIE-CIFQ-PEG 16.2 that "there are reasons why firms in competitive markets are unable to operate on the production possibilities frontier, including X-inefficiencies."
- Continuation of stretch factors linked to benchmarking strengthens utility performance incentives. Brattle avoids conceding this point in response to AQCIE-CIFQ-PEG *DDR* 16.3, stating that "The increased performance incentives from PBR are a function primarily of the duration of the plan and whether there is incorporation of earnings sharing" and then noting that Alberta's commission doesn't believe that stretch factors strengthen performance incentives. Alberta eschews the use of benchmarking in *MRIs.*
- Stretch factors should reflect in part the difference between the performance incentives generated by the *MRI* and those that are typical of sampled utilities. This difference may not diminish between plans.

With respect to the latter point, Brattle acknowledges on page III-24 of their report that the difference between the performance incentives of an *MRI* and those of typical utilities in a productivity sample is a consideration in setting the stretch factor. Further, "Our sample of U.S. transmission companies are under cost-of-service regulation by the FERC. Many of those companies are under "formula rates" meaning that the companies' rates are frequently aligned with underlying costs and there is less ability to take advantage of regulatory lag. At the same time, the FERC also provides incentives to transmission companies, most in the form of premiums on return on equity for meeting certain public policy objectives."

In response to Régie *DDR* 11.4, Brattle stated that

"The FERC regulatory regime, which generally applies to our sample companies, is rate of return regulation and embedded cost of service with some incentive mechanism tied to achievement of some public policy goals. Because there are many transmission companies that the FERC must regulate, it has adopted a streamlined regulatory review process call "formula rates" which gives the transmission companies the option, but not the obligation, to submit periodical cost information to the FERC within a standard format and procedure (thus the term formula rates). This obviates the need for extensive regulatory cost hearings. We have not undertaken an exhaustive review of how many of our sample companies are operating under formula rate, of those that are when they began operating under formula rates, or whether they have switched throughout the period between the two regulatory options that the FERC offers. We can state, however, based on our work and experience that use of formula rates is common."

We note in this regard that the expedited cost of service hearings that Brattle mentioned link transmitter revenue to cost occur annually. Furthermore, the main incentive mentioned by Brattle is a rate of return premium for capital expenditures.[63] This regulatory system has markedly weak cost containment incentives. Thus, there is a strong argument for a stretch factor adder to reflect the weak cost containment incentives of sampled transmitters.

2. Note also that Brattle states on page III-23 of their report that

"the assumption underlying the cost benchmarking and comparison approach to the stretch factor seems to be that the statistical model can estimate the production possibilities frontier, so that a top performer is expected to make no further improvements and gets a stretch factor of zero. There are two concerns with this assumption. First, most regulated firms—and even some firms in markets that are more competitive—are unable to operate on the production possibility frontier. The second is that cost benchmarking and comparison analysis relies on econometric estimates of cost models, the results of which can be sensitive to assumptions, specifications and estimators used, as the Ontario experience shows. In other words, even if some firms were operating on the production possibility frontier, it is unlikely that econometric

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[63] When asked in *DDR* 17.1 of AQCIE-CIFQ-PEG to confirm that rate of return premiums on capex were fairly widely applied Brattle responded that

"The term "fairly widely applied" is subjective and being responsive to this question would require a thorough review of relevant FERC decisions, . . . Moreover, it is not obvious how a policy that increases the return on equity in exchange for meeting policy objectives "materially weakens capex containment incentives" as any effects are likely to be small and of second order relative to cost of service and formula rates in general."

> analysis can explicitly account for all the factors that make one firm be far removed from the frontier and another firm be closer to the frontier. Some amount of misspecification is likely to occur in any econometric modelling, and can be a factor in explaining a firm's performance *vis-à-vis* other firms' performance."

We acknowledge the imprecision of econometric benchmarking but do not believe that its use should be discouraged by a false notion that it must somehow accurately identify the production possibilities frontier. Statistical benchmarking studies used in North American *MRIs* rarely consider the frontier.

6. The *CER* Issue

We do not support the idea of a *CER* for capital cost. Such a mechanism would further weaken incentives for capex containment that are already weakened in the Company's *MRI* by combining indexation of *CNE* revenue with a cost of service treatment of capital revenue. A utility penchant for exaggerating capital cost growth can addressed by other means such as trimming the revenue requirement in rebasings and more assiduous review of business plans. A complicated information quality incentive has been devised by the British energy utility regulator Ofgem to address this problem.

If the Régie remains intent on true ups of capital revenue to capital cost they should apply only to underspends. There is precedent for this in the *MRIs* of New York utilities. A partial true up of revenue to actuals would strengthen HQT's performance incentives.

7. Conclusions

Here are some salient conclusions from our review of the Company's *MRI* evidence in this proceeding.

- The dueling studies of Brattle and PEG illustrate some of the methodological issues that arise, and occasionally spark controversy, when statistical cost research is used in energy utility ratemaking. In this proceeding, the major issues have included the capital cost specification, the sample period, and the best estimation procedure for econometric cost benchmarking. Many regulators elect not to take positions on such issues, but when they do these controversies are often lessened in future proceedings. Regulators should know of the existence of controversies and get a notion of their flavor even if they do not care to master the arcane issues involved.
- While some of the controversies in this proceeding are difficult to resolve, we have demonstrated that Brattle's work has several serious deficiencies. Most if not all of these deficiencies favor the interests of their client.
- While Brattle's study is seriously flawed, with major flaws corrected, it provides the Régie with some useful additional results should it prefer a one-hoss shay capital cost specification. Most notably, there is a positive multifactor productivity trend for the sample period that Brattle recommends. This reflects Brattle's recommendation of a long sample period and their use of the one-hoss shay capital cost specification that most North American utility witnesses favor today. One-hoss shay results are less sensitive than those from geometric decay to a period of high capital spending. Utility witnesses have recently argued in several recent proceedings that "pure" measures of multifactor productivity growth are a reasonable basis for X factors even if they are not carefully designed to be relevant for ratemaking.
- In an application to power transmission, a salient problem in using productivity research to determine the X factor for a revenue cap index is that it is hard to determine, with available data, whether the productivity challenges utilities in the study faced are similar on balance to those that the subject utility will face during the term of its prospective *MRI*. To the extent that the Régie believes that HQT faces less daunting productivity challenges in the next few years than the typical U.S. utility has recently faced, it should consider basing X on a longer sample

period. Other options include a 0% *PMF* growth target and continuing the current annual target for CNE productivity until the end of the current plan.

8. Appendix

More on Benchmark Year Adjustments

In a benchmark year capital quantity calculation, the triangularized-weighted average method for deflating plant value is designed to be used with net plant value and geometric decay, not with gross plant value and one-hoss shay. An example may be able to illuminate our concern.

Assume for simplicity that capital has a three-year service life. In the three years prior to the first or benchmark year for the capital quantity calculation, 1 unit of capital has been added each year. If there is no decay in the quantity, as in a one hoss shay specification, the quantity of capital remaining at the end of three years is three units. Suppose, additionally, that the price of capital (P) is 1 in the first year, 2 in the second, and 3 in the third. The gross value of plant is then 1x1 + 1x2 + 1x3 = 6. The capital quantity can be calculated by dividing gross plant value by an arithmetic average of the three capital prices since gross plant value/average asset price = $6/[(P_1+P_2+P_3)/3] = 6/[(1+2+3)/3] = 3$.

Suppose instead that the quantity of capital is assumed to decay geometrically by 1/3 each year. The quantity of capital at the end of 3 years is then 1x(1/3) +1x(2/3) + 1x(3/3) =6/3 = 2. The corresponding net plant value is 1x[1x(1/3)] +2x1x(2/3) + 3x1x(3/3) =(1+4+9)/3 = 4.67. The capital quantity at the end of three years can be calculated as

net plant value/average asset price = capital quantity = 2.

Then

average asset price = net plant value/2 = {1x[1x(1/3)] +2x1x(2/3) + 3x1x(3/3)}/2

$$= P_1 \times (1/6) + P_2 \times (2/6) + P_3 \times (3/6).$$

The appropriate deflator is a triangularized-weighted average of the three asset prices.

In the Brattle study, the service life was 46 years instead of 3 in this example but the same effect is present. It is not appropriate to use a triangular weighting of asset prices (or construction costs) to deflate gross plant to obtain the initial capital stock needed for the one-hoss shay method. Assuming inflation in construction costs, a simple average of historical asset prices will be lower than a triangularized-weighted average because the lower older prices receive a higher weight in the simple average. Correctly using the lower price for one-hoss shay calculations will result in a higher calculated benchmark quantity and higher cost.