X Factor Calibration Guidelines for Hydro-Québec Distribution

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1 Introduction

In Decision D-2017-043 the Régie de l'energie ("Régie") established some key provisions of a *mécanisme de réglementation incitative* ("MRI") for Hydro-Québec Distribution ("HQD" or "the Company"). The MRI will take the form of a multiyear rate plan with a revenue cap (*plafonnement des revenus*). Growth in HQD's allowed revenue (*revenu requis*) will be escalated each year by a revenue cap index. The index formula (*formule d'indexation*) includes a measure of inflation (*facteur d'inflation*), a productivity or X factor (*facteur de productivité*), and 0.75 x growth in the number of HQD's customer accounts (*abonnements*).

In Decision D-2018-067, the Régie chose the X factor that will apply during the first few years of the plan using a process of *jugement* based on productivity studies and X factor decisions by regulators in other jurisdictions. However, empirical studies will be filed during the term of the approved MRI on productivity trends of power distributors. Separate studies will be undertaken for HQD and intervenors. These studies may prompt the Régie to revise the X factor for the last year of the MRI and/or be used to set the X factor for the next MRI.

The Régie asked for comments in D-2019-011 from parties on the appropriate scope of these productivity studies, stating that "*Il sera alors possible de définir, dans ses grandes lignes, la portée de l'étude sans pour autant limiter les experts dans le choix de la méthodologie qu'ils souhaitent utiliser pour la détermination du facteur de productivité à intégrer éventuellement à la formule d'indexation du MRI*."[1] The following scoping issues were identified by the Régie in D-2017-043.

- Selection of a peer group
- Sample period
- Data set
- Calculation of outputs
- Calculation of inputs
- Controls for external business conditions
- Key hypotheses and premises

[1] D-2019-011, p. 9.

- Mathematical models to calculate productivity

HQD submitted comments on scoping issues April 30.[2]

Pacific Economics Group Research LLC ("PEG") is a North American leader in the design of MRIs for gas and electric utilities. The calibration of X factors using research on the input price and productivity trends of energy utilities is a company specialty. In Canada, we have played a prominent role in MRI proceedings in Alberta, British Columbia, and Ontario, as well as in Québec. We are currently testifying on the productivity trends of U.S. power distributors in Massachusetts. The *Association Québecoise des Consommatuers Industriels d'Electricité* and the *Conseil de l'Industrie Forestiére du Québec* have asked us to prepare comments on the scoping issue in this proceeding.

The plan for this submission is as follows. In the next section we provide general commentary on key issues in the design of an X factor calibration study for a North American power distributor. Some remarks on scoping issues raised by the Régie and HQD are presented in Section 3. The Appendix contains a table that summarizes North American X factor calibration research precedents.

[2] HQD-1, document 1, R-4057-2018 – Phase 2.

2 Principles for X Factor Calibration Studies

2.1 Productivity Research and its Use in Regulation

This section of the report considers some technical and theoretical issues that arise in input price and productivity research to calibrate the X factors of MRIs. The discussion draws on material presented in our previous Québec evidence but new material is included. Issues have been emphasized which are salient in establishing guidelines for X factor calibration evidence.

2.1.1 Productivity Indexes

A productivity index measures the efficiency with which firms use production inputs to achieve certain outputs. The growth in a productivity index is the difference between the growth in an output index ("Outputs") and the growth in an input quantity index ("Inputs").

growth Productivity = growth Outputs – growth Inputs. [1]

Productivity thus grows when outputs rise more rapidly than inputs.

Productivity can be volatile but usually has a rising trend in the longer run. The volatility is typically due to fluctuations in outputs and/or the uneven timing of expenditures. The productivity growth of individual companies tends to be more volatile than the average productivity growth of a group of companies.

The scope of a productivity index depends on the array of inputs addressed by the input quantity index. Partial factor productivity indexes measure productivity in the use of certain inputs such as capital or *charges nettes d'exploitation* ("CNE") inputs. A multifactor productivity index measures productivity in the use of multiple inputs. In Québec, these are called indexes of *productivité multifactoriel* ("PMF").

The output (quantity) index of a firm summarizes growth in its outputs. If this index is multidimensional, the growth in each output dimension which is itemized is measured by a subindex, and growth in the summary output index is a weighted average of the growth in the subindices.

In designing an output index, choices concerning the output variables (and, if the index is multidimensional, their weights) should depend on the way that the index is to be used. One possible objective is to measure the impact of output growth on *revenue*. In that event, the output variables should measure trends in *billing determinants* and the weight for each itemized determinant should reflect its share of revenue.[3] In power distribution, the billing determinants with the greatest revenue impact are delivery volumes, peak demand, and the number of customers served. A productivity index calculated using a revenue-weighted output index ("$Outputs^R$") will be denoted as $Productivity^R$:

$$growth\ Productivity^R = growth\ Outputs^R - growth\ Inputs. \quad [2a]$$

Another possible objective of output research is to measure the impact of output growth on *cost.* In that event, the index should be constructed from one or more output variables that measure dimensions of "workload" that drive cost.[4] A productivity index calculated using a cost-based output index ("$Outputs^C$") will be denoted as $Productivity^C$:

$$growth\ Productivity^C = growth\ Outputs^C - growth\ Inputs. \quad [2b]$$

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

2.1.2 Sources of Productivity Growth

Economists have considered 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 productivity growth driver is incremental scale economies. These economies are realized in the longer run if a company's cost tends to grow less rapidly than its operating scale. Incremental scale economies will typically be smaller the slower is output growth. Incremental

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[3] This approach to output quantity indexation is due to the French engineer and economist Francois Divisia (1889-1964).

[4] 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 a business condition variable is commonly measured by its cost "elasticity." Cost elasticities can be estimated econometrically using data on the operations of utilities. Such estimates provide the basis for elasticity-weighted output indexes

[5] A seminal work in this area is 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.

scale economies may also depend on the current scale of an enterprise. For example, there may be diminishing incremental returns to scale as enterprises grow.

A third driver of productivity growth is X inefficiency. X inefficiency is the degree to which a company fails to operate at the maximum possible efficiency. Productivity growth will increase if X inefficiency diminishes. A company's potential for future productivity growth from this source is greater the greater is its current inefficiency.

Productivity growth is also affected by changes in the miscellaneous business conditions, other than input price inflation and output growth, which affect cost. A good example for a power distributor is forestation. In suburban or rural areas where forestation is increasing, rising vegetation management expenses will cause CNE and multifactor productivity growth to slow. Other business conditions that can affect a power distributor's productivity growth include government mandates to increase system undergrounding and improve reliability and resiliency.

System age can drive productivity growth in the short and medium term. Growth tends to be greater to the extent that the initial capital stock is large relative to the need to refurbish or replace aging plant. If a utility requires unusually high replacement capex, capital productivity growth can be unusually slow. On the other hand, productivity growth can accelerate after a period of unusually high capex as the surge capital depreciates.

A productivity index with a *revenue*-weighted output index has an important driver that doesn't affect a cost efficiency index. This is true since:

$$growth\ Productivity^R$$

$$= growth\ Outputs^R - growth\ Inputs + (growth\ Outputs^C - growth\ Outputs^C)$$

$$= (growth\ Outputs^C - growth\ Inputs) + (growth\ Outputs^R - growth\ Outputs^C)$$

$$= growth\ MFP^C + (growth\ Outputs^R - growth\ Outputs^C). \quad [3]$$

Relation [3] shows that the growth in $Productivity^R$ can be decomposed into the trend in a cost efficiency index and an "output differential" that measures the difference between the impact that output trends have on revenue and cost.

Output differentials of energy utilities are sensitive to changes in external business conditions that drive system use. For example, the revenue of a power distributor may depend chiefly on system use, while its cost depends chiefly on system capacity in the short and medium run. In that event, mild weather, slow economic growth, and larger conservation and demand management programs can depress revenue more than cost, reducing the output differential and slowing growth in $Productivity^{R}$.
Use of Index Research in Regulation

2.1.2.1 Revenue Cap Indexes

Cost theory and index logic support the design of revenue cap indexes. Consider first the following basic result of cost theory:

$$growth\ Cost = growth\ Input\ Prices - growth\ Productivity^{C} + growth\ Scale^{C}.^{6} \quad [4]$$

The growth in the cost of a company is the difference between the growth in its input price and cost efficiency indexes plus the trend in a consistent cost-based output index. This result provides the basis for a revenue cap index of general form:

$$growth\ Revenue^{Allowed} = growth\ Input\ Prices - X + growth\ Scale^{Utility} \quad [5a]$$

where

$$X = \overline{PMF^{C}} + Stretch. \quad [5b]$$

Here X, the "X factor," reflects a base PMF growth target ("$\overline{PMF^{C}}$") that is typically the average trend in the PMF^{C} of a group of utilities. Notably, a cost-based output index should be used in the supportive productivity research. Further, a "stretch factor" is often added to the formula which slows revenue cap index growth in a manner that shares the financial benefits of performance improvements which are expected under the PBR plan with customers. Since the X factor often includes *Stretch* it is sometimes said that the productivity research has the goal of "calibrating" (rather than solely determining) X.

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[6] Denny, Fuss and Waverman, *op. cit.*

An alternative basis for an RCI 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:

$$\textit{growth Cost} = \textit{growth Input Prices} + \textit{growth Input Quantities}. \quad [6]$$

Then,

$$\begin{aligned}\textit{growth Cost} &= \textit{growth Input Prices} + \textit{growth Scale}^{C} - (\textit{growth Scale}^{C} - \textit{growth Input Quantities}) \\ &= \textit{growth Input Prices} - \textit{growth Productivity}^{C} + \textit{growth Scale}^{C} \quad [7]\end{aligned}$$

For gas and electric power distributors, the number of customers served is a sensible scale escalator for a revenue cap index. The number of customers served drives costs of customer services (e.g., billing and collection) and some distribution costs (e.g., those of metering and connections) and is highly correlated with peak demand, another important cost driver. In econometric research on distribution cost, the customers variable typically has the highest estimated cost elasticity amongst the scale variables modelled. A revenue cap index scale escalator that includes volumes and peak demand as output variables diminishes a utility's incentive to promote conservation and demand management. This is an argument for excluding these variables from the scale escalator. For reasons like these, the Régie chose the number of *abonnements* as the scale index for the revenue cap index of HQD.

Relation [6] can then be expanded to obtain the following result:

$$\begin{aligned}\textit{growth Cost} &= \textit{growth Input Prices} + \textit{growth Input Quantities} + (\textit{growth Customers} - \textit{growth Customers}) \\ &= \textit{growth Input Prices} - (\textit{growth Customers} - \textit{growth Inputs}) + \textit{growth Customers} \\ &= \textit{growth Input Prices} - \textit{growth PMF}^{N} + \textit{growth Customers}\end{aligned}$$

where PMF^{N} is an PMF index that uses the number of customers to measure output. This result provides the rationale for the following revenue cap index formula

$$\textit{growth Revenue}^{Allowed} = \textit{growth Input Prices} - X + \textit{growth Customers}^{Utility} \quad [8a]$$

where

$$X = \overline{PMF}^{N} + \textit{Stretch}. \quad [8b]$$

2.1.2.2 Inflation Issues

Macroeconomic inflation indexes such as the Canadian GDPIPI are sometimes used as the sole inflation measure in a rate or revenue cap index. In that event, relation [8a] can be restated as

$$\begin{aligned} &\textit{growth Revenue}^{\textit{Allowed}} \\ &= \textit{growth Input Prices} - \textit{growth Productivity} + \textit{growth Customers} \\ &\quad + \textit{growth GDPIPI} - \textit{growth GDPIPI} \\ &= \textit{growth GDPIPI} - [\textit{growth Productivity} + (\textit{growth GDPIPI - growth Input Prices})] \\ &\quad + \textit{growth Customers}. \qquad [9] \end{aligned}$$

The GDPIPI measures inflation in the prices of the economy's final goods and services.[7] It can then be shown that the trend in the GDPIPI is well-approximated by the difference between the trends in the economy's input price and (multifactor) productivity indexes.

$$\textit{growth GDPPI} = \textit{growth Input Prices}^{\textit{Economy}} - \textit{growth PMF}^{\textit{Economy}}. \qquad [10]$$

The formula for the X factor of a revenue cap index can then be restated as:

$$X = (\overline{PMF}^{C} - \overline{PMF}^{\textit{Economy}}) + (\overline{\textit{Input Prices}}^{\textit{Economy}} - \overline{\textit{Input Prices}}^{\textit{Industry}}) + \textit{Stretch}. \qquad [11]$$

Here, the first term in parentheses is called the "productivity differential." It is the difference between the PMF trends of the industry and the economy. The second term in parentheses is called the "input price differential." It is the difference between the input price trends of the economy and the industry.

In addition to making a correction for any tendency of the GDPIPI to mismeasure the input price trends of utilities, this approach can correct for imperfections in the input price indexes used in the productivity research. To see why, consider that relations [1], [6], and [11] imply that, when the X factor is calculated on the basis of input price and productivity differentials,

$$\begin{aligned} X &= [(\overline{\textit{Outputs}} \text{-} \overline{\textit{Inputs}}) - \overline{PMF}^{\textit{ Economy}}] + (\overline{\textit{Input Prices}}^{\textit{Economy}} - \overline{\textit{Input Prices}}^{\textit{Industry}}) + \textit{Stretch} \\ &= [\overline{\textit{Outputs}} - (\overline{\textit{Cost}} - \overline{\textit{Input Prices}}^{\textit{Industry}})] - \overline{PMF}^{\textit{ Economy}} \\ &\quad + (\overline{\textit{Input Prices}}^{\textit{Economy}} - \overline{\textit{Input Prices}}^{\textit{Industry}}) + \textit{Stretch} \end{aligned}$$

[7] Final goods and services include consumer products, government services, and exports.

$$= (\overline{Outputs} - \overline{Cost}) + (\overline{Input\ Prices}^{Economy} - \overline{PMF}^{Economy}) + Stretch$$

$$= \overline{GDPIPI} - \overline{Unit\ Cost} + Stretch. \qquad [12]$$

In this relation, each $\overline{capped}$ term is the long-term trend of a group of utilities. Relation [12] shows that the X factor reflects the unit cost trend of utilities during the sample period and is insensitive to the input price specification. Furthermore,

$$growth\ Revenue^{Allowed} = growth\ GDPIPI – (\overline{GDPIPI} - \overline{Unit\ Cost} + Stretch)$$

$$= \overline{Unit\ Cost} + (growth\ GDPIPI - \overline{GDPIPI}) - Stretch \qquad [13]$$

Growth in allowed revenue equals the historical unit cost trend of sampled utilities plus the annual deviation of GDPIPI growth from its long-term trend.

2.2 Capital Cost Specification

2.2.1 Monetary Approaches to Capital Cost and Quantity Measurement

The capital cost specification is critical in research on the productivity trends of energy distributors because their technology is capital-intensive. The cost that a utility incurs for capital ("*CK*") includes depreciation expenses, a return on investment, and certain taxes. If the prices (unit value) of assets change over time 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 productivity research. Under these approaches, capital cost is decomposed into a consistent capital quantity index ("*XK*") and capital price index ("*WK*") such that

$$CK = WK \cdot XK.^{8} \qquad [14]$$

Capital quantity indexes are commonly constructed by deflating the value of annual plant additions using an asset price index and then subjecting the resultant quantity estimates to a mechanistic decay

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[8] The growth rate of capital cost equals the sum of the growth rates of the capital price and quantity indexes.

specification. In research on the productivity of U.S. power distributors, Handy Whitman power distribution construction cost indexes have traditionally been used as plant value deflators.

In rigorous statistical cost research, it is commonly assumed that a capital good provides a stream of services over a period of time. The capital quantity index measures this flow, while the capital price index measures the trend in the price of 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.

2.2.2 Alternative Monetary Approaches

Several monetary methods have been established for measuring capital quantity trends. One key issue in the choice between some monetary methods is the assumed pattern of decay in the service flow from capex in a given year. Decay can result from many factors including wear and tear, casualty loss, rising maintenance costs and declining reliability as assets age, and technological obsolescence. The pattern of decay in assets over time is sometimes called the age-efficiency profile. Another issue in the choice between monetary methods is whether plant is valued in historic dollars or replacement dollars.

Three monetary methods have been used in X factor calibration research. We briefly discuss each in turn.

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

$$XK_t = XK_{t-1} \bullet (1-d) + XKA_t \qquad [15a]$$

$$= XK_{t-1} \bullet (1-d) + \frac{VKA_t}{WKA_t}. \qquad [15b]$$

Here *d* is the (constant) rate of decay in the quantity of older capital. In Relation [13b], 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. Replacement valuation differs from the historical ("book") valuation used in North American utility accounting. 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 capital asset 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").

$$XK_t = XK_{t-1} + XKA_t - XKR_t. \quad [16a]$$

$$= XK_{t-1} + \frac{VKA_t}{WKA_t} - \frac{VKR_t}{WKA_{t-s}}. \quad [16b]$$

Since 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.

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

3. Cost of Service ("COS") Productivity studies have many uses, and the best methodology for one application may not be best for another application. One use of productivity research is to measure the trend in a utility's operating efficiency. Another is to calibrate the X factor in a price-cap or revenue-cap index.

Rate and revenue cap indexes used in MRIs are intended to adjust utility revenue between general rate cases that employ a cost of service approach to capital cost measurement. 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 each asset shrinks over time as depreciation reduces net plant value and the return on rate base.

The GD and OHS approaches for calculating capital cost use assumptions that are different from those used to calculate capital cost under traditional ratemaking. With both approaches, we have noted that the trend in capital cost is a simulation of the trend in cost incurred for capital services in a competitive rental market. It may be argued that the derivation of a revenue cap index using index logic does not require a service price treatment of the capital price.

An alternative capital cost specification has been developed that 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. Capital cost is not intended to simulate the cost of capital services in a competitive rental market, and the capital is not a simulated rental price. The formulae are complicated, making them more difficult to code and review.[9]

2.2.3 Benchmark Year Adjustments

Utilities have various methods for calculating depreciation expenses that they report to regulators. It is therefore desirable, when calculating capital quantities using monetary methods, to rely on the reporting companies chiefly for the value of gross plant additions but to 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 earlier years, the desired gross plant addition data are sometimes unavailable to the researcher. Consequently, it is customary to consider the net or (as the case may be) gross value of plant at the end of the limited-data period and then estimate the quantity of capital it reflects using construction cost indexes from earlier years and assumptions about the historical capital expenditure ("capex") 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.

2.2.4 Itemizing Capital Quantities

Capital quantity trends are ideally calculated separately for major asset quantities. Unfortunately, the FERC Form 1 data required for these detailed calculations are not readily available before the mid-1990s. To take advantage of the 1964 benchmark year, scholars have opted to calculate a capital quantity index for total distribution plant.

2.2.5 Capital Cost Controversies

The capital cost specifications used in X factor calibration studies have been a central issue in recent MRI proceedings. Critics of GD have stressed the following points:

- The service flows of individual electric utility assets do not typically exhibit a GD pattern.
- GD produces accelerated depreciation compared to 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 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 inconsistent with the tendency of distribution assets to have rising maintenance expenses and declining reliability as they age.
- 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.
- The approach to OHS used by consultants today does not consider the cost advantages of extending the service lives of assets.

2.3 Other Methodological Issues in X Factor Calibration

2.3.1 Choosing a Productivity Peer Group

Research on the productivity of other utilities can be used in several ways to calculate base productivity growth targets. Using the average historical productivity trend of the entire industry to calibrate X is tantamount to simulating the outcome of competitive markets. A competitive market paradigm has broad appeal.

On the other hand, individual firms in competitive markets routinely experience windfall gains and losses. Our discussion in Section 2.1 of the sources of productivity growth implies that differences in the external business conditions that drive productivity growth can cause utilities to have different productivity trends. For example, energy distributors experiencing brisk growth in the number of customers served are more likely to realize economies of scale that accelerate productivity growth than distributors experiencing slow customer growth.

There has thus been considerable interest in methods for customizing X factors to reflect local business conditions. The most common approach to customization in MRI proceedings has been to use the average productivity trends of similarly situated utilities. Relevant conditions for a power distributor include the growth in the number of electric and natural gas customers served.

Custom productivity peer groups have sometimes been used in X factor calibration research. Most notably, the Ontario Energy Board uses the PMF trend of Ontario power distributors to set the base productivity trends in fourth generation MRIs. In New England, utilities have proposed and regulators have approved X factors in index-based PBR plans that are calibrated using research on the productivity trends of Northeast utilities. Custom peer groups have been used by the Brattle Group and Concentric Energy Advisors in X factor calibration research for Enbridge Gas Distribution. PEG and NERA developed custom peer groups for Alberta energy distributors in MRI proceedings.

2.3.2 Data Availability

The availability of data needed for productivity research plays an important role in peer group selection. Data on the operations of U.S. utilities are well-suited for the requisite price and productivity research. Standardized data of good quality have been available from government agencies on utility operations for many years. For electric utilities, the primary source of these data is the Federal Energy

Regulatory Commission ("FERC") Form 1, which provides detailed cost data and some useful data on operating scale. Major investor-owned electric utilities in the United States are required by law to file this form annually. Cost and quantity data reported on Form 1 must conform to the FERC's Uniform System of Accounts. Details of these accounts can be found in Title 18 of the Code of Federal Regulations.

These data have been available for decades, providing the basis for more accurate capital quantity indexes. We have noted that the accuracy of these indexes is very important in studies of distribution productivity. The large size of the U.S. and the balkanized character of service territories means that data are available for a large number of utilities operating under diverse conditions. This facilitates development of custom productivity peer groups.

Unfortunately, the number of utilities, for which good data are available, which face productivity growth drivers similar to those facing the subject utility is sometimes limited. This is a chronic problem in Canada, where standardized data that could be used to accurately measure the productivity trends of appropriate peer groups are not readily available.

Standardized operating data are available for the numerous Ontario power distributors. PEG Research has used these data to estimate industry productivity trends in X factor calibration work commissioned by the Ontario Energy Board. These data have a number of limitations in productivity research that limit their usefulness in this proceeding.

- Most companies in the Ontario sample are small municipal distributors.
- Many companies have recently changed accounting standards, and this compromises the reported cost trends.
- Breakdowns of O&M expenses into labor and other inputs are unavailable.
- Plant value data needed to construct accurate capital quantity indexes are not available for a lengthy sequence of years.
- A good custom index of the construction price trends of Canadian electric utilities has not been available for many years.

Due to the limitations of Canadian data, regulators in Alberta and British Columbia have based X factors in their MRIs for gas and electric power distributors on the productivity trends of U.S.

distributors. The Ontario Energy Board used estimates of U.S. productivity trends to choose the productivity target in its third-generation plan for power distributors.

The complications of basing X on the productivity trends of other utilities have occasionally prompted regulators to base X factors on a utility's *own* recent historical productivity trend. This approach will weaken a utility's incentives to increase productivity growth if used repeatedly. Furthermore, a utility's productivity growth in one five or ten year period may be very different from its productivity growth potential in the following five years. For example, a ten-year period in which productivity growth was slowed by high capex may be followed by a period of brisk productivity growth.

It is nonetheless desirable to know the productivity trend of the subject utility. The Ontario Energy Board has on several occasions ordered utilities to file evidence on their productivity trends in custom MRI applications. Utilities that have done so include Enbridge Gas Distribution, Union Gas, Hydro One Networks and Ontario Power Generation.

2.3.3 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. Due to the inherent volatility of some cost and output data, the sample period should be at least ten years. 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 sample periods of longer length.

The need for a long sample period 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) and the output index does not assign a heavy weight to volatile output variables (e.g., peak demand and delivery volumes). If an input price differential must be calculated, another important consideration in the sample period selection is the volatility of capital prices. A sample period that is ideal for calculating the productivity trend may not be ideal for calculating the input price trend.

2.3.4 Data Quality

The quality of data used in index research is important for the relevance of the results for X factor calibration. Generally speaking, it is desirable to have publicly available data drawn from standardized collection forms such as those developed by government agencies. In the United States, the best quality data of this kind are gathered by commercial venders that work hard to ensure their quality, and that spread the cost of their work amongst numerous subscribers. Data quality also has a temporal dimension. It is customary for statistical cost research used in MRI design to include the latest data available.

2.3.5 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 PMF 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. It also depends on the company's operating efficiency. Statistical benchmarking studies can be used to measure efficiency.

The Régie acknowledged in D-2018-067 that a stretch factor can be a legitimate component of a revenue cap index. There is an S factor in the general revenue cap index formula set forth on page 112. The Régie nonetheless opted to set the stretch factor for HQD at 0 for its first MRI.[10] Its reasons included the lack of evidence on the Company's cost performance and the fact that the Company had been subject to a *facteur d'efficience* for its CNE since 2008.

We believe that the Régie should decide in this proceeding that an S factor may be included in HQD's next MRI depending on the outcome of econometric or other statistical benchmarking studies. The value of S could be zero (or even positive) if HQD is found to be a superior cost performer. Here are some salient advantages of this approach.

- The possibility of an S factor linked to a statistical benchmarking study will strengthen HQD's incentive to perform well.

[10] D-2018-067, p. 47.

- The incremental cost of such a study is substantially reduced when consultants are already calculating productivity trends for Hydro-Québec and an industry peer group.
- Operation under an MRI will typically generate stronger performance incentives than the regulatory systems of the typical utility in the productivity sample.
- A utility that has operated under only one MRI has likely not eliminated all inefficiencies. Even if incentives provided by this MRI were much stronger, it is notable that companies in competitive markets have widely varying degrees of operating efficiency.

The Régie noted in D-2018-067 that stretch factors are more frequently used in first generation MRIs. The AUC embraced this principle in its decision in its first generic MRI proceeding.[11] However, in its second generation MRI decision the AUC included an implicit stretch factor in its 0.30% X factor decision.[12] They argued that the inclusion of capital cost trackers in the first generation MRIs had weakened the companies' performance incentives.

Stretch factors have also been included explicitly in some other second generation or later MRIs.[13] For example, three generations of MRIs for power distributors in Ontario have included stretch factors, including the current plans. The OEB explained why it continues to include stretch factors in MRIs in a decision on 4th generation MRIs, stating that:

> The Board believes that stretch factors continue to be required and is not persuaded by arguments that stretch factors are only warranted immediately after distributors switch from years of cost of service regulation to IR. Stretch factors promote, recognize and reward distributors for efficiency improvements relative to the expected sector productivity trend. Stretch factors continue to have an important role in IR plans after distributors move from cost of service regulation.[14]

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[11] EB 2017-0307, Exhibit B, Tab 2, p. 14.

[12] Alberta Utilities Commission (2017), *Errata to Decision 20414 2018-2022 Performance-Based Regulation Plans for Alberta Electric and Gas Distribution Utilities*, pp. 38-40.

[13] Numerous MRIs, including most established through settlements, do not itemize the components of the X factor and thus do not indicate whether a stretch factor is included. This likely includes some second generation or later MRIss which had previously included an explicit stretch factor.

[14] Ontario Energy Board (2013), EB-2010-0379, *Report of the Board Rate Setting Parameters and Benchmarking under the Renewed Regulatory Framework for Ontario's Electricity Distributors,* Issued on November 21, 2013 and as corrected on December 4, 2013, p. 18-19.

Similarly, after several generations of MRIs, the British Columbia Utilities Commission approved stretch factors of 0.2% for FortisBC Energy Inc. (formerly Terasen Gas) and 0.1% for FortisBC (formerly West Kootenay Power) for their current plans. The BC Commission also endorsed the possibility of including stretch factors in future generations of IR plans that are based on benchmarking evidence. The Commission believed that there was a lack of evidence as to the efficiency of Fortis' operations relative to other utilities. This information would be helpful in making a determination on a stretch factor. A benchmarking study would provide the Commission with information on the utilities' efficiency relative to other utilities. While there is no such study available at this time, the Panel considers that it would be useful to have one completed prior to the application for the next phase of the PBR. **Accordingly, the Panel directs FEI and FBC to each prepare a benchmarking study to be completed no later than December 31, 2018.**[15] [Emphasis in original]

Telecommunications precedents for stretch factors are also pertinent. The U.S. Federal Communications Commission approved stretch factors in second-generation MRIs for AT&T and the interstate services of incumbent local exchange carriers.[16] PEG witnesses have advocated for the inclusion of stretch factors in second generation or later MRIs in testimony for several utility clients.[17]

2.4.1 Statistical Benchmarking

A quantitative benchmarking exercise involves one or more activity measures. These are sometimes called performance metrics or indicators. The value of each indicator achieved by an entity under scrutiny is compared to a benchmark value that reflects a performance standard. Given data on the cost of HQD and a certain cost benchmark we might, for instance, measure its cost performance by taking the ratio of the two values:

$$\textit{Cost Performance} = \textit{Cost}^{HQD}/\textit{Cost}^{Benchmark}.$$

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[15] British Columbia Utilities Commission (2014), *Decision,* In the Matter of FortisBC Energy Inc. Multi-Year Performance Based Ratemaking Plan for 2014 Through 2018, p. 86.

[16] Federal Communications Commission, FCC 93-326, Report Adopted June 24, 1993 in CC Docket 92-134. Federal Communications Commission, FCC 97-159, Fourth Report and Order Adopted May 7, 1997, in CC Dockets, 94-1 and 96-262. The latter decision was subsequently overturned by the U.S. Court of Appeals for the District of Columbia Circuit in 1999.

[17] See, for example, the X factor recommendations of PEG for Central Maine Power in 2007 and Gaz Metro in 2012.

Benchmarks are often developed statistically using data on the operations of agents engaged in the same activity. In utility cost benchmarking, data on the costs of utilities can be used to establish benchmarks. Various performance standards can be used in benchmarking, and these often reflect statistical concepts. One sensible standard for utilities is the average performance of the utilities in the sample. An alternative standard is the performance that would define the margin of the top quartile of performers. An approach to benchmarking that uses statistical methods is called statistical benchmarking.

2.4.2 External Business Conditions

In comparing costs that utilities incur, it is generally recognized that differences in their costs depend on differences in external business conditions that they face as well as on differences in their cost management. These conditions are sometimes called cost "drivers." The cost performance of a company depends on the cost it achieves given the business conditions it faces. Benchmarks should therefore properly reflect external business conditions.

Economic theory is useful in identifying cost drivers and controlling for their influence in benchmarking. Under certain reasonable assumptions, cost "functions" exist that relate the cost of a utility to business conditions in its service territory. When the focus of benchmarking is total cost, theory reveals that the relevant business conditions include the prices of capital and CNE inputs and the operating scale of the company. Miscellaneous other business conditions may also drive cost. When the focus of benchmarking is CNE, prices of CNE inputs and the quantity of capital used by the company matter.

The existence of capital input variables in CNE cost functions means that appraising the efficiency of a utility in using CNE inputs requires consideration of the kinds and quantities of capital inputs it uses. This result is important for several reasons. It is generally more costly to operate and maintain capacity the more of it there is. A utility that has newer facilities and services will spend less on maintenance than a distributor struggling with older facilities nearing replacement age.

Regardless of the particular category of cost benchmarked, economic theory allows for multiple scale variables in cost functions. For example, the cost of a power distributor depends on the number of customers it serves as well as on its peak load and the dispersion of its customers.

2.4.3 Econometric Benchmarking

The relationship between the cost of utilities and the business conditions they face (sometimes called the "structure" of cost) can be estimated statistically. A branch of statistics called econometrics has developed procedures for estimating parameters of models of economic variables using historical data.[18] Parameters of utility cost functions can be estimated using historical data on costs incurred by a group of utilities and business conditions that they faced. The sample used in model estimation can be a time series consisting of data over several years for a single company, a "cross section" consisting of one observation for each of several companies, or a "panel" data set that pools time series data for several companies.

2.4.3.1 Basic Assumptions

Econometric research involves certain critical assumptions. One is that the value of an economic variable (called the dependent or left-hand side variable) is a function of certain other variables (called explanatory or right-hand side variables) and an error term. The explanatory variables are generally assumed to be independent in the sense that their values are not influenced by the value of the dependent variable. In an econometric cost model, cost is the dependent variable and cost drivers are the explanatory variables.

The error term in an econometric cost model is the difference between actual cost and the cost predicted by the model. This term is a formal acknowledgement of the fact that the cost model is unlikely to provide a full explanation of the variation in the costs of sampled utilities. Reasons for errors include mismeasurement of cost and external business conditions, exclusion from the model of relevant business conditions, and failure of the model to capture the true form of the functional relationship. It is customary to assume that error terms in econometric models are random variables drawn from probability distributions with measurable parameters.

Statistical theory is useful for appraising the importance of explanatory variables in cost models. Tests can be constructed for the hypothesis that the parameter for each included business condition variable equals zero. A variable can be deemed a statistically significant cost driver if this hypothesis is rejected at a high level of confidence.

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[18] Estimation of model parameters is sometimes called regression.

2.4.3.2 Cost Predictions and Performance Appraisals

A cost function fitted with econometric parameter estimates is called an econometric cost model. We can use such models to predict a company's costs given local values for the business condition variables. These predictions are econometric benchmarks. Cost performance is measured by comparing a company's cost in year *t* to the cost projected for that year by the econometric model. Cost predictions can be made for historical or future years. Predictions of cost in future years can be used to benchmark cost forecasts or proposed revenue requirements for these costs.

Suppose, for example, that we wish to benchmark the cost of HQD. We might then predict the cost of HQD in period *t* using the following simple model.

$$\hat{C}_{HQD,t}=\hat{a}_0+\hat{a}_1 \cdot N_{HQD,t}+\hat{a}_2 \cdot D_{HQD,t}.$$

Here $\hat{C}_{HQD,t}$ denotes the predicted cost of the company, $N_{HQD,t}$ is the number of customers it serves, and $D_{HQD,t}$ is its maximum peak demand. The $\hat{a}_0$, $\hat{a}_1$, and $\hat{a}_2$ terms are parameter estimates. Performance might then be measured using a formula like

$$Performance = ln\left(C_{HQD,t} / \hat{C}_{HQD,t} \right)$$

where *ln* is the natural logarithm of the ratio in the parentheses.

2.4.3.3 Accuracy of Benchmarking Results

Statistical theory provides useful guidance regarding the accuracy of econometric benchmarks as predictors of the true benchmark. One important result is that a model can yield biased predictions of the true benchmark if relevant business condition variables are excluded from the model. It is therefore desirable to consider in model development numerous business conditions which are believed to be relevant and for which good data are available at reasonable cost.

Even when the predictions of an econometric model are unbiased they can be imprecise, yielding benchmarks that are too high for some companies and too low for others. Statistical theory suggests that these predictions will be more precise to the extent that

- the model successfully explains the variation in the historical cost data used in model development;
- the size of the sample used in model estimation is large;
- the number of cost-driver variables included in the model is small relative to the sample size;
- business conditions of sampled utilities are varied; and
- business conditions of the subject utility are similar to those of the typical firm in the sample.

These results suggest that econometric benchmarking will be more accurate to the extent that the model is estimated using a large sample of good operating data from companies with diverse operating conditions. It follows that it will generally be preferable to use *panel* data in the research, encompassing information from multiple utilities over time, when these are available.

2.4.3.4 Use in Regulation

Econometric cost benchmarking has been used many times in utility regulation. The Ontario Energy Board, for instance, uses an econometric model of total (non-energy) cost to set stretch factors in the MRIs of most provincial power distributors.[19] The model was estimated using only Ontario data. Benchmarking occurs yearly in the summer to consider the latest year of cost data. Poor performers receive a stretch factor of 0.60% while good performers receive a stretch factor of 0%. Results of econometric benchmarking are reported in the annual performance scorecards that the Board posts on its website for each distributor. Distributors are now required to benchmark proposed forward test year revenue requirements in rate cases.

The Australian Energy Regulator uses econometric CNE benchmarking models developed using Australian, New Zealand, and Ontario data. Results are submitted in rate proceedings and in annual benchmarking reports.[20] Two functional forms and two estimation procedures are considered.

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[19] This benchmarking work is undertaken by PEG Research LLC. See, for example, Kaufmann, L., Hovde, D., Kalfayan, J., and Rebane, K., *Productivity and Benchmarking Research in Support of Incentive Rate Setting in Ontario: Final Report to the Ontario Energy Board,* EB 2010-0379, 2013.

[20] See, for example, AER, *Annual Benchmarking Report: Electricity Distribution Network Service Providers*, November 2016.

Several American utilities have filed benchmarking studies in rate proceedings which use econometric models estimated using U.S. data. They have, for example, been filed in some New England MRI proceedings. Public Service of Colorado has on several occasions benchmarked proposed forward test year revenue requirements.[21]

[21] See, for example, the recent gas utility cost benchmarking study prepared by PEG Research LLC for Public Service of Colorado. Colorado PUC, 17AL-0363G, Attachment MNL-2, *Statistical Research for Public Service Company of Colorado's Multiyear Rate Plan*, June 2017.

3 Commentary on Specific Scoping Issues

3.1 Overview

We begin our commentary on specific scoping issues by noting some general considerations that are pertinent in establishing guidelines for the scope of an X factor calibration study.

- The Régie needs good information on which to base future X factor decisions. There is a particular need in a first generation proceeding of this kind for the Régie to get the "lay of the land" on the varied methodological options.
- There are controversies over the best research methods for X factor calibration. Alternative methods in some cases (but not others) produce materially different results.
- Consultants in MRI proceedings can (consciously or unconsciously) take bold positions on unsettled methodological issues to develop evidence that advances 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 consultant recommendations, and an extreme recommendation can materially shift the midpoint.
- Methods for X factor calibration continue to evolve, and debates in MRI proceedings stimulate progress. Witnesses could in principle be right about the appropriateness of a negative (or positive) X factor but use the wrong methodology to substantiate it. Correct methods should be encouraged.
- Regulators in some jurisdictions (e.g. Alberta) tend not to take positions on X factor methodological issues. When this happens, the same or similar controversies arise in later proceedings.
- It can be difficult to test the sensitivity of a consultant's results to their methodological choices. In particular, it can be difficult to know how results would change using a larger peer group or a longer sample period

- Consultants should have considerable freedom in choosing methods for their X factor research. However, they should be encouraged to provide additional evidence that makes it easy for other parties and the Régie to learn about the options and to test the sensitivity of their results to their methodological choices.

3.2 Sampled Companies (*Echantillon d'Entreprises*)

The productivity peer groups for X factor calibration studies should ideally face productivity growth drivers that are similar to those facing HQD. 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 for a comparison of productivity trends. The productivity growth drivers facing HQD are not necessarily similar to those in Ontario or the northeast U.S. For example, HQD may not have the same large need for replacement capital expenditures that Toronto Hydro has had in the last decade. We conclude that it would be desirable for each consultant in this proceeding to produce results for a large sample of distributors even if they base their X factor recommendations on results for a subset of these distributors.

It is desirable for Hydro-Quèbec to be included in the study. All parties to the proceeding benefit from knowledge of the Company's productivity trends. These calculations would be pertinent to the stretch factor determination and help the Régie ensure the Company's continual performance improvement. The Ontario Energy Board routinely computes the productivity trends of jurisdictional power distributors and has asked several other utilities to file productivity evidence.

3.3 Sample Period (*Horizon de Temps*)

The sample period for X factor calibration studies has been an area of major controversy in some recent MRI proceedings. The sample period is less important in this proceeding if the number of customers is used as the output measure and the input price differential is not an issue.

The case that was made by utility witnesses for a structural break (*bris structurel*) and a short sample period in the second-generation Alberta MRI proceeding does not apply to HQD since that controversy arose in the context of a productivity research methodology that used a volumetric output index. This index was sensitive to a a change in the output differential discussed in Section 2.1 that was due to a slowdown in the growth of residential and commercial average use of electricity which occurred around the year 2000. This slowdown is irrelevant to the design of an X factor for HQD. The Alberta study that was the focus of structural break tests also excluded customer service and administrative and general expenses.

We conclude that it would be desirable for each consultant to report results for a longer sample period than the one that it proposes as the basis for X factors if this is practical. Both utility witnesses did this in the second Alberta generic MRI proceeding.

3.4 Data Set (*Volume de Données*)

U.S. data should be the primary basis for the X factor calibration research. Data from Ontario are also pertinent but have known quality problems. The OEB has not updated its study of Ontario power distributor productivity trends for many years. Consultants may rely on some proprietary data and data rented from commercial vendors which cannot be accessed by other parties to the proceeding without a confidentiality agreement. These agreements are the norm in MRI proceedings.

3.5 Calculation of Outputs (*Extrants*)

Our analysis in Section 2.1 suggests that the number of customers should ideally be used as the output index in each consultant's productivity study because the Régie has chosen the number of customers as the revenue cap index scale escalator. The Alberta Utilities Commission has already acknowledged this. The Régie should acknowledge that it considers the number of customers to be the most pertinent scale variable for the HQD productivity research.

3.6 Calculation of Input Prices and Quantities (*Intrants*)

Our analysis in Section 2.1 suggests that the capital cost specification is the chief issue in the calculation of input prices and quantities. Results using OHS, GD, and COS specifications can all be pertinent if done correctly. This may be a major focus of the upcoming proceeding. It would be desirable for consultants to discuss the pros and cons of different specifications candidly and to present results using different specifications. Consultants should be encouraged to use a definition of cost in their studies that is consistent with the costs that will be indexed in the Company's MRI.

3.7 Input Price and Productivity Differentials

Input price and productivity differentials have been considered by regulators in several United States MRI proceedings but few if any Canadian MRI proceedings for energy utilities. One reason is that macroeconomic inflation indexes have been less frequently used as the sole inflation measure in Canadian rate or revenue cap indexes. Another reason is that the PMF trend of the Canadian economy has been much closer to zero than its American counterpart. A third is that the differential formula used in American proceedings is specific to U.S. input price inflation.

Notwithstanding these considerations, there are some reasons to calculate input price and productivity differentials for HQD. One is that the chosen inflation measure for the revenue cap index assigns a substantial weight to the CPI. The CPI effectively addresses the trends in prices of capital, materials, and services. The ability of the inflation measure to track the Company's input prices thus remains an issue. A second reason to calculate these differentials is that the PMF growth of the Canadian economy has accelerated in recent years. A third argument is that this approach can potentially rectify misspecifications of the input price indexes that are used in the research. In conclusion, we believe that the calculation of these differentials should be admissible evidence but not a requirement in the consultant studies.

3.8 Key Hypotheses and Premises

The capital cost specification is the key part of an X factor analysis where potentially restrictive assumptions are made. Most important is the specification regarding the decay of the capital quantity.

3.9 Mathematical Models to Calculate Productivity

The form of the price and quantity indexes is the most important issue in this category. This is chiefly an issue for the input price and quantity indexes inasmuch as the number of customers is the indicated output measure. Desirable forms for input price and quantity indexes include the Tornqvist and the Fisher Ideal.[22] Results are unlikely to differ greatly using these alternative index forms.

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

3.10 Statistical Benchmarking

We believe that the Régie should allow for the possibility of a stretch factor in HQD's next MRI and to permit if not require the consultants in this proceeding to develop and present supportive statistical benchmarking evidence. This would strengthen HQD's performance incentives and provide valuable information to the Company, intervenors, and the Régie on its cost performance. Econometric cost benchmarking has many advantages in this context. If statistical benchmarking studies are deemed admissible and pertinent in this proceeding, HQD should be expected to cooperate with the consultant for intervenors even if it chooses not to undertake its own study. The incremental effort by HQD that is required to assist in the benchmarking of the Company's cost levels will not be substantial if consultants are required to calculate HQD's productivity trends.

Scope of X Factor Calibration Evidence in North American MRI Proceedings[1]

Jurisdiction	Applicable Services	Utilities	MRI Term[3]	Inflation Measure[3]	Productivity Sample[4,5]	Input Price and Productivity Differentials?[3]	Statistical Benchmarking Research[4]
Alberta	Power & gas distribution	All Alberta distributors	2013-2017	Industry-specific	U.S. power distributors and gas utilities; Ontario power distributors	No	None
	Power & gas distribution	All Alberta distributors	2018-2022	Industry-specific	U.S. power distributors	No	None
British Columbia	Gas utility	BC Gas	1998-2001	CPI	U.S. and Pacific Northwest gas utilities	No	None
	Gas utility	FortisBC Energy	2014-2019	Industry-specific	U.S. gas utilities	No	None
	Bundled power service	FortisBC	2014-2019	Industry-specific	U.S. power distributors	No	None
Ontario	Gas utility	Union Gas	2001-2003	GDPIPI	Union Gas	Yes	None
	Gas utility	Enbridge Gas	2008-2012	GDPIPI	U.S. and Northeast gas utilities, Enbridge Gas, and Union Gas	No[6]	None
	Gas utility	Union Gas	2008-2012	GDPIPI	U.S. and Northeast gas utilities, Enbridge Gas and Union Gas	Yes[6]	None
	Gas utility	"Amalco"	2019-2023	GDPIPI	U.S. power distributors and gas utilities and Enbridge Gas, and Union Gas	No	None
	Power distribution	All Ontario distributors	2000-2003	Industry-specific	Ontaro power distributors	No	None
	Power distribution	All Ontario distributors	2010-2013	GDPIPI	U.S. and Ontario power distributors	No	Econometric CNE model and CNE unit cost indexes
	Power distribution	All distributors except those on "custom" MRIs	2014-2020	Industry-specific	Ontario power distributors	No	Econometric total cost model
	Hydroelectric power generation	Ontario Power Generation	2017-2021	Industry-specific	U.S. hydroelectric generators and OPG	No	None
	Power distribution	Hydro One Networks	2018-2022	Industry-specific	Ontario power distributors and Hydro One Networks	No	Econometric total cost models
	Power Transmission[2]	*Hydro One Sault Ste Marie*	*2019-2026*	*Industry-specific*	*U.S. power transmitters and Hydro One Networks*	*No*	*Econometric total cost models*
Québec	Gas utility	Gazifére (I)	2006-2010	CPI	Gazifére	No	None
	Gas utility	Gazifére (II)	2011-2015	CPI	Gazifére	No	None

Scope of X Factor Calibration Evidence in North American MRI Proceedings[1]

Jurisdiction	Applicable Services	Utilities	MRI Term[3]	Inflation Measure[3]	Productivity Sample[4,5]	Input Price and Productivity Differentials?[3]	Statistical Benchmarking Research[4]
California	Gas utility	Southern California Gas	1997-2002	Industry-specific	U.S. and Southwest gas utilities	No	None
	Gas utility	San Diego Gas and Electric	1999-2002	Industry-specific	U.S. gas utilities	No	None
	Bundled power service	PacifiCorp (I)	1994-1997, extended to 1999	Industry-specific	PacifiCorp	No	None
	Power distribution	Southern California Edison	1997-2002, extended to 2003	CPI	Southern California Edison	No	None
	Power distribution	San Diego Gas and Electric	1999-2002	Industry-specific	U.S. power distributors	No	None
Maine	Bundled power service	Central Maine Power (I)	1995-1999	GDPIPI	U.S. and Northeast electric utilities	Yes[6]	None
	Power distribution	Bangor Hydro Electric (I)	1998-2000	GDPIPI	Bangor Hydro Electric	No	None
	Power distribution	Central Maine Power (II)	2001-2007	GDPIPI	Northeast U.S. power distributors	Yes[6]	O&M unit cost
	Power distribution	Central Maine Power (III)	2009-2013	GDPIPI	Northeast U.S. power distributors	Yes[6]	Econometric total cost
Massachusetts	Gas utility	Boston Gas (I)	1997-2003	GDPIPI	U.S. and Northeast gas utilities	Yes	Econometric total cost
	Gas utility	Berkshire Gas	2002-2011	GDPIPI	U.S. and Northeast gas utilities	Yes	None
	Gas utility	Boston Gas (II)	2004-2013, terminated in 2010	GDPIPI	Northeast U.S. gas utilities	Yes	Econometric total cost
	Gas utility	Bay State Gas	2006-2015, terminated in 2009	GDPIPI	Northeast U.S. gas utilities	Yes	Econometric O&M model and O&M cost trend
	Power distribution	Nstar	2006-2012	GDPIPI	Northeast power distributors	Yes[6]	None
	Power distribution	Eversource Energy	2018-2023	GDPIPI	U.S. and Northeast power distributors	Yes	None

Scope of X Factor Calibration Evidence in North American MRI Proceedings[1]

Jurisdiction	Applicable Services	Utilities	MRI Term[3]	Inflation Measure[3]	Productivity Sample[4,5]	Input Price and Productivity Differentials?[3]	Statistical Benchmarking Research[4]
Vermont	Power distribution	Central Vermont Public Service	2009-2011, extended to 2013	CPI	U.S. and Northeast power distributors	No	None through 2010, O&M unit cost afterwards
	Power distribution	Green Mountain Power	2010-2013	CPI	U.S. and Northeast power distributors	No	O&M unit cost
United States	Oil pipelines	All U.S. interstate pipelines	1995-2001	PPI-Finished Goods	U.S. oil pipelines	Kahn Method[7]	None
	Oil pipelines	All U.S. interstate pipelines	2001-2006	PPI-Finished Goods	U.S. oil pipelines	Kahn Method[7]	None
	Oil pipelines	All U.S. interstate pipelines	2006-2011	PPI-Finished Goods	U.S. oil pipelines	Kahn Method[7]	None
	Oil pipelines	All U.S. interstate pipelines	2011-2016	PPI-Finished Goods	U.S. oil pipelines	Kahn Method[7]	None
	Oil pipelines	All U.S. interstate pipelines	2016-2021	PPI-Finished Goods	U.S. oil pipelines	Kahn Method[7]	None

[1] Plans with shaded information have expired.

[2] Plans in italics have not yet been approved by the regulator.

[3] This column addresses the regulator's conclusions on these issues.

[4] These terms reflect the evidence presented by parties to the proceeding. In some cases this includes evidence from prior proceedings.

[5] Only regional subsamples are listed when a national sample was also relied upon (e.g., customized peer groups that are not based on regions are excluded).

[6] Evidence resulted in a settlement wherein the X factor was agreed to. Input price and productivity differentials may have been reflected in the settlement X factor.

[7] The Kahn method implicitly considers input price and productivity differentials.

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.

U.S. Department of Energy, *Financial Statistics of Major U.S. Investor-Owned Electric Utilities*, various issues.