Cost Research Guidelines for Hydro-Québec Transmission

Mark Newton Lowry, PhD

President

17 October 2019

PACIFIC ECONOMICS GROUP RESEARCH LLC

44 East Mifflin, Suite 601

Madison, Wisconsin USA 53703

608.257.1522 608.257.1540 Fax

Table of Contents

1. Introduction

The Régie de l'énergie has established a proceeding to consider productivity and statistical benchmarking studies that can inform the design of revenue cap indexes for Hydro-Québec Transmission ("HQT" or "the Company"). Comments have been requested from the Company and intervenors on appropriate guidelines for these studies. A hearing on the issues has tentatively been scheduled for November.

A parallel proceeding is underway to consider productivity and statistical benchmarking studies that can inform the design of revenue cap indexes for Hydro-Québec Distribution. The Régie received comments on guidelines for these studies and on 15 July 2019 issued guidelines in D-2019-081. In comments filed on 4 October, HQT and its consultant embraced these guidelines as they might apply to the transmission-sector studies and argued that a hearing on the subject was unnecessary.

Pacific Economics Group Research LLC ("PEG") is a North American leader in the design of *mécanismes de réglementation incitative* ("MRIs") for electric and natural gas utilities. Productivity and statistical benchmarking studies that can be used to inform the design of rate and revenue cap indexes are a company specialty. In Canada, we have filed empirical evidence in support of rate and revenue cap index design multiple times in Alberta, British Columbia, and Ontario. On behalf of the *Association Québecoise des Consommateurs Industriels d'Electricité* and the *Conseil de l'Industrie Forestiére du Québec,* we have been active in the proceedings to develop the Hydro-Québec transmission and distribution MRIs and filed comments on the distribution study guidelines. In this document, we present our views on appropriate transmission study guidelines.

The plan for our commentary is as follows. In the next section we discuss key issues in a revenue cap index design study. Section 3 provides pertinent background information that should be considered in the development of transmission study guidelines. Some remarks on transmission study guideline issues are presented in Section 4.

2. Principles and Methods for X Factor Research

In this section of the report we discuss pertinent principles and methods for designing revenue cap indexes. We begin by discussing basic indexing concepts. There follow discussions of the use of indexing research in revenue cap index design and other important methodological issues. Some topics have been discussed in reports we have submitted in other Régie proceedings. Our goal was to put in one convenient place a range of considerations that are pertinent to the development of transmission study guidelines.

2.1. Revenue Cap Index Design

Basic Indexing Concepts

Input Price and Quantity Indexes

The growth rate of a company's cost can be shown to be the sum of the growth in a cost-weighted input price index ("*Input Prices*") and input quantity index ("*Inputs*").

$$\text{growth Cost} = \text{growth Input Prices} + \text{growth Inputs}. \quad [1]$$

These indexes summarize growth in the prices and quantities of the various inputs that a company uses. Capital, labor, and miscellaneous materials and services are the major classes of base rate (non-energy) inputs used in power transmission. Since power transmission technology is unusually capital-intensive, the heaviest weights are placed on the capital subindexes.

Productivity Indexes

The Basic Idea A productivity index is the ratio of an output quantity (aka scale) index ("*Outputs*") to an input quantity index.

$$Productivity = \frac{Outputs}{Inputs}. \quad [2]$$

It is used to measure the efficiency with which firms convert production inputs into the goods and services that they provide. Some productivity indexes measure productivity *trends*. The growth of a productivity trend index is the difference between the growth of the output and input quantity indexes.[1]

growth Productivity = growth Outputs – growth Inputs. [3]

Productivity grows when the output index rises more rapidly (or falls less rapidly) than the input index. Productivity can be volatile for various reasons that include fluctuations in output and/or the uneven timing of certain expenditures. The volatility of productivity growth tends to be greater for individual companies than the average for a group of companies.

The scope of a productivity index depends on the array of inputs that are addressed by the input quantity index. A *multifactor* productivity (*productivité multifactorielle* or "PMF") index measures productivity in the use of multiple inputs. These are sometimes called *total* factor productivity indexes even though they rarely encompass all inputs. Some indexes measure productivity in the use of a subset of inputs such as those that give rise to capital cost or CNE.[2]

Output Indexes The output (quantity) index of a firm summarizes growth in its outputs or operating scale. If the index is multidimensional, growth in each output dimension that is itemized is measured by a subindex, and growth in the summary index is a weighted average of the growth in the subindices.

In designing an output index, choices concerning sub-indices and weights should depend on the way the index is to be used. One possible objective of output research is to study the impact of output growth on *cost.*[3] In that event, the index should be constructed from one or more output (sometimes called scale) variables that measure dimensions of the "workload" that drive cost. If there is more than one output variable, the weights for these variables should reflect their relative cost impacts.

The sensitivity of cost to a small change in the value of an output or any other business condition variable is commonly measured by its cost "elasticity." Cost elasticities can be estimated

---

[1] This result holds true for particular kinds of growth rates.

[2] These indexes are sometimes called *partial* factor productivity indexes.

[3] Another possible objective is to measure the impact of output growth on *revenue*. In that event, the sub-indices should measure trends in *billing determinants* and the weight for each itemized determinant should reflect its share of *revenue*.

econometrically using data on the costs of utilities and on outputs and other business conditions that drive these costs. Such estimates provide the basis for elasticity-weighted output indexes.[4] We will denote a productivity index calculated using a cost-based output index ("$Outputs^C$") as $Productivity^C$.

$$growth\ Productivity^C = growth\ Outputs^C - growth\ Inputs. \qquad [4]$$

This may fairly be described as a "cost efficiency index."

When measuring multifactor productivity, the elasticity weights for a multidimensional output index should come from econometric total cost research. These same weights can in principle be used in a multifactor output index that is used to measure the productivity of CBE or capital inputs. However, elasticity weights obtained from econometric research on CNE or capital cost would also be sensible.

Sources of Productivity Growth

Economists have studied the drivers of productivity growth using mathematical theory and empirical methods.[5] This research has found the sources of productivity growth to be diverse. One important source is technological change. New technologies permit an industry to produce given output quantities with fewer inputs.

A second important source of productivity growth is output growth. In the short run, output growth can spur a company's productivity growth to the extent that it has excess capacity. In the longer run economies of scale can be realized, even if capacity additions are required, if cost nonetheless tends to grow less rapidly than output. Increased capacity utilization and incremental scale economies will typically be lower the slower is output growth.[6]

A third important productivity growth driver is changes in the miscellaneous external business conditions, other than input price inflation and output growth, which affect cost. An example for a

---

[4] An early discussion of elasticity-weighted output indexes is found in Denny, Michael, Melvyn A. Fuss and Leonard Waverman (1981), "The Measurement and Interpretation of Total Factor Productivity in Regulated Industries, with an Application to Canadian Telecommunications," in Thomas Cowing and Rodney Stevenson, eds., *Productivity Measurement in Regulated Industries*, (Academic Press, New York) pages 172-218.

[5] The seminal paper on this topic is Denny, Fuss and Waverman, *op. cit.*

[6] Incremental scale economies may also depend on the current scale of an enterprise. For example, larger utilities may be able to achieve smaller incremental scale economies.

power transmitter is system undergrounding. To the extent that growth of a service territory's urban core(s) requires more undergrounding of transmission facilities, cost surges and PMF growth slows.

System age can drive productivity growth in the short and medium term. Productivity growth tends to be greater to the extent that the capital stock is large relative to the need to replace plant that is nearing retirement age. If a utility requires unusually high replacement capital expenditures ("capex"), capital productivity growth can be unusually slow. The utility is, effectively, replacing depreciated older facilities with newer facilities that will last for many years and may be sized to accommodate future demand growth but are for these reasons more expensive.

The need for replacement capex is potentially cyclical. The degree of cyclicality varies between utilities and also varies between utility industries. A key consideration is the extent to which plant additions were historically bunched due, for example, to rapid demand growth.

Productivity growth is also driven by changes in X inefficiency. X inefficiency is the degree to which a company fails to operate at the maximum possible efficiency. Productivity growth will increase to the extent that X inefficiency diminishes. A company's potential for future productivity growth from this source is greater the higher is its current inefficiency.

Productivity in the management of CNE inputs is driven by the changes in the stock of capital that the company owns. For example, replacement of aging facilities may reduce the need for CNE inputs.

Our analysis suggests that productivity growth can differ between utilities, and over time for the same utility, for reasons that are beyond their control. For example, a utility with unusually slow output growth and an unusually high share of its assets needing replacement can have unusually slow productivity growth.

Use of Index Research in Regulation

Revenue Cap Indexes

Cost theory and index logic support the design of revenue cap indexes. The following basic result of cost theory is useful.

$$\text{growth Cost} = \text{growth Input Prices} - \text{growth Productivity}^C + \text{growth Outputs}^C. \qquad [5]$$

The growth in the cost of a utility is the difference between the growth in its input price and cost efficiency indexes plus the trend in a consistent cost-based output index.

Assuming that growth in the revenue cap index should track growth in the cost of the typical utility, this result provides the basis for a revenue cap index of general form:

$$growth\ Revenue^{Allowed} = growth\ Input\ Prices - (X + S) + growth\ Outputs^{C}_{Utility} \qquad [6a]$$

where

$$X = \overline{Productivity}^{C}_{Industry} + Stretch. \qquad [6b]$$

And S is the stretch factor (*dividend client*). Here $Outputs^{C}_{Utility}$ is an index of growth in the outputs of the subject utility. X, the "X factor," reflects the base $Productivity^{C}$ growth trend ("$\overline{Productivity}^{C}$") of the industry and a stretch factor. The base $Productivity^{C}$ growth trend is typically the trend in the $Productivity^{C}$ of the regional or national utility industry, but could also be the trend of a custom productivity peer group. Notably, a consistent cost-based output index should be used in the supportive productivity research.

An alternative basis for a revenue cap index can be found in index logic. It can be shown that the growth in the cost of an enterprise is the sum of the growth in an appropriately designed input price index and input quantity index:

$$growth\ Cost = growth\ Input\ Prices + growth\ Inputs. \qquad [7]$$

Then,

$$\begin{aligned} growth\ Cost &= growth\ Input\ Prices + growth\ Outputs^{C} - (growth\ Outputs^{C} - growth\ Inputs) \\ &= growth\ Input\ Prices - growth\ Productivity^{C} + growth\ Outputs^{C} \qquad [8] \end{aligned}$$

Scale Escalators

For gas and electric power distributors, the number of customers served is a sensible scale escalator for a revenue adjustment index. The customers variable typically has the highest estimated cost elasticity amongst the scale variables considered in econometric research on the cost of energy distributors. A scale escalator that includes delivery volumes and/or peak demand as scale variables diminishes a utility's incentive to promote DSM. The length of distribution lines is another pertinent scale variable for a distribution revenue cap index but consistently reported data on line lengths are not readily available for a large sample of U.S. electric utilities.

In power transmission no single scale variable is dominant. Data are readily available in the United States on lengths of transmission lines. A multidimensional scale index with weights based on econometric research on the drivers of transmission cost is therefore more feasible.

Revenue cap indexes do not always include explicit scale escalators. A revenue adjustment index of general form

$$\textit{growth Revenue}^{Allowed} = \textit{growth GDPIPI} - X \quad [9a]$$

where

$$X = \overline{Productivity}^{C}_{Industry}$$

is equivalent to the following:

$$\textit{growth Revenue}^{Allowed} = \textit{growth GDPIPI} - (X + S) + \textit{growth Outputs}_{Utility} \quad [9b]$$

where

$$X = \overline{Productivity}^{C}_{Industry} + \textit{Expected}\ (\textit{growth Outputs}_{Utility}) \quad [9c]$$

It can be seen that if the revenue cap indexes do not otherwise compensate the utility for growth in its operating scale, the expected scale index growth of the utility is an implicit stretch factor. The value of this implicit stretch factor will be larger the more rapid is the utility's expected scale index growth.

2.2. Capital Specification

Monetary Approaches to Capital Cost and Quantity Measurement

The capital cost ("CK") specification is especially important in statistical research on the transmission cost and PMF because transmission technology is unusually capital intensive. The annual cost of owning plant includes depreciation expenses, a return on investment, and some taxes. If the asset is valued in replacement dollars, this cost may also be net of any capital gains or losses.

Monetary approaches to the measurement of capital prices and quantities are conventionally used in statistical research on the total cost and PMF trends of U.S. utilities. These approaches permit the decomposition of capital cost into a consistent capital quantity index ("*XK*") and capital price index ("*WK*") such that

$$CK = WK \cdot XK.^{7} \qquad [10]$$

The growth rate of capital cost then equals the sum of the growth rates of the capital price and quantity indexes.

When using U.S. electric utility operating data, the capital quantity indexes are typically constructed by deflating the value of gross plant additions using a Handy Whitman electric utility construction cost index and subjecting the resultant quantity estimates to a mechanistic decay specification. The corresponding capital price indexes are calculated from these same construction cost indexes and from data on the rate of return on capital.[8]

Alternative Monetary Approaches

Several monetary methods have been established for measuring capital costs, prices, and quantities. One key issue in the choice between some monetary methods is the assumed pattern of decay in the quantity of capital that results from plant additions in a given year. Decay can result from many factors including wear and tear, casualty losses, obsolescence, and rising maintenance costs and declining reliability as assets age. Another issue in the choice between monetary methods is whether plant is valued in historic or current (replacement) dollars.

Several monetary approaches are candidates for a transmission productivity and benchmarking study. We briefly discuss each in turn to give the Régie some insight into the potential issues.

1. <u>Geometric Decay</u> ("GD") Under the GD method, the flow of services from investments in a given year declines at a constant rate over time. In each period *t*, the quantity of capital at the end of

---

[7] In rigorous statistical cost research, it is often assumed that a capital good provides a stream of services over some period of time (the "service life" of the asset). The capital *quantity* index measures this flow, while the capital *price* index measures the trend in the simulated price of renting a unit of capital service. The design of the capital service price index is consistent with the assumption about the decay in the service flow. The product of the capital service price index and the capital quantity index is interpreted as the annual cost of using the flow of services.

[8] If taxes are included in the study, capital prices are also a function of tax rates.

the period ("XK_t") is related to the quantity at the end of *last* period and the quantity of gross plant *additions* ("XKA_t") by the following "perpetual inventory" equation:

$$XK_t = XK_{t-1} \cdot (1-d) + XKA_t \quad [11a]$$

$$= XK_{t-1} \cdot (1-d) + \frac{VKA_t}{WKA_t}. \quad [11b]$$

Here d is the (constant) rate of decay in the quantity of older capital. In relation [11b], the quantity of capital added each year is measured by dividing the reported value of gross plant additions by the contemporaneous value of an asset price index ("*WKA*").

The GD method assumes a replacement (i.e., current dollar) valuation of plant. Cost is computed net of capital gains and the capital service price reflects this.

2. One-Hoss-Shay ("OHS") Under the OHS method, the flow of services from a plant addition is assumed to be constant until the end of its service life, when it abruptly falls to zero. This is the pattern that is typical of an incandescent light bulb. The quantity of plant at the end of the year is the sum of the quantity at the end of the prior year plus the quantity of gross plant additions less the quantity of plant retirements ("XKR_t").

$$XK_t = XK_{t-1} + XKA_t - XKR_t. \quad [12a]$$

$$= XK_{t-1} + \frac{VKA_t}{WKA_t} - \frac{VKR_t}{WKA_{t-s}}. \quad [12b]$$

Since reported utility retirements are valued in historic dollars, the quantity of retirements in year t is calculated by dividing the reported value of retirements by the value of the asset price index for the year when the assets retired were added ($t-s$).

Plant is once again valued at replacement cost. Cost is computed net of capital gains and the capital service price reflects this.

3. Hyperbolic Decay ("HD") Under the HD specification, the decay of the flow of services from capital assets increases as they age. Plant is once again valued at replacement cost. Cost may be computed net of capital gains and if so, the capital service price reflects this.

4. Cost of Service ("COS") Productivity studies have many uses, and the best methodology for one application may not be best for another. One use of productivity research is to measure a utility's operating efficiency. Another is to choose an X factor for a *formule d'indexation*. In North America, the calculation of capital cost for ratemaking typically involves an historical valuation of plant and straight-line depreciation. Absent a rise in the target rate of return, the cost of owning each asset shrinks over time as depreciation reduces net plant value and the return on rate base.

   The GD, HD, and OHS approaches for calculating capital cost use assumptions that are different from those used to calculate capital cost under traditional ratemaking. For example, all assume a current valuation of plant. The capital price index simulates the trend in the price of capital services in a competitive rental market. The derivation of a revenue cap index formula using index logic which we detailed on page 6 above does not require either of these assumptions.

   An alternative capital cost specification has been developed which decomposes capital cost, computed using a simplified version of traditional COS accounting, into a price and quantity index. This approach is based on the assumptions of straight-line depreciation and historic valuation of plant. Under this approach, capital cost is not intended to simulate the cost of capital services in a competitive rental market, and the capital price is not a simulated rental price. However, the formulae are complicated, making them more difficult to code and review.

Capital Cost Controversies

The capital cost specifications used in productivity research have been a central issue in recent MRI proceedings. These include the second Alberta generic MRI proceeding, the recent Ontario gas utility MRI proceeding, and a recent Massachusetts power distribution MRI proceeding. In these debates, utility witnesses have typically championed a particular OHS approach while other witnesses have championed GD or an alternative method.

Critics of GD have stressed the following points:

- The service flows of individual electric utility assets do not typically exhibit a GD pattern.

- The constant depreciation rate assumed under GD is accelerated in the early years of an asset's life compared with the straight-line depreciation featured in traditional cost of service regulation.

Critics of OHS make the following points:

- In North American energy utility productivity studies, the OHS assumption is, due to data limitations, typically applied to *total* annual distribution plant additions, and the assets encompassed have varied expected service lives. An assumption of declining service flow from each cohort of heterogenous assets makes sense even if the service flow of individual assets is constant.
- A constant service flow is also inconsistent with the tendency of utility assets to have rising maintenance expenses and declining reliability as they age.
- The simple approach to OHS which consultants have typically used does not capture the cost advantages of extending the service lives of assets.
- Relation [12b] indicates that OHS requires deflation of the annual value of retirements, but the average service lives of these assets is unknown. OHS results are unusually sensitive to the assumed average service life, and this can be used as a fudge factor to produce client-favorable results. The appropriate average service life is controversial.

Hyperbolic decay constitutes an intriguing middle ground between the GD and OHS specifications but has rarely if ever been used in the statistical cost research for MRI proceedings.

Benchmark Year Adjustments

Utilities have diverse methods for calculating depreciation expenses that they report to regulators. When calculating capital quantities using a monetary method, it is therefore customary to rely on the reporting companies chiefly for the value of *gross* plant additions and then use a standardized decay specification for all companies. Since some of the plant a utility owns may be 40-60 years old, it is desirable to have gross plant addition data for many years in the past.

For the earlier years that are pertinent in these calculations the desired gross plant addition data are unfortunately unavailable. It is then customary to take the total value of plant, with its diverse vintages, at the end of this limited-data period and to estimate the quantity of capital that it reflects using construction cost indexes from earlier years and assumptions about the historical plant addition pattern. The year for which this estimate is undertaken is commonly called the "benchmark year" of the capital quantity index. Since the estimate of the capital quantity in the benchmark year is inexact, it is preferable to base capital and total cost research on a sample period that begins many years after the benchmark year. Research on capital and total cost will be less accurate to the extent that this is impossible.

2.3. Other Methodological Issues

Long-Run Productivity Trends

To calculate the long-run productivity trend using indexes it is common to use a lengthy sample period for the index calculation. A period of at least ten years is needed to smooth the inherent volatility of some cost and output data. A considerably longer period may be needed to the extent that the industry as a whole is subject to a pronounced replacement cycle. However, a period of more than twenty-five years may be unreflective of current technological change and other productivity drivers. Moreover, consistent series of quality data are sometimes unavailable for long sample periods. The need for a long sample period to capture the long term productivity trend is lessened to the extent that the input index doesn't assign a heavy weight to volatile costs (e.g., pension and uncollectible bill expenses), the output index does not assign a heavy weight to volatile output variables, and the industry does not display a marked replacement cycle.

Dealing with Cost Exclusions

Many MRIs do not use rate or revenue cap indexes to address certain costs. The exclusions affect the method for calibrating the X factor. Suppose, for example, that costs of taxes and pensions are going to be Y factored under the MRI. These costs should then be excluded from the definition of cost that is used in the productivity and any input price research.

2.4. Stretch Factor

The stretch factor term of an MRI should reflect an expectation of how the productivity growth of the subject utility will differ from the base productivity growth target. This depends in part on how the performance incentives generated by the plan compare to those in force for utilities in the productivity studies that are used to set the base productivity trend. PEG has developed an incentive power model that is useful for making these comparisons.

The stretch factor should also depend on the company's operating efficiency. Statistical benchmarking studies can be used to measure efficiency. When the stretch factor is linked to the results of a good benchmarking study, utility performance incentives can be strengthened.

3. Background

3.1. Québec Regulation

In Decisions D-2018-001 and D-2019-060, the Régie established key provisions of an MRI for Hydro-Québec's transmission services. Growth in HQT's allowed revenue (*revenu requis*) for most *charges nettes d'exploitation* ("CNE") and some other costs will be escalated each year by a revenue cap index.[9] Most capital costs will continue to be subject to cost of service regulation.

The revenue cap index formula (*formule d'indexation*) will include an inflation factor (*facteur d'inflation*), productivity (or X) factor (*facteur de productivité*), and a growth (or C) factor (*facteur de croissance*). The inflation factor will be a cost-weighted average of growth in Statistics Canada's consumers price index (*indice des prix á la consommation*) for Québec ("$IPC^{Québec}$") and Québec average hourly earnings (*rémuneration hebdomadaires des salariés*). The C factor will be similar to that in the formula (*formule paramétrique*) that HQT currently uses in its rate cases (*dossiers tarifaires*) to evaluate growth in CNE which results from plant additions in the categories *maintien et amelioration de la qualité du service* and *croissance des besoins de la clientéle.*[10]

A 0.57% X factor will apply during at least the first few indexing years of the plan. This number was based on a Kahn method calculation undertaken by HQT using its own CNE data. In D-2019-060, the Régie noted the sensitivity of results to the choice of a sample period and chose the value resulting from a ten-year period. The Régie also approved a 0% S factor. The absence of suitable benchmarking studies on which to base S was a stated reason for this decision.

---

[9] The costs addressed by the *formule d'indexation* will exclude retirement costs but include taxes, capitalized labor costs (*coûts liés aux prestations de travail relatives aux investissements*), purchases of transmission services (*achats de services de transport*), other operating revenues such as *facturation externe* and *autres revenus de facturation interne* (e.g., *rendements sur les actifs des fournisseurs internes*) and *intérêts reliés au remboursement gouvernemental.* (D-2018-001, p. 83).

[10] The growth in CNE resulting from plant additions in these categories is based on an assumption about the incremental CNE growth related to investments as outlined in Attachment J of HQT's OATT. In the May 2019 version of HQT's OATT, the present value of the CNE resulting from the additions to the grid over a 20-year period is estimated to be 19% of the relevant plant additions and customer contributions, where HQT assumes responsibility for CNE expenses.

A formula was also approved to appraise growth in the company's capital cost (*dépenses en capital*). This formula also features an inflation factor, X factor, and C factor. The C factor is the growth in HQT's installed transmission capacity, data on which are published in the Company's annual reports.

The Régie authorized productivity studies, for execution during the term of the approved MRI, which are pertinent to the choice of X factors for HQT's *formule d'indexation* and *formule paramétrique*. These studies may prompt the Régie to revise the X factor for the last year of this MRI and/or be used to set the X factor of any succeeding MRI, and/or to upgrade the *formule paramétrique* for *dépenses en capital*. Statistical benchmarking studies were also authorized which may inform the choice of S factors.

A parallel proceeding is underway to consider productivity and statistical benchmarking studies that can be used to inform the design of revenue cap indexes for Hydro-Québec Distribution. In D-2019-011, the Régie requested comments on guidelines for these studies and on 15 July 2019 the Régie in D-2019-081 issued guidelines (*principes directeurs*).

In April 2019, the Régie in D-2019-047 requested comments on appropriate guidelines for the transmission productivity and benchmarking studies. On 4 October, HQT filed comments that generally embraced the guidelines established by the Régie in D-2019-081 as they might apply to the transmission-sector studies and commented that a hearing on the subject was unnecessary. In a message on 20 September, the Régie requested comments on the transmission study from other parties and their statistical cost research consultant.

3.2 Ontario Transmission MRI Proceedings

Two recent Ontario Energy Board proceedings have considered the design of MRIs for transmission services of Hydro One Networks. The first proceeding concerned Hydro One Sault Ste. Marie, a small transmission subsidiary serving a region on the eastern shore of Lake Superior. The second pertained to Hydro One's main transmission business.

In both proceedings, Hydro One proposed a revenue cap index that would apply to capital cost as well as CNE. The proposed indexes included an inflation factor, productivity factor, and stretch factor but no growth factor.[11] In the plan for its main transmission business, Hydro One has also proposed a

[11] Hydro One does not expect much growth in the scale of its transmission business in the next few years.

capital factor that would compensate the company for the difference between the growth in its approved multiyear capital revenue requirement and the growth of the revenue cap index which would otherwise occur.

Hydro One proposed 0% productivity factors and stretch factors for both companies. In June 2019 the Board in Decision and Order EB-2018-0218 chose a 0% productivity factor and a 0.3% stretch factor for Hydro One Sault Ste. Marie. The other proceeding has not concluded.

Hydro One presented statistical cost research in support of its revenue cap index proposals. This research included an econometric total transmission cost benchmarking study and calculations of transmission PMF trends for Hydro One and a large sample of U.S. electric utilities. The studies were undertaken by Power Systems Engineering ("PSE"), a Madison, Wisconsin consultancy.[12] The Board commissioned PEG to prepare independent transmission productivity and benchmarking studies.

Several aspects of these studies merit note.

- Both consultants employed the GD approach to the calculation of capital costs.
- PSE obtained its transmission operating data from SNL Financial, a commercial vendor owned by S&P Global. Parties to the proceeding were obliged to sign confidentiality agreements in order to peruse the data of each consultant.
- Both consultants considered Hydro One's transmission PMF trend and total cost performance from 2005-2022. Thus, the performance inherent in Hydro One's multiyear cost proposal was considered as well as its historical cost performance.
- Both consultants used multidimensional output indexes in their productivity research. These indexes featured two scale variables: transmission line km and ratcheted peak demand.[13] The weights for these subindexes were drawn from each consultant's econometric cost research.

---

[12] Study author Steven Fenrick was formerly an employee of PEG.

[13] The term ratcheted peak demand means that the value of the variable equals the highest monthly peak demand that has yet been attained during the sample period. This variable is a reasonable proxy for the expected maximum possible peak demand for grid services.

- In the ongoing Hydro One proceeding, the utility consultant chose a thirteen-year sample period from 2005 to 2016 during which the PMF of sampled utilities averaged a 1.45% annual decline.[14] PEG used a 21-year sample period from 1996 to 2016 during which PMF growth averaged a 0.25% annual decline. The slowdown in PMF growth was the result of numerous circumstances that included high capex to replace aging facilities, access remote renewable resources, and improve the functioning of bulk power markets, new service quality standards, and the adoption by many utilities of formula rate plans for their transmission services.

These Ontario studies illuminate the path forward for the Québec transmission productivity and benchmarking studies but can be improved upon in many ways to make them suitable for HQT.

- These were first-generation studies. The budgets provided by the OEB for the productivity and benchmarking studies by its consultant were quite limited. PEG has at Board Staff's request devoted a lot of its effort in the ongoing Hydro One proceeding to developing alternative mechanisms for providing extra capital revenue.
- The studies can be upgraded in many ways. For example, there is much more to learn about the relative importance of drivers of transmission cost. This is important since we want to learn the productivity growth that should be expected of transmitters facing cost pressures like those of HQT. Productivity calculations and econometric benchmarking models can be upgraded.
- U.S. transmission operating data are now available for 2017 and 2018, and an update would be desirable to shore up our understanding of recent trends and sharpen econometric model parameter estimates.
- Geometric decay was the only capital cost specification considered.
- Accurate statistical benchmarking of HQT's cost must still be done and is likely to be quite challenging.
- CNE and capital cost performance and productivity trends are issues in this proceeding as well as total cost performance and PMF trends.

---

[14] In reply evidence filed on October 15th, PSE reported a -1.61% transmission PMF trend for the longer 2005-2018 period. However, no other party to the proceeding has vetted these calculations.

3.3 The Brattle Group

HQT informed the Régie in its October 4 letter that it had retained the Brattle Group ("Brattle") to undertake the benchmarking and productivity studies. This selection is notable in several respects.

- Brattle has never to our knowledge released a publicly available study of power transmission productivity. They previously released a study of U.S. power distribution productivity in the second Alberta generic MRI proceeding and a study of U.S. gas utility productivity in an Ontario MRI proceeding. In the Alberta proceeding, most of the data that Brattle used were obtained from National Economic Research Associates ("NERA"), who prepared a productivity study for the Alberta Utilities Commission in its first generic MRI proceeding.[15] In the Ontario proceeding, Brattle obtained most of their data from PEG, the consultant for the Ontario Energy Board. Both of these Brattle studies were funded by utilities.
- In the Ontario proceeding, Brattle embraced the geometric decay capital cost specification used by PEG whereas in the more recent Alberta proceeding Brattle embraced the one hoss shay approach that NERA had used.
- PEG knows of few statistical energy utility benchmarking studies by Brattle that are in the public domain. Another Brattle principle recently prepared a benchmarking study on the CNE of BC Hydro for a revenue requirement application.[16] This study employed simple unit cost metrics (e.g., $ per delivered MWh). Power production CNE, other CNE, and total CNE were separately benchmarked. Transmission CNE was not.

---

[15] Dr. Augustin Ros, now with Brattle, participated in this study.

[16] British Columbia Utilities Commission Project No. 1598990, Appendix T.

4. Commentary on Transmission Study Guidelines

In this concluding section of our report we comment on transmission study guidelines. After first providing some overview remarks, we consider the Régie's pronouncements on various guideline issues in the parallel distribution proceeding before providing our own comments on these and other issues. Generally speaking, we embrace the Régie's guidelines as they might apply to the transmission studies. However, we believe that some of the guidelines should be refined, extended, revised, or clarified. We agree with the Company that an *audience* is not necessary.

4.1. Overview

Here are some general considerations that are pertinent in establishing guidelines for productivity and statistical benchmarking studies.

- The Régie needs good information on which to base its X and S factor decisions. There is a particular need in the first proceeding of this kind for the Régie to learn about salient methodological issues and options. More complete evidence now will reduce the likelihood that the Régie will commit to suboptimal methods.
- There have been controversies over the best methods for productivity and benchmarking research in MRI proceedings, including some recent ones. Controversial issues have included the sample period, capital cost specification, and econometric model variables. Alternative methods in some cases produce materially different results but in many cases do not.
- Since there are many methodological issues in a proceeding of this kind, and only some are important, witnesses should focus most of their commentary on important issues, and make clear which issues are less important if they choose to discuss them.
- Statistical cost research methods, like other kinds of technology, continue to evolve, and debates in MRI proceedings can stimulate progress.
- Bold positions by witnesses on X and S factors and methodological issues can advance their client's interests. An extremely favorable X factor recommendation might, after all, be chosen by the regulator. The regulator might instead choose a number in the middle of the

various witness recommendations, and an extreme recommendation can materially shift the midpoint. Bold positions on X and S factor issues are often supported by histrionic language.

- Extreme controversy may also encourage regulators to abandon the use of statistical cost research in regulation.
- Witnesses could in principle be right about the appropriateness of a particular negative (or positive) X factor but use the wrong methodology to substantiate it. Correct methods that are not too complicated should generally be encouraged because they will be more serviceable in the long run.
- Regulators in some jurisdictions (e.g., Alberta) tend not to take positions on methodological issues that arise in productivity research. When this happens, similar controversies are more likely to arise in later proceedings. Regulators in other jurisdictions have embraced specific methods and thereafter been resistant to new evidence that alternative methods are preferable. Striking the right balance between these approaches is difficult.

4.2. General Principles

Régie Decision

On pages 23-24 of D-2019-081 it is stated that

La Régie retient comme principes directeurs généraux les éléments suivants :

1. **L'étude PMF doit être applicable au Distributeur et servir à mesurer la croissance de la productivité globale d'une industrie de référence pertinente.**
2. **L'étude PMF doit être accompagnée d'une étude statistique comparative (Statistical Benchmarking) ou d'une étude économétrique de comparaison des coûts pour établir un Facteur S.**
3. **L'étude PMF doit faire la comparaison de manière transparente, sur la base de données fiables et accessibles au public.**
4. **L'étude statistique comparative ou l'étude économétrique de comparaison des coûts requiert les données propres au Distributeur. Il s'agit des données disponibles dans les rapports**

annuels et autres publications d'Hydro-Québec et du Distributeur. Au besoin, les experts pourront soumettre des demandes de données spécifiques additionnelles au Distributeur.

5. **Les résultats détaillés des études doivent être déposés dans un chiffrier électronique. Les calculs produits à l'aide de programmes informatiques doivent être suffisamment documentés afin de permettre à la Régie et aux intervenants de les comprendre, de les valider et, au besoin, de les reproduire.**

6. **Toutes les hypothèses, les choix méthodologiques et la calibration des modèles, les intrants, les extrants et les calculs doivent être documentés afin de bien comprendre les résultats et de faciliter la réalisation d'analyses de sensibilité par la Régie et les intervenants. Des analyses de sensibilité doivent également être présentées afin de permettre de comprendre l'impact de l'utilisation d'une hypothèse, d'un choix méthodologique, intrant, extrant ou calcul pouvant faire varier de façon significative les résultats.**

7. **L'étude PMF et l'étude statistique doivent être applicables par la Régie et lui être utiles pour fixer les tarifs du Distributeur.**[17]

PEG Comments

PEG embraces these general guidelines with the following exceptions, qualifications, and suggestions.

- We believe that the Régie should expressly require the preparation of power transmission industry productivity studies. The recently-filed studies in Ontario MRI proceedings show that they are feasible. Brattle has not, to the best of our knowledge, previously prepared a transmission productivity study and could argue that a power distribution productivity study is an acceptable alternative. If this seems unlikely, please note that NERA has argued in two MRI proceedings that its power distribution productivity studies were satisfactory evidence for the choice of productivity factors for *gas* utilities. In Alberta's two generic MRI proceedings, the commission based productivity factors for gas utilities on power distribution productivity evidence.

---

[17] D-2019-081, R-4057-2018 Phase 2, 2019-07-15, pp. 23-24.

- If Brattle has never done a transmission productivity study, their data gathering and processing tasks would be much easier if they could rent the data from a respected commercial vendor like SNL Financial, like PSE did in the Hydro One Transmission proceeding. SNL's operating data, like those of PEG, are gathered from public sources with considerable effort and are not typically available for examination by other parties to an MRI proceeding until they sign a confidentiality agreement.[18] Parties who sign confidentiality agreements are free to use the data in productivity and cost benchmarking during the course of the proceeding. We therefore encourage the Régie to reconsider whether such agreements are permissible in this proceeding.

- We also encourage the Régie to use stronger language to oblige HQT to accede to reasonable information requests. Many of the Company data required for quality benchmarking studies will not be readily available. If Brattle does not do an econometric total cost benchmarking study, HQT may be incentivized to claim that it cannot provide the capital cost data required for such a study to other consultants. As discussed in Section 2.2 above, it is desirable to have the requisite capital cost data (e.g., gross plant additions) for a longer period than the period for which costs are benchmarked.

  In Ontario, standardized capital cost data are available for most utilities since 1989.[19] Standardized CNE data are available since 2002. In Alberta, standardized cost data are available for most utilities since 2005. In both provinces, detailed cost data must be reported annually and conform to a uniform system of accounts.

  Pension and benefit expenses should be itemized for easy removal. Non-quantitative information may also be needed from HQT to do good benchmarking work.[20]

---

[18] PEG is open to making its gathered transmission data public but requests the same confidentiality treatment that the Régie approves for Brattle.

[19] Hydro One Networks is one of the few Ontario utilities for which the requisite capital cost data are available only since 2002.

[20] Legitimate questions of this kind would include "Please discuss the special cost challenges that HQT faces" and "Please explain the revenue requirement category labelled '*autre composants du coût des avantages sociaux futurs.*'"

- The Régie decided not to apply the *formule d'indexation* to capital cost, but approved a *formule paramétrique* to appraise these costs. This raises the question of whether the consultants should provide itemized productivity and/or benchmarking results for indexed costs and capital costs as well as for total costs. PEG provided itemized econometric benchmarking results for CNE, capital cost, capital expenditures, and total cost in a report that it recently prepared for the Ontario Energy Board in a Toronto Hydro IR proceeding.[21] We routinely report the productivity trends of CNE and capital inputs as well as PMF trends.
- Brattle may provide only CNE benchmarking results, as it did in the ongoing BC Hydro proceeding. CNE benchmarking is pertinent in the current MRI, where the *formule d'indexation* with its S factor applies chiefly to CNE. However, it would be much less useful in a *dossier tarifaire* or to a future MRI where capital revenue is indexed. The Régie should consider whether it is satisfactory for HQT not to provide a quality benchmarking study that addresses its capital cost.

4.3. Sampled Companies (*Echantillon d'Entreprises*)

Régie Decision

In D-2019-081 it is stated on that

Ainsi, la Régie demande à chaque expert :

- **de justifier le choix des entreprises;**
- **de choisir des entreprises qui proviennent d'une industrie (ou d'industries) représentative(s) de la tendance de la productivité du Distributeur;**
- **de sélectionner des entreprises qui doivent être suffisamment nombreuses et diversifiées afin de représenter adéquatement la tendance de la productivité de l'industrie (ou des industries) dont elles sont issues;**

[21] EB-2018-0165, Exhibit M1, 22 May 2019.

- **d'utiliser toutes les entreprises de l'échantillon afin de calculer les résultats, tout en maintenant la possibilité, aux fins des recommandations à l'égard du Facteur X, de choisir un sous-ensemble d'entreprises;**
- **de produire des analyses de sensibilité à l'égard du Facteur X, en retranchant à l'échantillon les entreprises qui influencent de façon significative sa valeur.**[22]

On page 21 of D-2019-081 it is stated that

> **La Régie est d'avis que la réalisation d'une étude statistique de comparaison des coûts rend la réalisation d'une étude PMF propre au Distributeur non nécessaire, contrairement à ce que recommande PEG. L'étude PMF concerne l'industrie dans son ensemble et non pas le Distributeur. La Régie estime que l'inclusion des données propres au Distributeur pourrait donner lieu à des débats sur la comparabilité des données. Les données du Distributeur pourraient également être perçues comme atypiques et fausser l'évaluation de la tendance de l'industrie.**[23]

PEG Comments

- The productivity peer groups for X factor calibration studies should ideally face productivity growth drivers that are similar to those facing HQT. However, choosing a productivity peer group can be a controversial exercise. Quite often, the criteria for peer group selection ventured by witnesses in MRI proceedings have seemed more pertinent for a comparison of cost *levels* than to a comparison of productivity trends. Peer group selection criteria are often proffered without empirical substantiation. The productivity growth drivers facing HQT are not necessarily similar to those in Ontario or the northeast U.S. For example, HQT may not have the same large need for replacement capital expenditures in the next five years that Hydro One Networks has had in the last decade.

- We encourage the Régie to reconsider its decision not to include HQT in the productivity trend study. Productivity trend results for HQT can inform the selection of sample periods and peer groups for industry productivity studies and need not be included in industry averages. For example, if the recent productivity trend of HQT has been more rapid than the U.S. norm, why is

[22] D-2019-081, *op. cit*., p. 25.

[23] D-2019-081, *op. cit*., p. 21.

this so? HQT productivity calculations would also be pertinent to the choice of an S factor and help the Régie ascertain whether the Company's performance is improving. Total cost benchmarking studies generally do not produce the same results as productivity studies concerning cost efficiency trends because they have different output specifications and control for changes in additional business conditions. Moreover, HQT may not file a total cost benchmarking study in this proceeding. The Ontario Energy Board routinely computes the productivity trends of jurisdictional power distributors and has asked several other utilities, including Hydro One Transmission, Ontario Power Generation, and the new gas utility "Amalco" to calculate and report their PMF growth. Calculation of HQT's productivity growth will involve little incremental effort if the requisite data for an econometric total cost study are gathered.

- U.S. data should be the primary basis for the benchmarking and productivity studies. Data from Hydro One are also pertinent if available.

4.4. Sample Period (*Horizon de Temps*)

Régie Decision

The Régie stated in D-2019-081 that

Ainsi, afin de s'assurer que les études PMF permettent de mesurer adéquatement ce facteur, la Régie établit les principes directeurs spécifiques suivants quant à l'horizon de temps :

- **L'horizon de temps doit être d'au moins 10 ans et permettre de mesurer la croissance à long terme de l'industrie. Cet horizon doit être suffisamment long pour atténuer les variations qui pourraient fausser la mesure de la croissance de la productivité à long terme de l'industrie de référence.**
- **Les experts doivent expliquer comment l'horizon choisi permet de mesurer adéquatement la croissance de la productivité à long terme de l'industrie de référence.**
- **Toutes les années de l'horizon choisi doivent être utilisées afin de calculer les résultats. Cependant, les experts peuvent, aux fins de leurs recommandations à l'égard du Facteur X, choisir un horizon plus court à l'intérieur de cet horizon.**

- **Les experts doivent produire des analyses de sensibilité à l'égard du Facteur X en retranchant à l'horizon choisi les années qui influencent de façon significative sa valeur.**[24]

PEG Comments

The sample period for X factor calibration studies has been an area of major controversy in some recent MRI proceedings. Given what is already known about U.S. transmission productivity, the choice of a sample period is if anything more important in this proceeding than in the analogous proceeding for Hydro-Québec Distribution. The Régie seeks to establish long-run productivity trends. Evidence from the recent Ontario MRI proceedings suggests that a period of ten years is insufficient to identify the long-run transmission productivity trend of U.S. electric utilities. Even a period of twenty years may be insufficient. The data required for a twenty-year sample period are available from SNL Financial. In the second generic Alberta MRI proceeding, Brattle submitted productivity evidence for a 1972-2014 sample period exceeding forty years. We accordingly urge the Régie to require a full sample period of at least twenty years. Consultants would still be free to choose a shorter sample period as the basis for their X factor recommendations.

4.5. Calculation of Outputs (*Extrants*) and Inputs (*Intrants*)

Régie Decision

It is stated on p. 26 of D-2019-081 that

La Régie considère que la calibration des méthodologies relève de l'expert. (…) elle demande à chaque expert d'utiliser, dans son étude PMF, des coûts et des formules d'indexation cohérents avec les coûts et la formule d'indexation pris en compte dans le MRI du Distributeur.[25]

PEG's Questions and Comments

This guideline is sensible but raises several issues. One is that the Régie has already chosen scale escalators for a *formule d'indexation* for the Company's CNE and a *formule paramétrique* for the appraisal of the Company's *dépenses en capital*. In Section 2.1 of this report, we discussed the use of multidimensional output indexes with cost elasticity weights. These can be developed at low

---

[24] D-2019-081, *op. cit*., pp. 24-25.

[25] *Ibid*., p. 26.

incremental cost from the results of econometric benchmarking studies. Are the consultants in this proceeding obliged to use output indexes in their productivity research that are consistent with the Régie's chosen escalators, or are they free to use alternative escalators that have stronger empirical support and/or better incentive properties?

Another issue is that exact conformance of the costs in the studies to the costs that will be subject to the *formules d'indexation* may be problematic. For example, taxes and capitalized labor are inherently capital costs. The former can be volatile, complicating identification of a longer-term CNE productivity trend. Data on capitalized transmission labor expenses are not itemized on FERC Form 1. Neither are data on other transmission operating revenue.

Our analysis in Section 2.2 suggests that the capital cost specification is the chief issue in the calculation of input quantities. Results using the OHS, GD, HD, COS, and Kahn methodologies can all be pertinent to the choice of transmission X and S factors if done correctly.[26] Since Brattle has recently embraced the use of OHS in a power distribution application, capital cost specifications may be a major area of controversy in the upcoming proceeding.

4.6. Adjustment Factors

Régie Decision

La Régie retient de la preuve que le recours aux facteurs d'ajustement relève de l'expert. Elle estime donc que les experts, s'ils le jugent nécessaire, peuvent recourir à des facteurs d'ajustement.

Elle précise cependant que toutes les hypothèses liées aux facteurs d'ajustement doivent être documentées afin de bien comprendre les résultats et de faciliter la réalisation d'analyses de sensibilité par la Régie et les intervenants. Elle demande également que des analyses de sensibilité soient présentées afin de permettre de comprendre l'impact de chacun des facteurs d'ajustement utilisés sur les résultats.[27]

---

[26] We do not mean to suggest that each consultant should consider all of these specifications.

[27] D-2019-081, *op. cit*., p. 26.

PEG Comments

PEG notes that the principal means of adjusting or customizing results is likely to be the choice of a sample period.

4.7. Other Issues

S Factor

In Section 2.4 we noted that the S factor of a revenue cap index should depend in part on how the expected incentive power of the MRI compares to the incentive power of the utilities in the productivity sample. This issue looms especially large in this proceeding because many U.S. utilities have operated under formula rate plans in recent years and these plans weakened their cost containment incentives.

PEG has developed a model that is useful for comparing the incentive power of alternative regulatory systems. We presented results of some research using this model in our Phase 1 Report in proceeding R-3897-2014. Results were also presented in a white paper on MRIs that we recently wrote for Lawrence Berkeley National Laboratory. Our current incentive power model was calibrated at a time when utility productivity trends were more rapid than they are today. The model would be more credible in this proceeding if its parameters were recalibrated to be more reflective of current conditions.

Statistical Benchmarking

Statistical benchmarking results will be useful in general rate cases even if the Régie decides to return to cost of service regulation for HQT. In Ontario, econometric total cost benchmarking is used to assess the forward test year cost proposals of utilities as well as to set S factors. The Board should clarify whether it would like to have the consultants benchmark HQT's forecasted costs.

References

Denny, Michael, Melvyn A. Fuss and Leonard Waverman (1981), "The Measurement and Interpretation of Total Factor Productivity in Regulated Industries, with an Application to Canadian Telecommunications," in Thomas Cowing and Rodney Stevenson, eds., *Productivity Measurement in Regulated Industries*, (Academic Press, New York) pages 172-218.

Handy-Whitman Index of Public Utility Construction Costs (2013), Baltimore, Whitman, Requardt and Associates.

Tornqvist, L. (1936), "The Bank of Finland's Consumption Price Index," *Bank of Finland Monthly Bulletin*, 10, pages 1-8.