

GAZIFÈRE INC.  
BUDGET DEGREE DAYS

Overview

1. In Decision D-2007-130 rendered in Phase II of Gazifère's 2008 rate case application, the Régie de l'énergie requested that Gazifère (the "Company") submit, in its next rate case application, the improvements that it intends to make in its sales and energy savings forecasting and in its weather stabilization account. These requests were made in light of the amounts that have accumulated in the Company's stabilization accounts, specifically the weather stabilization account. In response to this request the Company has undertaken a detailed review (the "Review") of alternative degree day forecasting methods.
  
2. The purpose of this evidence is to describe the Review of alternative degree day forecasting methods. Specifically, the Company has examined a variety of forecasting methods that have been or are currently used by utilities in Canada to forecast degree days for the purpose of setting rates. In accordance with the Review of these methods, the Company is requesting that the 10-Year Moving Average approach continue to be used to forecast degree days for Gazifère. Based on the Review described below, the 10-Year Moving Average method provides the most accurate forecasts and performs well in terms of symmetry and stability. The expectation is that the continued use of this method will minimize the errors associated with degree day forecasting and in turn lessen the related impact on the weather stabilization account.
  
3. Using the 10-Year Moving Average method, the 2009 forecast of balance point degree days for Gazifère is 3,294.

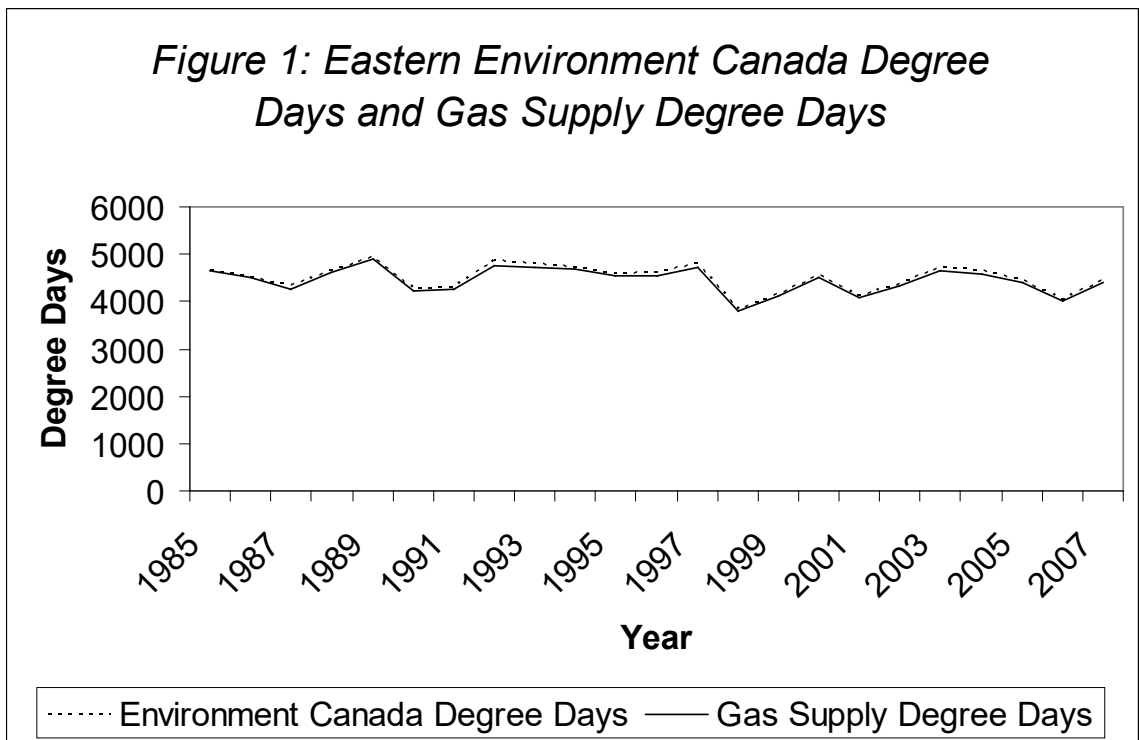
#### Environment Canada degree day data versus Gas Supply degree day data

4. In order to carry-out the Review, Environment Canada degree days for Ottawa are used. Historically, the Company has generated its forecast of degree days based on Gas Supply degree days which are then converted to balance point degree days<sup>1</sup>. However, due to data limitations a comprehensive Review of relevant forecasting techniques cannot be completed using the Gas Supply degree day data.
  
5. In general, degree days for a particular day are calculated as:  $\max(\text{balance point} - \text{average temperature for the day}, 0)$ . Environment Canada degree days are calculated by observing hourly temperature data over a 24 hour period. Over this timeframe, Environment Canada observes the maximum and minimum hourly temperature and calculates an arithmetic average of the two values to determine the average temperature for that particular day. Gas Supply degree days and balance point degree days are determined by observing hourly temperatures over a 24 hour period and calculating the arithmetic average of all twenty four hourly observations to arrive at average temperature for that day. Temperature readings for both Environment Canada and Gas Supply degree days are taken at the Macdonald-Cartier Airport in Ottawa. Environment Canada degree days and Gas Supply degree days use a balance point of 18°C while Gazifère uses a balance point of 14°C per decision D-97-46.
  
6. Daily Gas Supply degree day data, and consequently balance point degree day data, is only available from 1985 forward, while annual Environment Canada degree day data stretches back to 1941. Given the large data

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<sup>1</sup> Balance point degree days are a linear transformation of Gas Supply degree days.

requirements for some of the models<sup>2</sup>, and the daily data requirements of Gazifère's current forecasting methodology, coupled with the generally understood econometric modeling practice of using the largest amount of available and pertinent observations, the Company has opted to utilize annual Environment Canada degree days for the Review. It is the Company's position that utilizing Environment Canada degree days does not compromise the legitimacy of the error statistics which are used to rank the forecasting techniques presented in the Review below. The relationship between Gas Supply degree days and Environment Canada degree days is extremely close as shown in Figure 1<sup>3</sup>:



Environment Canada degree day data

<sup>2</sup> For example, the Energy Probe and de Bever methods require 58 years of annual data in order to estimate each respective model

<sup>3</sup> The correlation between both time series over the period presented is 0.9967

7. Temperatures in the last decade have been among the lowest since record-keeping began in the early 1940s. The average yearly decrease in degree days in Ottawa from 1941 to 2007 is 3.9; while during the period of 1998 to 2007 average yearly degree days have decreased by 33.9.
8. In addition to the recent downward pattern, the volatility in weather has increased markedly, as shown by an increase in the standard deviation of degree days. For example, during the 1998 to 2007 period the standard deviation increased 27 percent relative to the 1988 to 1997 period and 91 percent compared to the 1958 to 1967 period (Table 1).

*Table 1*  
Standard deviation of Environment Canada degree days for adjacent ten-year periods

<i>Col. 1</i>	<i>Col. 2</i>
Period	Standard Deviation
1948-1957	229.6
1958-1967	149.4
1968-1977	198.1
1978-1987	194.6
1988-1997	224.1
1998-2007	285.5

9. In view of the recent downward movement in degree days, the use of a method that places an emphasis on the recent weather experience, like the 10-Year Moving Average, is not unreasonable. This model has the ability to adjust the forecast to recent weather patterns, while not undermining the forecast with longer-term movements that may not reflect the current weather pattern. In future years the forecast could be higher or lower depending on how weather has unfolded over the prior ten years.
10. The 10-Year Moving Average is well equipped to deal with the increasing volatility in degree days in the sense that its forecast is based on the average

of the last ten yearly observations. Given the high volatility of degree days in 10-year intervals, this method should limit the forecast errors that may be associated with a model based on a longer-term history whose volatility may be less representative of the current experience.

#### Review parameters and criterion

11. The Review considers eight methods given in Table 2. The Naïve method, which assumes degree days in period  $t+2$  are equal to the last observable data point, is important because it is among the simplest methods available and thus serves as a benchmark. The additional moving average methods are given consideration because each is used by at least one Canadian gas utility. Also included is the de Bever method, which has been used by Enbridge Gas Distribution, and the Energy Probe model which is currently used by Enbridge Gas Distribution to forecast Ottawa degree days. The remaining two that the Review considers are the 20-Year Trend and the average of the 20-Year Trend and 30-Year Moving average (i.e. 50/50). Appendix 1 contains a detailed explanation of each method.

The Company believes that the following measures should be used to evaluate the suitability of the forecast methods because these metrics are widely accepted and encourage a comprehensive and balanced assessment of the forecasted values from each model: Accuracy (as represented by Mean Absolute Percent Error (MAPE) and Root Mean Percent Squared Error (RMPSE)), Symmetry (as represented by Mean Percent Error (MPE) and Percent Over-Forecast (POF)) and Stability (as represented by Standard Deviation or STDEV).

*Table 2*  
Degree day forecasting methods under consideration

<i>Row 1</i>	Naïve
<i>Row 2</i>	10-Year Moving Average
<i>Row 3</i>	20-Year Moving Average
<i>Row 4</i>	20-Year Trend
<i>Row 5</i>	30-Year Moving Average
<i>Row 6</i>	Average of 20-Year Trend and 30-Year Moving Average
<i>Row 7</i>	de Bever
<i>Row 8</i>	Energy Probe

12. Accuracy is concerned with the difference between forecast and actual degree days. MAPE is appealing because of its simplicity. It is the average of the yearly absolute percent errors, where the absolute percent error in any year is the absolute error divided by the actual value. The RMPSE is similar but it squares each percentage error, providing a penalty for large forecasting errors, adding another dimension to the evaluation. For both MAPE and RMPSE, smaller statistics signify better/more desirable results.

13. Symmetry deals with the bias of a particular forecasting method (i.e., whether it consistently forecasts low or high). The MPE is the average of the yearly percent errors, where the percent error is the error divided by the actual value. If the forecasting method is unbiased, the MPE produces a percentage that is close to zero. The POF measure is equal to the number of over-forecasts divided by the number of years under consideration. The closer this statistic is to fifty percent, the less biased (more symmetrical) the method.

14. Stability relates to the variability of the forecasts over time and is measured by standard deviation. The analysis assigns a high ranking to methods that produce forecasts with a relatively low standard deviation to recognize the notion that steady forecasts are attractive from the perspective of rate stability. However, the Company places half as much importance on Stability

(compared to Accuracy and Symmetry) because methods that perform well in this regard are generally poorly equipped to respond to changing weather.

15. Accuracy and symmetry are equally important. Neither ratepayers nor shareholders are well served by a methodology that produces relatively inaccurate results. Furthermore, since no method will be perfectly accurate, placing an importance on symmetry ensures that risks are not unevenly distributed amongst stakeholders. Meanwhile, stability is less important than accuracy and symmetry. Forecasts that are relatively more variable can result in greater rate shock. While rate shock is important, the consequences of inaccurate and/or biased forecasts are more significant.

16. Figure 2 presents the calculation of the error statistics used herein, for reference.

**Figure 2**  
**Computation of test statistics**

$$\begin{aligned}
 MAPE &= \frac{\sum_{t=1}^n \frac{|Forecast_t - Actual_t|}{Actual_t}}{n} & RMSPE &= \sqrt{\frac{\sum_{t=1}^n \left( \frac{Forecast_t - Actual_t}{Actual_t} \right)^2}{n}} \\
 MPE &= \frac{\sum_{t=1}^n \frac{Forecast_t - Actual_t}{Actual_t}}{n} & STDEV &= \sqrt{\frac{n \sum_{t=1}^n Forecast_t^2 - \left( \sum_{t=1}^n Forecast_t \right)^2}{n(n-1)}} \\
 POF &= \frac{O}{n}
 \end{aligned}$$

O is the number of over-forecasts and n is the number of years

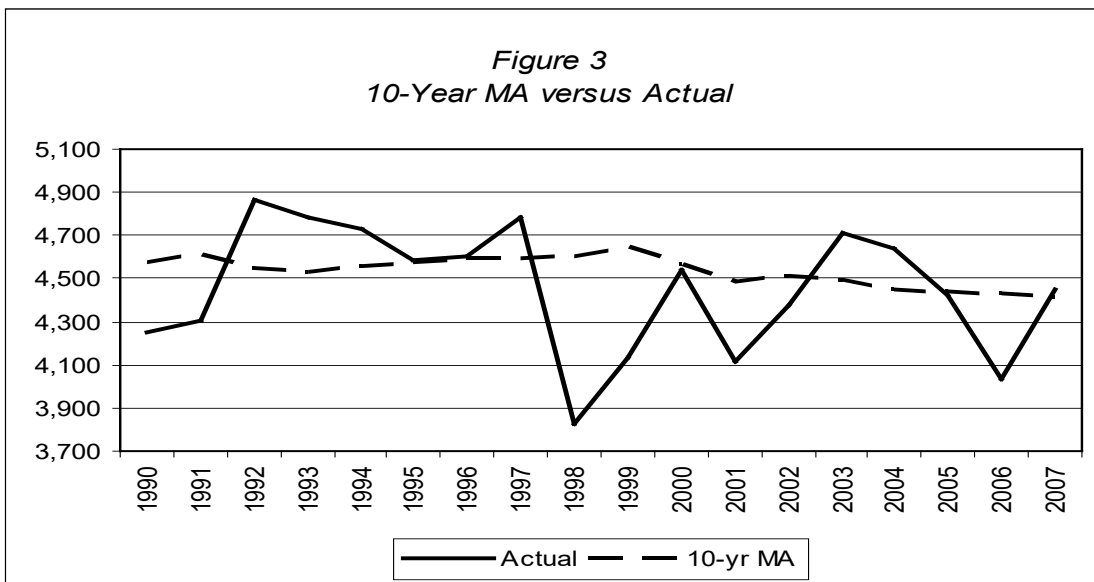
### Results

17. Table 3 provides the out-of-sample forecasts of Environment Canada degree days that each method generates. For out-of-sample forecasting, the data is divided into an initialization and holdout set. Accordingly, the forecasts are a

measure of genuine forecasting ability. Figure 3 graphs the actual degree days along with the 10-year Moving Average forecasts from Table 3 (i.e., columns 2 and 4).

*Table 3*  
Actual and forecast Ottawa degree days ('out-of-sample'), 1990 to 2007

<i>Col. 1</i>	<i>Col. 2</i>	<i>Col. 3</i>	<i>Col. 4</i>	<i>Col. 5</i>	<i>Col. 6</i>	<i>Col. 7</i>	<i>Col. 8</i>	<i>Col. 9</i>	<i>Col. 10</i>
Fiscal Year	Actual	Naïve	10-yr MA	20-yr MA	30-yr MA	50/50	de Bever	Energy Probe	20-yr Trend
1990	4,250	4,640	4,579	4,670	4,688	4,585	4,620	4,472	4,483
1991	4,303	4,931	4,613	4,682	4,695	4,619	4,674	4,648	4,543
1992	4,861	4,250	4,546	4,649	4,688	4,583	4,599	4,525	4,479
1993	4,780	4,303	4,533	4,625	4,679	4,551	4,538	4,453	4,424
1994	4,730	4,861	4,554	4,617	4,680	4,603	4,628	4,548	4,526
1995	4,585	4,780	4,579	4,635	4,675	4,605	4,665	4,579	4,535
1996	4,603	4,730	4,598	4,635	4,680	4,624	4,687	4,533	4,567
1997	4,786	4,585	4,591	4,639	4,673	4,607	4,687	4,531	4,540
1998	3,828	4,603	4,601	4,618	4,670	4,626	4,673	4,546	4,581
1999	4,137	4,786	4,647	4,628	4,667	4,641	4,678	4,611	4,614
2000	4,543	3,828	4,566	4,572	4,635	4,559	4,512	4,417	4,484
2001	4,115	4,137	4,486	4,550	4,617	4,504	4,570	4,395	4,392
2002	4,381	4,543	4,515	4,531	4,605	4,522	4,566	4,447	4,440
2003	4,715	4,115	4,497	4,515	4,582	4,460	4,408	4,357	4,338
2004	4,637	4,381	4,449	4,501	4,561	4,444	4,380	4,412	4,327
2005	4,421	4,715	4,442	4,510	4,571	4,474	4,538	4,530	4,377
2006	4,037	4,637	4,433	4,516	4,568	4,488	4,586	4,525	4,408
2007	4,447	4,421	4,416	4,504	4,565	4,485	4,572	4,503	4,406



18. Table 4 summarizes the relative performance of the key methods over the time period of 1990-2007<sup>4</sup> by using the values in Table 3 to compute the error statistics in Figure 2.<sup>5</sup> For each of the five statistics, the methods are assigned a score from one to eight based on their performance (one is best, eight is worst). The scores are summed to arrive at an overall score and rank. The Company feels that the timeframe of 1990-2007 is relevant as it allows for a reasonable sample length for which to assess the models' forecasting ability. As well, the starting date of 1990 for the assessment period allows for ample observations to incorporate the de Bever method and its derivatives. The 10-year Moving Average is the winner.

*Table 4*  
Out-of-sample forecast performance, all available years (1990-2007)

Col. 1	Col. 2	C3	Col. 4	C5	Col. 6	C7	Col. 8	C9	Col. 10	C11	Col. 12	Col. 13
	Accuracy				Symmetry				Stability		Score	Overall Rank
	MAPE	Rank	RMSPE	Rank	MPE	Rank	Percent Overforecast	Rank	Standard Deviation	Rank		
Naïve	8.7%	8	10.5%	8	1.9%	3	61%	3	295	8	30	7
<b>10-Year MA</b>	<b>5.5%</b>	<b>1</b>	<b>7.4%</b>	<b>2</b>	<b>2.3%</b>	<b>4</b>	<b>50%</b>	<b>1</b>	<b>69</b>	<b>4</b>	<b>12</b>	<b>1</b>
20-Year MA	5.7%	3	7.8%	5	3.5%	6	67%	6	63	2	22	5
20-Year Trend	5.8%	4	7.4%	1	0.8%	1	39%	3	85	6	15	2
30-Year MA	6.1%	6	8.3%	6	4.6%	8	67%	6	50	1	27	6
de Bever	6.5%	7	8.5%	7	3.5%	7	61%	3	90	7	31	8
Energy Probe	6.0%	5	7.5%	3	1.5%	2	50%	1	77	5	16	3
50/50 (20ytr,30yma)	5.7%	2	7.6%	4	2.7%	5	67%	6	65	3	20	4

19. Again referring to Table 4, the 10-Year Moving Average outperforms each model in terms of MAPE and finishes second in the RMSPE category. Overall, the 10-Year Moving Average model ranks highest in terms of accuracy. For Accuracy as a whole, the Naïve method performs the worst. It

<sup>4</sup> Years prior to 1990 cannot be legitimately tested due to the large data requirements of the de Bever method and related methods like the Energy Probe method.

<sup>5</sup> A lower score indicates a better result and is the sum of the rankings in the five individual categories (i.e., MAPE, RMSPE, MPE, PO and STDEV). The values in column 6 of Table 4 are actually the absolute value of the MPE – the end result is not affected.

is unable to account for the variability of weather and consequently produces the largest errors.

20. The 20-Year Trend produces superior results where symmetry is concerned for the 1990 to 2007 period, yielding a MPE of 0.8 percent. Meanwhile, the 10-Year Moving Average technique has a slight over-forecasting bias given the MPE of 2.3 percent. On average from 1990-2007, the 10-Year Moving Average forecast is too high by 83 Environment Canada degree days compared to 17 too high for the 20-Year Trend technique.

In terms of POF, the 10-Year Moving Average remains perfectly balanced over the sample period under-forecasting and over-forecasting nine times each, while the 20-Year Trend under-forecasts 11 out of 18 times.

For Symmetry in total, the 30-Year Moving Average is most deficient, consistently over-forecasting over the course of the relevant period with the largest bias.

21. Still referring to Table 4, the standard deviation of the 10-Year Moving Average forecasts falls in the middle of the forecasting techniques, meaning the forecasts of the 10-Year Moving Average method generates a wider distribution of forecasted degree days than that of three other models. All else being equal, the 30-Year Moving Average method generated the lowest standard deviation in forecasts. Application of the 30-Year Moving Average over the sample period would have subjected ratepayers to relatively less volatility in rates compared to the 10-Year Moving Average.

22. In summary, the 10-Year Moving Average method is best suited to the historical data set, given its superior long-run results on the basis of Accuracy, Symmetry and Stability. Therefore the Company proposes to

maintain the use of the 10-Year Moving Average technique for deriving forecast degree days for the purpose of volumetric forecasting.

Calendar 2009 balance point degree days

23. Table 5 provides the Gazifère Region balance point<sup>6</sup> degree day forecast for 2009 using each of the tested forecasting techniques. The 10-Year Moving Average method produces a forecast of 3,294 balance point degree days for 2009.

*Table 5*  
Gazifère Gas Supply Balance Point Degree Days

<i>Col. 1</i>	<i>Col. 2</i>
Forecast Method	2009
Naïve	3,249
10-Year MA	3,294
20-Year MA	3,280
20-Year Trend	3,122
30-Year MA	3,314
de Bever	3,298
Energy Probe	3,215
50/50 (20yrtr,30yrma)	3,219

Summary

24. The 10-Year Moving Average is the winner of the comprehensive Review of competing degree day forecasting methods. As a result, the Company proposes the continued use of this method to develop the degree day budget for 2009.

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<sup>6</sup> The forecast of Environment Canada degree days is converted to Gas Supply degree days by regressing Gas Supply degree days onto Environment Canada degree days. The resultant regression equation is then used to convert Environment Canada degree days to Gas Supply degree days.

APPENDIX 1: Explanation of each method and regression results<sup>7</sup>

25. Naïve Method – The Naïve method uses the last known actual data point from period t to forecast period t+2. A two-step ahead forecast is needed because the degree day budget is typically set more than 12 months in advance of the budget year, so data for the year prior to the budget year is not available (ex. 2009 budget degree days use 2007 degree days).

26. 10-Year Moving Average – Calculates an arithmetic average of the last ten years of available degree days which is used as the degree day forecast for period t+2.

**Figure A1**

**10-Year moving average equation**

$$DD_{t+2} = \frac{DD_t + DD_{t-1} + \dots + DD_{t-9}}{10}$$

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<sup>7</sup> The mnemonics in Figures A1 through A6 are as follows:

t	Time
DD	Ottawa Environment Canada Degree Days
C	Constant
TREND 1950)	Trend (20-Year Trend method – 1=1988, Energy Probe method – 1 =
5YRWA	5-Year weighted average of Ottawa Environment Canada degree days for year t = as $(5*DD_{t-2} + 4*DD_{t-3} + 3*DD_{t-4} + 2*DD_{t-5} + DD_{t-6})/15$ where DD is the actual degree day value
5YRMA	5-Year moving average of Ottawa Environment Canada degree days for year t = $(DD_{t-2} + DD_{t-3} + DD_{t-4} + DD_{t-5} + DD_{t-6})/5$ where DD is the actual degree day value

27. 20-Year Moving Average – Calculates an arithmetic average of the last twenty years of available degree days which is used as the degree day forecast for period t+2.

**Figure A2**

**20-Year moving average equation**

$$DD_{t+2} = \frac{DD_t + DD_{t-1} + \dots + DD_{t-19}}{20}$$

28. 20-Year Trend – Using an ordinary least squares regression model, this method regresses a 20-year history of degree days on a 20-year trend variable. Use the resulting regression equation (i.e. constant and coefficient of the trend variable) to extend the trend out two additional years to generate the forecast of degree days for period t+2.

**Figure A3**

**20-Year Trend forecasting equation and test statistics**

Dependent Variable: Ottawa DD  
Sample: 1988 2007

Method: Least Squares  
Included observations: 20

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5,525.16	643.16	8.59	0.00
TREND	-18.07	11.13	-1.62	0.12

Adjusted R-Squared      0.127694      F-statistic      0.121917  
Durbin-Watson stat      1.913357

29. 30-Year Moving Average – Calculates an arithmetic average of the last thirty years of available degree days which is used as the degree day forecast for period t+2.

**Figure A4**

**30-Year moving average equation**

$$DD_{t+2} = \frac{DD_t + DD_{t-1} + \dots + DD_{t-29}}{30}$$

**30. de Bever Method** – Developed by Leo de Bever in Enbridge Gas

Distribution’s EBRO 464 rate case. This forecasting method attempts to capture the short term changes and the long term trend of degree days. Specifically, the de Bever method uses a 5-year weighted average of degree days, lagged two years, as an independent variable to forecast degree days in period t+2, over an appropriate sample period called the long-term cycle length.

**Figure A5**

**de Bever forecasting equation and test statistics**

Dependent Variable: Ottawa DD  
Sample: 1950 2007

Method: Least Squares  
Included observations: 58

<i>Col. 1</i>	<i>Col. 2</i>	<i>Col. 3</i>	<i>Col. 4</i>	<i>Col. 5</i>
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2,751.82	1,080.31	2.55	0.01
5YRWA	0.40	0.23	1.71	0.09

Adjusted R-Squared      0.032854      F-statistic      2.936295  
Durbin-Watson stat      1.743923

**31. Energy Probe Method** – The Energy Probe method was filed by Energy Probe Research Foundation in Enbridge Gas Distribution’s RP-2005-0001 rate case. Similar to the de Bever method, this process attempts to isolate short term changes and long term trends in degree days. In addition to a 5-year weighted average of degree days, lagged two years, this method

includes a trend variable and 5-year moving average, lagged two years, as independent variables. It is estimated using the same cycle length as the de Bever method.

**Figure A6**

**Energy Probe forecasting equation and test statistics**

Dependent Variable: Ottawa DD  
Sample: 1950 2007

Method: Least Squares  
Included observations: 58

<i>Col. 1</i>	<i>Col. 2</i>	<i>Col. 3</i>	<i>Col. 4</i>	<i>Col. 5</i>
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4,003.55	1,255.41	3.19	0.00
TREND	0.59	0.74	0.79	0.43
5YRMA	-4.26	2.11	-2.02	0.05
5YRWA	-0.42	0.79	-0.53	0.60

Adjusted R-Squared      0.068567                      F-statistic      2.398675  
Durbin-Watson stat      1.834868

32. 50/50 Method – The 50/50 method calculates the arithmetic average of the degree day forecasts for period t+2 from the 30-Year moving average and the 20-Year trend method's. This average is used as the degree day forecast for period t+2.