Data used in this study for years after 1993 were downloaded directly from the federal government and processed by PEG. Data for prior years were transcribed from EIA publications.

Other sources of data were also accessed in the research. These were used primarily to measure input price trends. We obtained construction cost indexes from Whitman, Requardt & Associates, employment cost indexes from the US Bureau of Labor Statistics, and a macroeconomic price index from the US Bureau of Economic Analysis. The specific data drawn from these and the other sources mentioned are discussed below.

5.1.3 Sample

Data were potentially eligible for inclusion in our sample from major investor-owned US electric utilities engaged in hydroelectric power generation that, together with any important predecessor companies, have filed the FERC Form 1 continuously since 1964. We considered a larger sample of investor-owned US electric utilities than the group featured in LEI's report. All utilities with hydroelectric generating plant exceeding $100 million in 2014 were considered. To be included in the study the data were required, additionally, to be of good quality and plausible.

The 20 utilities in our sample are identified in Table 2. We believe that the data for these companies are the best available for rigorous work on hydroelectric productivity trends to support the development of an X factor for OPG.

The full sample period considered was 1975-2014.[65] Our featured results are for the 1996-2014 period. We also prepared results for the 2003-14 period that is featured in LEI's report.

Data for generation capacity were unavailable from 1976 to 1993. This data issue did not prevent us from accurately calculating productivity trends over the 1975-1995 period. However, we could not calculate the year-to-year productivity growth rates during the "gap" years.

[65] That is to say that the earliest year for growth rate calculations was 1975.

One criteria for choosing between the sample periods we considered is that it should be one in which drivers of MFP growth for sampled utilities were most similar to those which OPG is expected to experience in the foreseeable future. It is also pertinent that a longer sample period more effectively smooths the effects of volatility in the sample. On the other hand, a more recent sample period reflects more recent business conditions, and the effects of the benchmark year adjustment are further in the past. Taking stock of all these considerations, we recommend that the productivity factor for OPG be based on the 0.29% MFP trend for our large sample during the 1996-2007 period.

Stretch Factor OPG proposes a stretch factor that can range from 0 to 0.6%. The proposed range of possible stretch factor values is the same as that used in IRM4, where a 0.3% stretch factor is assigned to average performers. OPG proposes to fix the stretch factor at 0.3% for the entirety of the IR term based on its performance in the benchmarking study prepared by Navigant.

Navigant's benchmarking methodology differs greatly from that which the Board employs in setting stretch factors for power distributors. One critical difference is that Navigant's study doesn't emphasize *total* cost performance, which includes the cost of older plant. OPG's total cost has been elevated by the revaluation of its older assets and the recent large plant additions. This could lower its measured performance and raise its indicated stretch factor in a total cost benchmarking study. Note also that the Navigant benchmarking study relies on simple unit cost indexes while the Board uses a sophisticated econometric model of total cost. OPG also deviates from the common practice in IRM4 in that it is not proposing to update benchmarking results annually.

We believe that Navigant's study does not by itself provide a satisfactory basis for a stretch factor determination. However, our productivity research suggests that OPG's recent MFP growth trend has been normal even when the NTP is included. In the absence of fully satisfactory benchmarking evidence, we believe that a 0.3% stretch factor is reasonable for OPG's first generation IRM.

OPG claims that the difference between its 0% proposal and LEI's -1% MFP trend is, effectively, an additional implicit stretch factor of 1%. The Company states in this regard that

> OPG believes that this implicit additional stretch factor does not reflect the company's actual productivity growth trends (per the LEI TFP study) and will pose a significant challenge for OPG during the 2017-2021 term.

EP Interrogatory #31

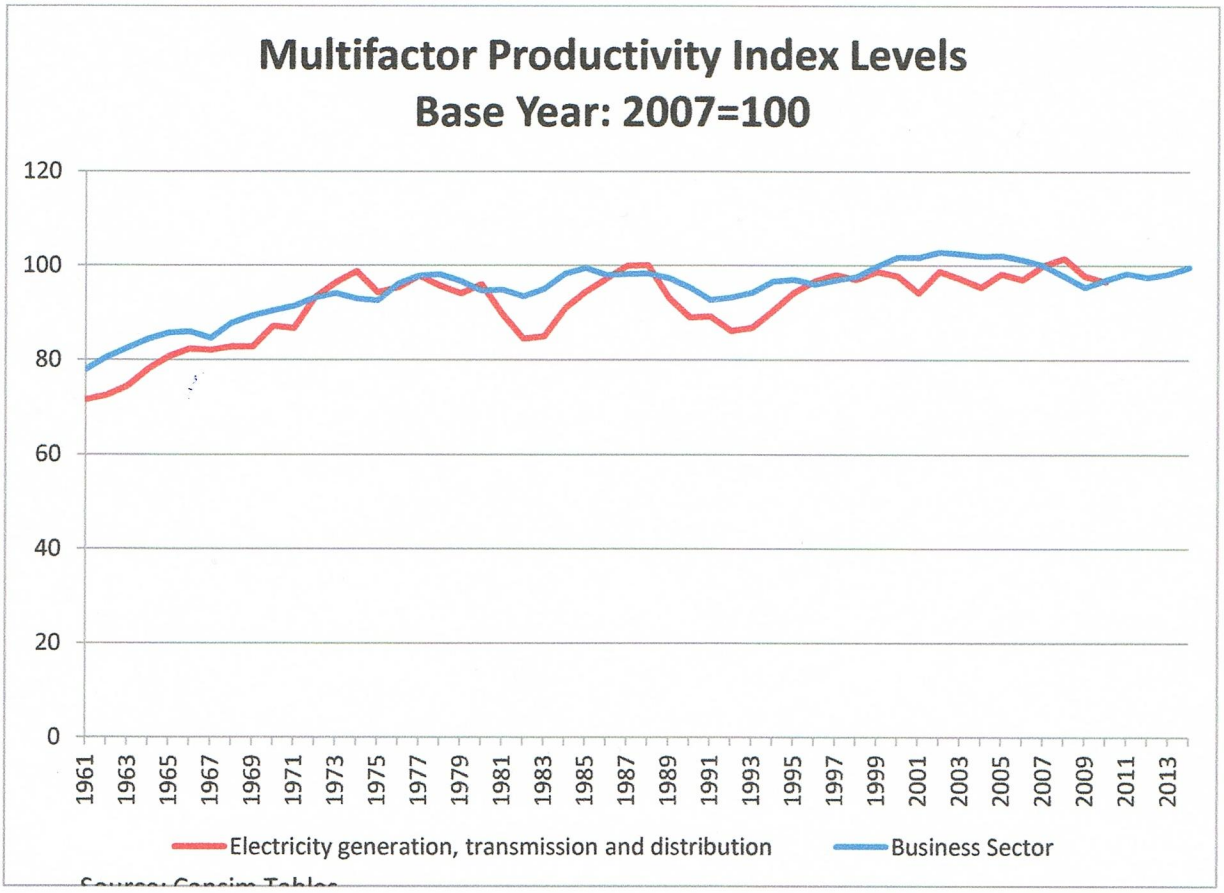
Issue Number: 11.1
Issue: Is OPG's approach to incentive rate-setting for establishing the regulated hydroelectric payment amounts appropriate?

Interrogatory

Reference:
Application Ex A1-Tab 3-Sch 2 and Attachment 1

> CANSIM Table 383-0021: Multifactor productivity...in the Canadian business sector
>
> CANSIM Table 383-0032: Multifactor productivity...in Electric power generation, transmission and distribution

Statistics Canada maintains and updates the Canadian Productivity Accounts, and has multi-factor and other productivity data for years going back to 1961. Data in CANSIM Table 383-0021 indicate that levels of multi-factor productivity in the Canadian business sector fell in eight of the eleven years 2000-2010 inclusive. In the industry category "Electric power generation, transmission and distribution", data in CANSIM Table 383-0032 productivity levels fell in seven of those years. The following chart is based on the CANSIM tables referenced above.



Source: Cansim Tables

The LEI Updated Report used a study period of 2002-2014. According to Figure 27 of the Updated Report, total-factor productivity growth was negative in five of those years.

The CANSIM data tend to support LEI's conclusion of declining productivity growth in the study period used in its Updated Report. In the overlapping eight years, the CANSIM series has 5 negative growth years and the mean annual growth rate is -0.25%; the Updated Report (Figure 27) has 3 negative growth years and the mean annual growth rate is -0.54%.

In the Report of the Board in EB-2010-0379, the Board refers to the "long-run productivity of the sector" (at p.15).

1. Please confirm that the study period used in the Updated Report was selected, in part, because LEI could not obtain comparable data for earlier years.

2. Does OPG regard LEI's study period as providing evidence on the "long-term productivity growth rate" to which the Board has referred?

3. Do the charted CANSIM data suggest that the long-term productivity growth rate for hydroelectric generation would be more accurately measured by examining a much longer time period if the relevant data were available?

4. Do the charted CANSIM data tend to support the conclusion that the long-term productivity growth rate for hydroelectric generation would be negative or zero if the relevant data were available?

5. Might the fact that levels of multi-factor productivity in the Canadian business sector fell in eight of the years 2000-2010 plausibly suggest that the negative growth rate for hydro reported by LEI had much more to do with factors and events external to OPG rather than those factors suggested by LEI?

6. Please confirm that for the 49 years from 1961-2010 inclusive, the mean productivity growth rate for the industry category "Electric power generation, transmission and distribution" was 0.668% per year with a standard deviation of 3.347%. Energy Probe will provide the charted data from CANSIM Table 383-0032 on annual productivity levels.

Response

The following response was provided by LEI, except for part 2, which was prepared by OPG.

1. Yes, while FERC Form 1 data is available going back to 1994, data for non-FERC jurisdictional entities, such as Seattle City & Light and Southeastern Power Administration, is not readily available going back for earlier years.

2. Yes, OPG believes that LEI's study and the period on which it was based provide evidence on the long-term productivity growth rate of the North American hydroelectric generation industry.

   In the context of studying the productivity of the electricity distribution industry, Pacific Economics Group observed dramatic changes in TFP results when 2012 data was added to their 2002 to 2011 data set.[1] PEG identified three unusual and one-time events that appeared to create the largest impact, and updated the analysis to exclude those events. In contrast, when two additional years of data were included in LEI's TFP study, the negative 1 percent TFP values did not change (Ex. A1-3-2, p. 16). The consistency of the TFP result supports the conclusion that the study period provides evidence of a long-term trend.

3. No. The CANSIM data from Table 383-0032 is for the broad electric utility industry and therefore includes productivity trends associated with other electric utility operations,

[1] Report of the Board: *Rate Setting Parameters and Benchmarking under the Renewed Regulatory Framework for Ontario's Electricity Distributors*, EB-2010-0379, Issued on November 21, 2013 and as corrected on December 4, 2013, p. 15.

such as transmission and distribution, as well as non-hydroelectric generation. As such this data is not specific to hydroelectric generation. It is worth noting that this data series has been terminated by Statistics Canada and no data is available subsequent to 2010.

4. Without analyzing the CANSIM data further, it is difficult to draw concrete conclusions with respect to correlation. That said, the data on multifactor productivity trends in the two data series are showing a negative growth trend as implied in the question over the 2002-2010 period. Indeed, the CANSIM data shows a negative average MFP trend even if we go back to the late 1990s.

5. LEI has not investigated the CANSIM data and drivers of the productivity trends presented in the data series that have been highlighted in this question. On the other hand, LEI has specifically calculated a total factor productivity growth trend for the hydroelectric generation industry using actual operating data from North American peers of OPG and OPG, itself. It is clear in LEI's Report that the negative TFP trend estimated for the hydroelectric industry is wholly based on drivers specific to inputs and outputs for the industry and not external factors as presupposed in the question

6. LEI confirms that taking the average of year over year productivity growth rates for the 1961-2010 period results in 0.668% with a standard deviation of 3.347%. As noted in Ex. L-11.1-6 EP-30, the data cited in this question is for the electric power generation, transmission and distribution industry, of which hydroelectric generation is only a small part.

specifically received for hydroelectric generation were in many cases unavailable, so that LEI had to estimate this revenue. Thus, the weights for the summary input quantity indexes are based on proxies for capital cost that must be estimated. This is not ideal, but the methodology does produce fairly sensible cost shares.

Index Forms LEI used multifactor input quantity indexes of Chained Fisher Ideal form. This form is known to have good statistical properties, as LEI discusses on page 52 of its report.

Currency Conversions Currency conversions play only a small role in LEI's study. However, it should be noted that conversions using *purchasing power parities* (which compare the prices of goods and services between countries) --- LEI's approach -- are generally considered to be more accurate than conversions using *exchange rates*.

Calculating the Peer Group Trend

To summarize the peer group trends LEI aggregated the generation volume, capacity, and O&M expense data of the sampled utilities.[59] This implicitly weights results for individual companies on the basis of their size and gave substantial weights to results for a few companies that are much larger than the others in the sample. For example, the shares of OPG, Pacific Gas & Electric, Duke Energy, Virginia Electric, Idaho Power, and Alabama Power in 2014 generating capacity were 21%, 11%, 9%, 7%, 5%, and 5%, respectively.[60]

4.2 Results Using LEI's Methodology

LEI reported a -1.01% average annual MFP growth rate over the full 2003-2014 sample period. The input quantity index averaged 0.38% annual growth despite a 0.64% average annual decline in the hydroelectric generation volume. The capital quantity averaged 0.15% growth using LEI's method, while O&M quantities averaged 1.85% growth. Thus, capital productivity averaged a 0.79% annual decline while O&M productivity averaged a steeper 2.49% annual decline.

[59] OPG Response to Staff 242, p. 1.

[60] Calculated using data provided by LEI.

Energy Probe Interrogatory #1

Issue Number: 11.1
Issue: Is OPG's approach to incentive rate-setting for establishing the regulated hydroelectric payment amounts appropriate?

Interrogatory:

Reference: Exhibit M2

The parties appear to agree that methods of statistical inference can be usefully applied in this case. For example, in its econometric cost analysis, the PEG report states:

> Results of the econometric work for the cost model are reported in Table 7. The table also reports the values of the *t* statistic that correspond to each parameter estimate. A parameter estimate is deemed statistically significant if the hypothesis that the true parameter value equals zero is rejected. This statistical test requires the selection of a critical value for the test statistic. (p.75)

Regarding its analysis of output quantity specification, the PEG report concludes that

> The estimated cost elasticities for the generation capacity and volume were 0.906 and 0.009, respectively. The parameter estimate for the volume variable was not statistically significant. (p.48)

Both PEG and LEI base their estimate of annual total factor productivity growth from samples of hydro generators over certain time periods. Figure 27 in LEI's expert report shows that the average TFP Index Growth for the years 2002-2003 to 2013-2014 was -1.01%. In response to Undertaking JT3.24 following the Technical Conference, LEI confirmed that the standard deviation of the annual TFP Growth rate in Figure 27 was 8.40% on a sample basis and 8.06% on a population basis.

Table 3 of the PEG report provides multifactor productivity ("MFP") growth rates for the years 1996-2014. For the 1996-2014 period, the mean annual MFP growth rate was 0.29% based on capacity and -2.03% based on volume. PEG did not provide the standard deviation for either estimate.

Table 3 of the PEG report also shows that MFP growth for the period 2003-2014 averaged 0.05% per year based on capacity and -1.83% based on volume. Again, PEG did not provide the standard deviations.

a) On page 48 of the PEG report, PEG reports that the parameter estimate for the volume variable was not statistically significant. Is this, as it appears, a regression-analysis result? Please provide the full estimated regression equation, the statistics typically calculated for the purpose of hypothesis-testing in a regression analysis, and the summary statistics typically calculated for the purpose of assessing the variance accounted for by the exogenous variables and the unexplained variance.

b) Please confirm/disconfirm that with a standard deviation of 8.4% in LEI's sample, the population mean, if it lies within one standard deviation would lie between -9.41% and 7.39%

c) To make the above more precise, please confirm/disconfirm that it is conventional in statistical inference (relying on the Central Limit Theorem) to characterize the sample mean as a normally-distributed random variable. Please additionally confirm/disconfirm that on LEI's data, the population mean inferred therefrom lies between -9.41% and 7.39% with a probability of 2/3.

d) Please calculate and confirm/disconfirm that the standard deviations for PEG's MFP growth rates (i.e. capacity and volume) for the 1996-2014 period are 1.71% and 13.56% respectively.

e) Please calculate and confirm/disconfirm that the standard deviations for PEG's MFP growth rates (i.e. capacity and volume) for the 2003-2014 period are 0.74% and 15.62% respectively.

f) The large standard deviation in LEI's sample of 8.4% suggests that the true population mean growth rate may not be statistically different from zero. Please perform the conventional one-sample statistical test of significance on LEI's sample data in Figure 27 of its report. Please use a 2-tailed test and a 5% significance criterion. Show all calculations and state the conclusion that PEG arrives at, along with any qualifying remarks that PEG feels are important.

g) Are PEG's mean annual MFP estimates for capacity and for volume for 1996-2014 and for 2003-2014 statistically significant? Please perform a 2-tailed test using a 5% significance level as was requested in the previous question e. Please show all calculations needed to compute the relevant test statistic and state the conclusion that PEG arrives at, along with any qualifying remarks that PEG feels are important.

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Response:

The following response was provided by PEG:

a) Yes, this estimate was obtained econometrically and subjected to a standard statistical significance test. Please see Table 7 of the report for further details of the econometric work.

b) Confirmed.

c) It is confirmed that conventionally the sample mean is characterized as a normally-distributed random variable. Assuming all of the assumptions of the central limit theorem are satisfied, then the population mean inferred from LEI's data lies between -9.41% and 7.39% with a probability approximately equal to 2/3.

d) Confirmed. The standard deviations of PEG's average annual MFP growth rates using capacity and volumes as output are 1.71% and 13.56%, respectively. Please see Attachment M2-11.1-EP, Tab 1.

e) Confirmed. Please see Attachment M2-11.1-EP, Tab 1.

f) Please see Attachment M2-11.1-EP, Tab 2. The t-statistic is -0.42 and the critical value for the requested test is 2.201. Since .42 is less than 2.201, we cannot reject the null hypothesis that the population mean is 0. However, we note that the small sample can lead to inaccurate results when performing the requested test.

g) Please see Attachment M2-11.1-EP, Tab 1. The t-statistics for the 1996-2014 period are 0.73 and -0.65 using capacity and volume as the output measures, respectively. The t-statistics for the 2003-2014 period are 0.27 and -0.51 using capacity and volume as the output measures, respectively. The critical value for the requested test is 2.101. Since the absolute values of all four t-statistics are less than 2.101, we cannot reject the null hypothesis that the population mean is 0 in any of the four scenarios.