DISTRIBUTION BUSINESS LOAD FORECAST AND METHODOLOGY

1.0 INTRODUCTION

This exhibit discusses Hydro One Distribution's system load forecast and methodology. It provides information on a distribution total basis that assists Hydro One Distribution in forecasting the work programs that need to be undertaken by Hydro One Distribution to meet customers' growing electricity demands, and to accommodate new customer connections.

Hydro One Distribution uses a number of methods, such as econometric models, end-use models, and customer forecast surveys to produce the forecasts required for its distribution business. Similar methods are used by major utilities throughout North America.

All forecasts presented in this section are weather-normal, meaning that abnormal weather effects are removed from the base year for load forecasting purposes so that the forecast assumes typical weather conditions based on the average of the last 31 years. The weather correction methodology used by Hydro One Distribution is a proven technique that has performed well in past years. The same methodology was reviewed and approved by the Board in the Distribution Cost Allocation Review (EB-2005-0317) and for Hydro One's 2006 and 2008 Distribution Rate cases (RP-2005-0020/EB-2005-0378 and EB-2007-0681).

All forecasts produced are internally consistent. This means that the forecasts for all customer groups add up to the total for the entire customer base served by Hydro One Distribution. Also, the forecasts presented in this exhibit are consistent with the economic assumptions which are used in the business planning process and that are described in Exhibit A, Tab 14 Schedule 1.

Hydro One Distribution's load forecast staff has significant experience in preparing provincial and local electricity demand forecasts and load profiles. The methodology described in this exhibit is the same as Hydro One's 2006 and 2008 Distribution Rate cases (RP-2005-0020/EB-2005-0378 and EB-2007-0681). The performance of Hydro One Distribution's system load forecast, since Hydro One Distribution's separation from the former Ontario Hydro, has been fairly consistent as shown in Table 1 below.

Table 1

Comparison of Hydro One Distribution Forecast with Actual
(Variance of forecast expressed as percent of actual on weather corrected basis)

Forecast made for Plan Year	Variance for Plan Year	Variance for 2nd Year	Variance for 3rd Year
1997	0.12	-2.03	1.91
1998	-2.03	-3.39	-2.02
1999	-0.85	0.73	-0.15
2000	0.46	-0.03	0.76
2001	-1.80	-1.56	-2.44
2002	1.98	2.39	2.12
2003	-0.82	-1.37	-0.74
2004	0.14	0.62	0.76
2005	0.25	0.12	0.46
2006	-0.06	-0.12	0.99
2007	-0.09	0.93	n/a
2008	-0.57	n/a	n/a
Mean (1997-2001)	-0.82	-1.26	-0.96
One standard deviation (+/-)	1.13	2.57	3.00
Mean (2002-2008)	0.12	0.15	0.27
One standard deviation (+/-)	1.06	2.41	2.77

Note: The forecast performance pertains to Hydro One Retail purchases, which account for about 96 percent of the revenue requirements in the Distribution Rate case. The remaining 4 percent pertains to revenue attributed to load distributed through the system for about 80 embedded Direct and embedded LDC customers.

Between 1997-2001, the average variance of customers' energy purchase forecast compared to the weather corrected actual energy consumed is within one standard deviation of the forecast, despite large variances resulting from unusual events such as Ice Storm in 1998 and September 11 in 2001. One standard deviation means there is one in three chances that the actual will be outside the plus or minus range (alternatively, there is two in three chances that the actual will fall within the plus or minus range). The performance of the forecast in subsequent years, namely 2002 to 2008, shows that the forecast is tracking very well and certainly well within one standard deviation band for the corresponding energy purchases. The use of the one standard deviation as a measure of forecasting accuracy is an accepted standard in the utility industry.

Section 2 below provides more detailed discussion in respect of the various economic considerations that Hydro One Distribution staff take into consideration when applying the methodology for deriving the load forecasts.

Hydro One Distribution's forecasting methodology comprises a combination of elements that include consensus input, updates to changes in economic forecasts, energy prices, population and household trends, industrial development and production, residential and commercial building activities, and efficiency improvement standards. Economic inputs were based on analyses prepared by major economic establishments in the country such as IHS Global Insight, Conference Board of Canada, Centre for Spatial Economics, University of Toronto, Canada Mortgage and Housing Corporation, and Altus Group (formerly Clayton Research). Efficiency standard assumptions used in the end-use models are based on discussion with Ontario Ministry of Energy staff. Specific customer development is based on forecast survey results from major customers. Inputs from these entities form the economic database (referred to henceforth as economic forecast) that is used to establish Hydro One Distribution load forecast. Section 3 below provides a detailed description of the methodology used by Hydro One to develop its load forecasts. Detailed modeling equations and definitions are presented in the Appendices.

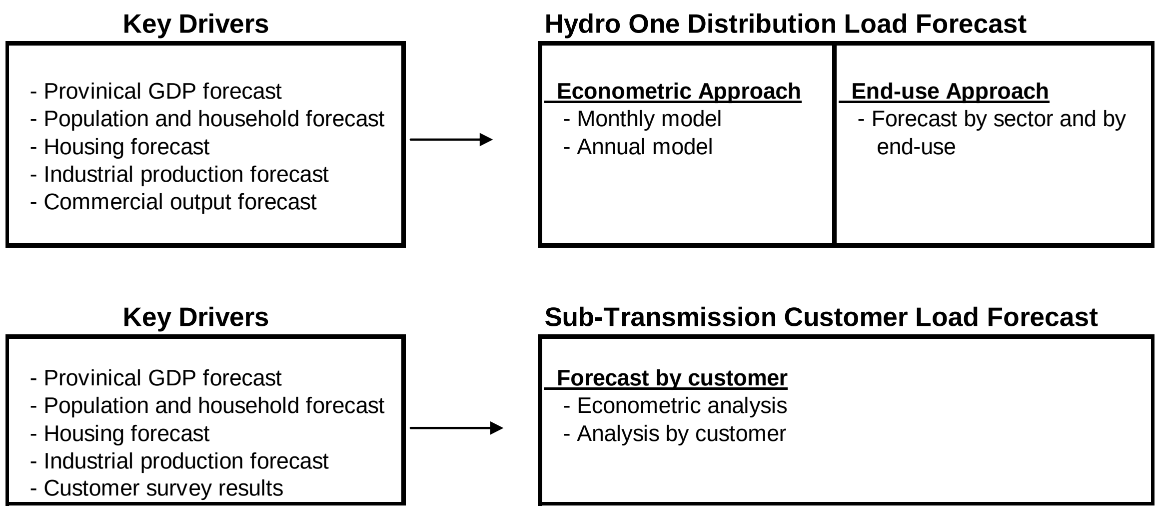
Using Hydro One Distribution's approved forecasting methodology, Hydro One Distribution expects to deliver 38,306 GWh to some 1,196,000 distribution customers in 2010, and 38,049 GWh to 1,204,000 customers in 2011. The 2010 figures represents a decrease of 4.3 percent over the 2008 demand forecast and an increase of 1.3 percent over the 2008 customer count. The reduction in demand is mainly due to the load impact of CDM and the current economic downturn. Section 4 below provides more detailed discussion in respect of the comparison of the 2010 and 2011 forecasts in relation to the historic (2008) and bridge (2009) years. The CDM assumptions are consistent with the OPA's IPSP targets filed with the Board in August 2007.

The Board in its EB-2007-0681 Decision directed Hydro One Distribution to come forward in its next rate case with a detailed proposal to incorporate the impacts of CDM in its load forecast, both attributable to its own actions and those not attributable to Hydro One Distributions' actions. A consulting study has been initiated and the final report is expected by the end of September 2009.

2.0 DISCUSSION OF THE ECONOMIC CONSIDERATIONS THAT INFLUENCE HYDRO ONE DISTRIBUTION'S LOAD FORECASTS

In this section we discuss some of the key economic considerations that must be taken into account in the process of developing load forecasts and in the application of forecasting methodologies. The elements of the forecasting process used by Hydro One Distribution are for the most part based on the knowledge of how the major economic drivers that affect the usage of electricity demand are likely to pan out over the forecast period, which in this case is for the years 2010 and 2011. Consequently for the purpose of this application the focus is on the short term and the load forecast will reflect those impacts that are likely to have a major effect in this respect. The major economic drivers used in the analysis are summarized in Figure 1 below.

Figure 1
Hydro One Distribution Load Forecast Methodology



Key information used in the analysis includes the Ontario GDP, provincial demographic, industrial production and commercial output forecasts and regional analysis included in the economic forecast. Also taken into consideration are Hydro One Distribution CDM plans, which have a direct impact on distribution system energy demands.

The load forecast in support of this application was prepared and released in April 2009 using economic information and forecasts that were available in April 2009. The timing of the load forecast is driven by the needs of the business planning process which in turn are geared to match the timeline for this submission.

2.1 Provincial GDP Forecast

The provincial GDP forecast is a key driver for the load forecast. The Ontario GDP grew 2.6 percent in 2006, slowed to 2.3 percent in 2007, and to -0.4 percent in 2008. As in most other countries, the Ontario economy is now experiencing a recession that is affecting not only the industrial sector but also the commercial and residential sectors of the economy. Overall, the Ontario GDP is expected to decline by about 2.5 percent in 2009. Based on the consensus forecast, the Ontario economy is expected to start turning around in the last quarter of 2009. The Ontario GDP is forecast to grow by 2.3 percent in 2010 and by 3.5 percent in 2011.

2.2 Provincial Population Forecast

Ontario population grew by about 1 to 1.1 percent between 2006 and 2008. Population growth for the province is forecast to continue to outperform the nation in the forecast period. The economic forecast indicated that Ontario population is expected to grow at about 1.3 percent in 2009, 2010 and 2011. Steady population growth contributes positively to the load forecast.

2.3 Provincial Housing Forecast

Helped by relatively low interest rates, housing starts remained very strong in the last few years, 74,400 units in 2006, 68,000 in 2007, and 74,700 in 2008. Due to the economic downturn, housing starts are expected to slow to about 56,000 units in 2009, gradually recovering to 58,000 units in 2010 and 63,000 units in 2011.

2.4 Commercial Output Forecast

With the help of low interest rates, commercial activities remained strong in Ontario in 2006 and 2007, growing at an average annual rate of about 3.4 percent. With the provincial economy entering into a recession, commercial output growth slowed to 1.7 percent in 2008. The commercial output is forecast to decline further by about 1.6 percent in 2009, followed by a rebound of 2.0 percent in 2010 and 3.3 percent in 2011. Commercial output is important to the load forecast because commercial load comprises about 25 percent of Hydro One Distribution's load.

2.5 Industrial Production Forecast

The manufacturing sector in Ontario has been on a declining path since 2005, primarily due to the impact of higher Canadian dollar and more recently, the slowing of the US and Canadian economies. The industrial production declined about 2.0 percent in 2006, followed by a drop of 2.5 percent in 2007 and a significant drop of 8.6 percent in 2008 due to the current economic downturn. Industries that are hit hardest include transportation equipment, mining, primary metals, fabricated metals and forestry products. Industrial output in Ontario is forecast to decline by another 6.7 percent in 2009. With the expected turnaround of the economy in 2010, industrial output is expected to grow by 3.5 percent in 2010 and 4.8 percent in 2011. The industrial production forecast is important to the load forecast because industrial activity comprised about 10 percent of total load and also because it is prone to economic cycles.

2.6 Conservation and Demand Management

Hydro One Distribution supports the Ontario Government's conservation and demand management ("CDM") target. Table 2 summarizes the cumulative CDM impact assumed in Hydro One's distribution system load forecast. The CDM impact includes programs undertaken by Hydro One Distribution and programs implemented by other agencies such as federal and provincial governments and the OPA. Hydro One Distribution's 2008 CDM impact was approved by the Board in its Decision on December 18, 2008 for EB-2007-0681. The CDM impacts for 2009, 2010 and 2011 are based on Hydro One Distribution's share of approximately 15 percent of the provincial CDM target consistent with the IPSP filed by the OPA with the Board on August 29, 2007. The aggregate provincial CDM target from the IPSP for 2008-2010 was approved by the Board in Hydro One's 2008 Transmission Rate case (EB-2008-0272).

Table 2

CDM Impact on Hydro One Distribution Load
(GWh)

Year	Hydro One Retail	Embedded Direct and LDC Customers	Total
2006	194	151	345
2007	311	245	557
2008	432	340	771
2009 (Bridge)	601	471	1,072
2010	1,325	1,035	2,360
2011	1,604	1,249	2,853

CDM programs will be planned and delivered through a number of agencies including the OPA, IESO, federal and provincial governments and LDCs. Programs implemented in the past two years, or that are in the process of being implemented include the following initiatives:

- improved building codes for new housing and more stringent efficiency standards for appliances;
- conservation programs to encourage more efficient use of lighting and appliances;

- demand response programs to reduce air conditioning and water heating load in the summer months;
- use of smart metering and TOU rates to encourage consumers to shift consumption patterns to off-peak period; and
- programs to increase supply or reduce demand such as fuel switching, using back-up generation or requesting large industrial customers to reduce consumption on a temporary basis.

The CDM impact on Hydro One Distribution load can be grouped in the following categories:

- CDM impact resulted from programs initiated by Hydro One Distribution;
- CDM impact resulted from programs initiated by other agencies such as the OPA, federal and provincial governments;
- CDM impact resulted from conservation actions initiated by Hydro One Distribution's retail customers on their own that are above and beyond the natural conservation efforts assumed in the load forecast. These conservation actions are difficult to measure because they are not program specific and therefore the savings are not easily traceable and measureable; and
- CDM impact resulted from Hydro One Distribution's embedded direct and LDC customers.

Recent CDM program results and analyses show that Hydro One Distribution's retail customers have responded to the conservation challenge, have participated in CDM programs offered by the OPA, Hydro One Distribution and other government agencies and have taken various conservation actions on the own to save electricity. As a result of their conservation actions, the impact of CDM savings on Hydro One Distribution has met and most likely exceeded the CDM impact target for 2008.

In its Decision for Hydro One Distribution's 2008 Rate case (EB-2007-0681), the Board directed Hydro One Distribution to come forward in its next rate case with a detailed proposal to incorporate the impacts of CDM in its load forecast, both attributable to its own actions and those attributable to other factors. A consulting study has been initiated and the final report will be filed upon completion expected by the end of September, 2009.

2.7 Customer Forecast

Through its distribution system, Hydro One is expected to serve about 1.196 million customers in 2010 and 1.204 million in 2011. Detailed customer information is retained in the Customer Settlement System ("CSS") for billing and account management. Customer data are extracted from CSS regularly for tracking, analysis and reporting. Customer forecast was developed on an as-required basis to support the annual business planning process, system development plans and rate submissions to the Board. Active customer accounts and service points are used as the basis from which to prepare the customer forecast by rate class. The customer forecast takes into consideration the new customers requiring distribution services, existing customers moving out, provincial housing demand, population and household forecasts, vacancy rates and specific growth patterns of various customer groups.

Customer growth in Hydro One Distribution averaged about 11,000 per year over the 2006-2008 period (2007 customer growth included an addition of 1,100 customers from Terrace Bay). Customer growth for the forecast period is expected to slow due to the current economic downturn and the resultant reduction in housing starts. Net customer additions for 2009, 2010 and 2011 are forecast to be about 7,100, 8,400 and 8,700 respectively.

3.0 LOAD FORECASTING METHODOLOGY

Hydro One Distribution system's load forecast is developed using both econometric and end-use approaches. The forecast base-year is corrected for abnormal weather conditions and the forecast growth rates are applied to the normalized base-year value. Thus the forecast is weather-normal in the sense that it predicts the future load under normal weather conditions.

3.1 Weather Correction Analysis

This section discusses the weather correction methodology used by Hydro One Distribution. Weather correction analysis removes the abnormal or extreme weather effects from the load data to yield average conditions that reflect the more normal or expected weather that is used in the forecast. It is essential that abnormal and extreme weather related impacts are removed before establishing the base-case load data, on which basis the load forecast will be developed. The volatility of abnormal or extreme weather conditions would likely adversely impact on the ability to provide a consistent and meaningful forecast for load growth. Hourly load data and hourly weather data of various weather stations across the province are used in the analysis.

Hydro One Distribution's weather correction methodology was developed jointly by forecasting and meteorology staff of the former Ontario Hydro. This weather correction method was used to forecast the total system load since 1988 and for forecasting local electric utility load since 1994. The weather correction methodology used by Hydro One Distribution is a proven technique that has performed well in the past years. The same methodology was reviewed and approved by the Board in the Distribution Cost Allocation Review (EB-2005-0378) and for Hydro One's 2006 Distribution Rate case (RP-2005-0020/EB-2005-0378).

Weather correction is a statistical process designed to remove the impact of abnormal or extreme weather conditions from historical load data. Normal weather data is defined to be data that is based on the average weather conditions experienced over the last 31 years. A weather-normal load forecast is a forecast of load assuming normal weather conditions with a weather-corrected base year. As shown in Table 3, using a fewer number of years for historic weather normalization has only a small impact on the total weather corrected energy consumption. This is an expected outcome since weather normalization has a more significant impact on peak than it does on energy due to the fact that energy consumption is less sensitive to short-term weather conditions. In Hydro One Distribution Rate case, weather normal energy (and not peak) is a key measure for the load forecast.

Table 3

Comparison of Different Time Periods Used for Weather Normalization (in GWh)

Number of Years Used to Calculate Normal Weather	Actual Load for Hydro One Retail Customers in 2008	Weather Correction required for Hydro One Retail Customers in 2008	Weather Corrected Load for Hydro One Retail Customers in 2008
Last 31 Years *	22624	221	22845
Last 20 Years	22624	286	22910
Last 10 Years	22624	262	22886

* Used by Hydro One Distribution to normalize the base year (2008) load.

Hydro One Distribution's weather correction methodology uses four years of daily load and weather data to establish a sound statistical relationship between weather and load at the applicable transformer station or delivery point used to supply customer demand. Weather variables used in the analysis include temperature, wind speed, cloud cover and humidity. The estimated weather effects are then aggregated up to the required time interval. Past experience shows that weather correction should best be done on a daily basis, rather than weekly, monthly or annual basis.

Daily weather-correction is preferred because the timing of extreme temperatures combined with wind speed and humidity can have a substantial impact on load that would otherwise not be captured by averages over longer period of time. In particular, when abnormal weather conditions continue for several days, the cumulative impact is much greater than would be the case if the same weather conditions prevailed over a much longer period of time.

The loads that are most impacted by changes in weather conditions are electric space heating and cooling in residential and commercial buildings. Across Ontario, the penetration rate of such loads varies widely, which means the weather sensitivity of load supplied from one transformer station or delivery point may differ quite significantly from that of load supplied from another transformer station or delivery point, even in the same climate zone. The climate in Ontario varies considerably from the Niagara Peninsula to Thunder Bay, so it is important to use data from the appropriate weather stations that are in close proximity to the transformer station or the customer delivery point when correcting for weather effects.

3.2 Hydro One Distribution Forecasting Methodology

Both econometric (top-down) and end-use (bottom-up) models are used to prepare load forecast for Hydro One Distribution. Both monthly and annual econometric models are used to forecast Hydro One Distribution’s total distribution system load. End-use models using the results from the provincial end-use models are used to analyse the distribution system load by customer rate class (i.e. various residential and general service customers). Key information used in the analysis includes economic, demographic, industrial production and commercial output forecast provided in the economic forecast. The purpose of using both the econometric and end-use forecast models is to arrive at a balanced forecast that represents a consistent set when looked at from macro (econometric) and micro (end-use) perspectives. The load impacts of CDM are added back to the historical data set during the modelling process.

Monthly Econometric Model

The monthly econometric model uses a multivariate time series approach to develop the monthly forecast for the Distribution system load. The model links monthly energy consumption to Ontario GDP and residential building permits. Appendix 1 provides the detailed regression equations and definitions.

Annual Econometric Model

The annual econometric model uses personal disposable income per household, relative energy price and cooling and heating degree-days to prepare the forecast. Appendix 2 provides the detailed regression equations and definitions.

End-Use Model

The end-use models cover the residential (year round and seasonal), commercial, industrial and agricultural sectors. Detailed equations of the end-use models are provided in Appendix 3.

The above models are used to prepare forecast for the following 12 rate classes:

- Urban residential (high density)
- R1 Residential, medium density
- R2 Residential, low density
- Seasonal
- Urban general service, energy-billed

- Urban general service, demand-billed
- General service, energy-billed
- General service, demand-billed
- Sub-transmission
- Street lighting
- Sentinel lighting
- Distributed generation

3.3 Methodology for Sub-Transmission Customers

This section discusses the load forecasting methodology used for the Sub-Transmission (ST) customers. These are the embedded customers who are directly connected to Hydro One's ST system or have a delivery point embedded in Hydro One's distribution service territory and include distribution utilities, industrial and commercial customers. Both econometric and customer analysis based on survey results from the customers, when available, are used in the forecast. This is supplemented by the economic data provided in the economic forecast.

In 2008, Hydro One Distribution conducted a customer load forecast survey with the embedded distribution utilities and embedded industrial customers with more than 5 MW of loads. In addition to questions relating to the total load of the customer, information at each of the delivery point was also collected. The customer survey results are used in preparing the customer forecast.

For embedded distribution utility customers, econometric analysis is used to prepare the load forecast as a group. For industrial customers, several information sources are used to prepare the forecast. These include:

- historical load profile of the customer,

- knowledge of the customer through industry monitoring,
- forecast provided by customer through the survey,
- company information through Hydro One Distribution account executives, industry and company forecasts from industry associations and government agencies, and
- production and industry forecasts provided in the economic forecast.

The econometric approach was used to forecast the load for embedded utilities and industrial analysis was used to forecast the load for the embedded industrial customers. In both cases, results from customer survey, when available, were taken into account in developing the forecast.

3.4 Methodology for Hourly Load Profiles

This section discusses the methodology for generating the hourly load profiles by customer class and for specific customer delivery points. This information presented in this section was reviewed and approved in Hydro One's 2008 Distribution Rate case (EB-2007-0681).

Hourly Load Shape by Customer Class

Hydro One Load Research team was the project lead undertaking joint load research work on behalf of the Ontario Load Data Research Group consisting of about 45 LDCs in the province. The load research methodology to collect new hourly load data for developing the generic load shapes by customer rate class was examined in detail by the Distribution Cost Allocation Working Group and was approved by the Board in RP-2003-0228 and EB-2005-0317.

The province-wide generic load shapes were prepared by the Hydro One Load Research team under the guidance of Professor Dean Mountain of McMaster University. Hydro One Load Research team subsequently used the generic load shapes to generate utility-specific load profiles for about 80 LDCs in Ontario, including Hydro One Distribution, for their cost allocation review filings under proceeding EB-2005-0317. Appendix 4 summarizes the methodology used by Hydro One Load Research team to weather-normalize the total utility load and for each rate class. Appendix 5 summarizes the methodology used to prepare the utility-specific load shapes using the generic load shapes. Hydro One Distribution used the above methodology to prepare hourly load shapes for all rate classes.

Hourly Load Shape by Customer Delivery Point

Electricity Power Research Institute ("EPRI")'s Hourly Electric Load Model ("HELM") is used to normalize the hourly load for each of the customer delivery points, taking out abnormal weather effects and load patterns. The customer forecast is used to drive the customer delivery point forecast. Key information used in the analysis includes hourly load and weather data.

The most up to date customer totalization table is used to retrieve hourly electricity demand data for each of the customer delivery points connected to the ST system. The totalization table reflects the latest records from Hydro One Distribution. For each customer delivery point, at least one full year of hourly data is retrieved and checked for data quality. Hourly weather data is also retrieved to prepare weather sensitivity analysis. Weather data analyzed include temperature, wind speed, cloud cover and humidity. Data for five weather stations across Ontario are used in the analysis. They include Toronto, Windsor, Ottawa, North Bay and Thunder Bay. Each delivery point is linked to the closest weather station.

In preparing the database for the load shape analysis, missing values are estimated by load on a similar day and hour during the same month. For weather-sensitive load, weather conditions are also taken into account in estimating the missing values. To perform the latter task, an hourly regression model (relating load to weather conditions) for each delivery point with missing values is developed.

EPRI's HELM is used to prepare the hourly weather response analysis by each delivery point. The model takes into account differences in load depending upon time of use (that is weekdays, weekends and holidays) and weather conditions. Load of industrial customers is assumed to be insensitive to weather and as such are forecast in relation to load on a similar day and hour during the historical period.

4.0 LOAD FORECAST FOR 2010 AND 2011

Hydro One Distribution' distribution system is forecast to deliver a total of 38,306 GWh in 2010 and 38,049 GWh in 2011 on a weather-normal basis. Table 4 presents the load forecast before and after deducting the impact of CDM.

Before deducting the impact of CDM, Hydro One Distribution's load forecast is forecast to grow from 40,808 GWh in 2008 to 40,667 GWh in 2010 and to 40,902 GWh in 2011 on a weather-normal basis. The forecast reflects the current economic downturn in Ontario for 2009 and a gradual economic recovery in 2010 and 2011.

Hydro One Distribution is expected to serve about 1,196,000 customers in 2010 and about 1,204,000 customers in 2011. Compared to 2009, this represents an increase of about 8,400 customers in 2010 and an additional 8,700 customers in 2011.

After removing the impact of CDM, Hydro One Distribution's load is forecast to decrease from 40,036 GWh in 2008 to 38,306 GWh in 2010 and to 38,049 GWh in 2011 on a weather-normal basis.

Table 4

Hydro One Distribution Load Forecast Before and After CDM Impact
(GWh)

Year	Retail Customers	Embedded Customers	Total
Load Forecast Before Deducting Impact of CDM			
2006	23,115	17,839	40,955
2007	23,278	17,808	41,085
2008	23,277	17,531	40,808
2009 (Bridge)	23,230	17,255	40,485
2010	23,332	17,334	40,667
2011	23,455	17,447	40,902
Load Impact of CDM			
2006	194	151	345
2007	311	245	557
2008	432	340	771
2009 (Bridge)	601	471	1,072
2010	1,325	1,035	2,360
2011	1,604	1,249	2,853
Load Forecast After Deducting Impact of CDM			
2006	22,921	17,688	40,609
2007	22,966	17,562	40,529
2008	22,845	17,191	40,036
2009 (Bridge)	22,629	16,784	39,413
2010	22,007	16,300	38,306
2011	21,851	16,198	38,049

Note. All figures are weather-normal.

Since the forecast is weather-normal; the actual load could be below or above the forecast depending on the weather conditions and/or a different economic growth pattern. Table 5 presents the upper and lower bands of one standard deviation for the Hydro One Distribution system load forecast. Based on historical data, there is a two in three chance that the actual in 2010 and 2011 will fall within the upper and lower bands. The bands are derived using Monte Carlo simulation technique relating variations in load to variations in Ontario GDP and weather.

Table 5

One Standard Deviation Uncertainty Bands for Hydro One Distribution Load (GWh)

Year	Lower Band	Forecast	Upper Band
2006		40,609	
2007		40,529	
2008		40,036	
2009	38,730	39,413	40,058
2010	37,264	38,306	39,364
2011	36,891	38,049	39,222

Appendix 1: Monthly Econometric Model

The monthly econometric model uses the State-Space approach in the regression equation, where the left-hand side of the equation represents the energy estimates, and the right-hand side contains the explanatory variables including the dummy variables that are used to capture special events that could affect the energy estimates because these events would likely cause variations in the load. The dummy variables are used to minimize the variability of the energy estimates around the forecast.

LRTLT = f (LGDPONT, LBPONT, D98Jan)

where:

LRTLT = logarithm of Distribution load,
LGDPONT = logarithm of Ontario GDP in constant 1997 dollars,
LBPONT = logarithm of Ontario residential building permits in constant dollar,
D98Jan = dummy variable to account for the load impact of 1998 Ice Storm, equals 1 in January 1998 and zero elsewhere,

The output parameters from the model are presented below. The State-Space (SS) estimated parameters are not associated with standard error and t-ratios (statistical relevance test).

Seasonal Factors	State-Space (SS) parameters:
A[1]	-0.141800
K[1]	-0.563035

Non-Seasonal Factors	SS parameters:
A[1]	0.510753
K[1]	-0.363304
GDPONT[-4]	0.0787721
BPONT[-9]	0.00445412
D98JAN	-0.0154869

R-squared = 0.989, R-squared corrected for mean = 0.989, Durbin-Watson Statistics = 2.30.

The goodness of fit, or the extent to which variability in the energy estimates is captured in the forecast, is measured in terms of R-squared (adjusted for mean), which in this case is close to 1. This result reflects statistical significance of the explanatory variables that are used to explain for the variations in load. In fact, the results show that in this case the fit is very good, and therefore there is confidence that the forecast will produce outcomes that are within the expected range of variability.

Using the forecast values for GDP, building permits and dummy variables, the above parameters are used in the monthly regression equation described on the previous page to generate the forecast for Hydro One Distribution load.

Appendix 2: Annual Econometric Model

Annual econometric model uses personal disposable income per household, relative energy price and cooling and heating degree-days to prepare the forecast. The annual model is expressed in the following regression equation:

LRTLT=C(1)+C(2)*LYPDPHH+C(3)*(LPELRES(-1)-LPGASRES(-1))
+C(4)*LCDD+C(5)*LHDD+C(6)*LRTLT(-1)-C(4)*C(6)*LCDD(-1)-C(5)
*C(6)*LHDD(-1)+C(7)*D99A+C(8)*TR+C(9)*TR2

where:

LRTLT = logarithm of Distribution load,
LYPDPHH = logarithm of Ontario personal disposable income per household in constant $,
LPELRES = logarithm of electricity price for Ontario residential sector,
LPGASRES = logarithm of natural gas price for Ontario residential sector,
LCDD = logarithm of cooling degree days for Pearson International Airport,
LHDD = logarithm of heating degree days for Pearson International Airport,
D99A = dummy variable to account for annexation of retail customers by municipal utilities equals 1 after 1999 and zero elsewhere,
TR = a dummy variable to account for a shift in growth pattern of Distribution load, increases by 1 per year prior to 1989 and no increase afterwards,
TR2 = TR to power 2,
C(1) – C(9) = variable coefficients.

The estimated coefficients and associated statistics are presented below.

	Estimated Coefficient	Standard Error	t-ratio
C(1)	5.894713	1.118161	5.271792
C(2)	0.267763	0.120535	2.221461
C(3)	-0.065953	0.021754	-3.031819
C(4)	0.008049	0.006616	1.216602
C(5)	0.203434	0.037929	5.363494
C(6)	0.259819	0.089005	2.919160
C(7)	-0.025268	0.006859	-3.684096
C(8)	-0.109073	0.020999	-5.194275
C(9)	0.002825	0.000491	5.752271

R-squared = 0.995, Adjusted R-squared = 0,994, Durbin-Watson Statistic = 1.79.

Similar to the regression analysis in the case of the Monthly Econometric model above, the goodness of fit, measured by (Adjusted) R-square for the Annual Econometric Model, is also found to be close to 1. Therefore the assessment on an annual basis also leads to a forecast outcome which provides consistent results, thus giving confidence to the econometric method. The t-ratios show most of the factors used to explain the variations in load are statistically significant.

Using the forecast values for personal disposable income, energy prices, cooling and heating degree days and dummy variables, the above parameters are used in the annual regression equation described on the previous page to generate the forecast for Hydro One Distribution load.

Appendix 3: End-Use Model

The following briefly describes the methodology used in the end-use model.

<u>Residential Sector</u>

The residential energy forecast is determined by forecasting the number of accounts times appliance saturation rates and unit energy consumption expressed in the following equation:

$$USE_{Res} = \sum_i \sum_j N_{i,j} * S_{i,j} * UEC_{i,j}$$

Where

- USE_{Res} is residential energy consumption
- N is the number of residential accounts
- S is the residential appliance saturation rate
- UEC is the unit energy consumption per end use
- I is the index for appliances (space heating, space cooling, water heater and base load)
- J is the index for customer types—year-round residential customers and seasonal residential customers

The following section describes each component of the equation in detail.

- The base-year number of households is taken from Hydro One Distribution billing system. The forecast in the growth of the number of residential accounts is based on a forecast of housing starts. The number of residential accounts is the current number of residential accounts plus the forecast of net additional accounts to be added each year.
- The base-year end-use shares (space heating, water heating and air conditioning), and fuel switching (space/water heating) information are based on Hydro One Residential Appliance Survey conducted in 2005 and 2007 for year-round and seasonal customers.

- The trends for end-use shares and fuel switching over the forecasting period reflect the provincial trends from the Hydro One provincial residential end-use model, as well as information specific to Hydro One Distribution.
- The base-year end-use UEC's are based on the provincial residential end-use model with adjustments for heating degree days, cooling degree days, income, household size, square footage and household vintage.

Commercial Sector

The commercial energy forecast is based on the following equation:

$$USEcom = USEcom(-1) * (1+\text{Expected annual growth rate})$$

Where

- $USEcom$ is the commercial energy consumption for the forecast year
- $USEcom(-1)$ is the commercial energy consumption for the previous year. The base year (2008) consumption is taken from the latest Hydro One Distribution billing system corrected for abnormal weather effects
- Expected annual growth rates are based on the Hydro One provincial commercial end-use model. Where appropriate, the values are adjusted to reflect specific distribution business characteristics.
- The model uses an end-use framework to provide estimates of energy use by building type. The building types include multi-residential, office, elementary and secondary school, college and universities, health, public service, retail, grocery, accommodation, recreation, religious/cultural, warehouse, commercial miscellaneous. non-building related segments and streetlight.

<u>Industrial Sector</u>

The industrial energy forecast is based on the following equation:

$USEind = USEind$ (-1) * (1+Expected annual growth rate)

Where

- *USEind* is the industrial energy consumption for the forecast year
- *USEind* (-1) is the industrial energy consumption for the previous year. The base year (2008) consumption is taken from the latest Hydro One Distribution billing system corrected for abnormal weather effects
- Expected annual growth rates are based on the Hydro One provincial industrial end-use model. Where appropriate, the values are adjusted to reflect specific distribution business characteristics.
- The model uses an end-use framework to provide estimates of energy use by industrial segments including Fishing, logging, Forestry Service, Mining, Petroleum, Food and Beverage, Tobacco, Rubber and Plastic, Textile and Clothing, Wood and Furniture, Paper and Printing, Primary Metal, Fabricated Metal Products, Transportation Equipment, Electronics etc.

<u>Agricultural Sector</u>

The Agricultural sector forecast is based on the following equation:

$USEagri = USEagri$ (-1) * (1+Expected annual growth rate)

Where

- *USEagri* is the agricultural energy consumption for the forecast year
- *USEagri* (-1) is the agricultural energy consumption for the previous year. The base year (2008) consumption is taken from the latest Hydro One Distribution billing system corrected for abnormal weather effects

- Expected annual growth rates are based on the Hydro One provincial agricultural end-use model. Where appropriate, the values are adjusted to reflect specific distribution business characteristics.
- The model uses an end-use framework to provide estimates of energy use by agricultural segments including Animal Production, Fruit and Vegetable Farming, Grain Farming, Green Housing and Floriculture and Miscellaneous etc.

Appendix 4: Weather Normalization for Total Utility Load and by Rate Class

Weather Normalization for Total Utility Load

Hydro One's weather normalization methodology for total utility load is summarized as follows.

- An equation relating daily energy and daily weather conditions is developed using the latest 4 years of data. This time frame allows the analysis to reflect the most recent load mix while having sufficient data to quantify its weather sensitivity. For example, the share of space cooling energy relative to total energy has increased rapidly over the past decade; using too long a time series of historical data may lead to significant under-estimation of the weather sensitivity of load in the summer.

- To better isolate the impact of weather, systematic changes in daily loads are identified and filtered out before the regression analysis begins. The systematic effects removed include growth trends, cyclical variations, day-of-the-week effects and holiday effects. The objective is to filter the data to weather-related load and noise (random effect).

- Different types of weather data are used in the analysis. For winter loads, weather data include temperature, wind speed and cloud opacity. For summer loads, weather data include temperature, humidity and cloud opacity. Because weather effects cumulate over several days, the temperatures for the current day as well as the previous 3 or 4 days are also used as explanatory variables in the model. The relationship between energy and weather may be represented by the following function:

Weather- Related Energy = f (Weather Conditions) + Random Term (1)

where the random term reflects any remaining variations that are not explained systematically by weather. The random term is assumed to be distributed independently, identically and normally with mean equals to zero.

- The coefficients from Equation (1) are estimated using the most recent 4 years of daily load and weather data. These coefficients indicate the sensitivity of load in the service territory relative to today's temperature, yesterday's temperature and all other weather variables included in the equation. The estimated coefficients are multiplied by the actual weather data for the corresponding weather variable in the equation to determine the estimated weather-related energy for the day. This process is repeated for each day of the period for which weather-correction is performed.

Estimated Weather-Related Energy = f (Actual Weather Conditions and Estimated Coefficients) (2)

- Equation (2) is used to determine what "normal" weather-related loads would be for each day of the year given the current mix of weather-sensitive loads in that service territory. This is done by running the equation with each of the last 31 years of daily weather data for that day plus the seven days on either side of it. The average of the estimated weather-related loads for the 15 days times 31 years (465 observations) is deemed to be the "normal" weather-related energy for that day. Using 31 years of weather history is considered adequate to approximate normal weather.

Normal Weather-Related Energy (for each day) = Average (31 years of Estimated Weather-Related Energy for that Day +/- 7 Days) 3)

- On a daily basis, the weather correction is derived as the difference between the estimated and normal weather- related energy:

  Weather Correction for Energy = Normal Weather-Related Energy – Estimated Weather-Related Energy (4)

- Weather-corrected energy is defined to be actual energy plus the weather correction in any given period. For any period that is more than one day (e.g., a month), the total weather correction is the sum of the daily weather correction.

  Weather-Corrected Energy = Actual Energy + Weather Correction for Energy (5)

- For example, a summer day for which the combination of temperature and humidity are above normal yields a negative weather correction. The weather correction in this case should be viewed as the amount to be subtracted from the above normal actual to get the weather-corrected energy. Similarly, a warm winter day would have a positive weather correction as the weather corrected value for that day should be higher than the below normal actual.

<u>Weather Normalization by Rate Class</u>

Weather correction by rate class is derived from weather correction for the total utility using the electric space heating and cooling shares by rate class or segment as detailed below.

- Weather correction for the total utility load is discussed above using daily energy for the utility. The amount of weather correction is measured on a daily basis.

- Using average daily temperature for each day, the daily weather correction is grouped into "weather correction for space heating" and "weather correction for space cooling". For example, if average daily temperature is -1, the weather correction for that day is allocated to "weather correction for space heating" load. The daily weather correction results are aggregated into annual or monthly weather correction estimates.

- Using load shape analysis and residential appliance saturation estimates for the utility and the region, the amount of space heating and cooling load over a year or month are estimated for each rate class. The weather correction for each rate class is calculated using the space cooling and heating load of that rate class. The methodology used is summarized as follows.

- **Residential cooling/heating load**: Residential load shapes are developed using the generic load shapes (cooling, space heating, electric water heating, etc.) from the Ontario Load Data Research Group. Based on these generic load shapes and specific appliance saturation estimates for the utility and the region, total residential space heating and cooling load are calculated. The generic load shapes may vary by region, reflecting different weather conditions across the province.

- **Non-residential cooling/heating load**: For non-residential rate classes, the generic load shapes from the Ontario Load Data Research Group (or available load shapes from Hydro One for load shapes not covered by the joint load research project) are used to calculate the cooling and heating load percentages by rate-class or segment (e.g., by SIC or industry segment). Again, these generic load shapes may vary by region, reflecting different weather conditions across the province. Some industrial segments may not be weather-sensitive; in this case the space heating and cooling loads would be zero. The corresponding percentages of space cooling and heating load multiplied by rate-class or segment load would provide the cooling and heating load of that rate class or segment.

- **Total cooling/heating load and shares**: Total space heating and cooling load for the utility are calculated by adding residential and non-residential space heating and cooling loads from above. Using this total, the shares of cooling and heating load for each rate class relative to the total cooling and heating load are calculated.

- **Weather correction by rate-class:** For each rate class, the cooling and heating weather correction amount are calculated using the total cooling and heating weather correction amount for the utility multiplied by the corresponding cooling and heating shares calculated from above. Shares of some industrial segments could be zero since they are not weather sensitive. The weather-corrected load for each rate class is estimated by adding the weather correction estimates by rate class to the corresponding (actual) load for each rate class.

Appendix 5: Methodology for Preparing Utility-Specific Load Shapes

Hydro One's method makes use of the following information:

- Generic load shapes prepared for the Ontario Load Data Research Group for residential and general service customers.
  - The residential load shapes have weather-normal profiles for 4 end-use categories (electric space heating, electric water heating, air conditioning and base load) and 4 regions (Central, East, West and North).
  - The general service customer load shapes have load profiles for about 35 industry segments using NAICS-2002 (North American Industry Classification Systems) and by number of working shifts.
- Hydro One weather normalization methodology for total utility load and by rate class.
  - Hydro One weather normalization method, which was approved by the Board in RP-2005-0020/EB-2005-0378 and EB-2005-0317, uses 4 years of daily load and weather data to establish the relationship between weather and load and the average of 31 years of weather data to define typical weather conditions.
  - Weather variables used in the weather correction analysis include temperature, wind speed, cloud cover and humidity. In addition to temperature, wind speed is important in the winter months, while humidity is important for the summer months.
  - Estimation of space heating and cooling loads for residential customers makes use of generic load shapes and appliance saturation estimates.
  - Estimation of space heating and cooling loads for general service customers makes use generic load shapes and industry classification.
- Weather-normalized load shapes for battery mats prepared by the Hydro One Load Research team using information provided by the local cable company. For the informational filing to OEB, weather-sensitive load profiles for battery mats are

required only for LDCs using future test year and not required for LDCs using historic test year in their 2006 EDR applications.

- Results of residential appliance survey undertaken by LDCs using survey questions recommended by the OEB's load research expert. For LDCs opted not to undertake residential appliance survey, estimates of appliance saturation are prepared using monthly energy patterns for each residential customer.
- Deemed street lighting and sentinel lighting load profiles approved by the OEB.
- Interval meter customer load profiles by rate class and by industry classification.
- Special tabulation of Household Equipment Survey results from Statistics Canada.
- Residential appliance survey results undertaken by former Ontario Hydro.

Hydro One's utility-specific load shape methodology is summarized as follows:

Weather correction analysis

- Weather correction analysis is performed for each region and LDC.
- For each region, weather correction analysis is undertaken using the total regional load.
- For each LDC, the weather correction analysis is undertaken for the total utility load as well as by rate class. Weather sensitive loads for space heating and space cooling are determined for each day.
- The relationship of weather sensitivity between the region and the LDC is used to calibrate the utility-specific space heating and cooling loads with the regional estimates.
- Using the weather correction analysis, generic load shapes and monthly profiles, weather-corrected loads are estimated for the total utility load and by rate class.

Residential Customers

- Using number of customers, appliance saturation and generic load profiles, the energy consumption by end-use are estimated.
- The relationship of weather sensitivity between the region and the LDC is used to calibrate the utility-specific energy consumption for space heating and cooling loads.
- The relationship of appliance saturation and housing characteristics between the region and the LDC is used to calibrate the utility-specific profiles for water heating and base loads.
- Weather-normal hourly load shapes are estimated using generic load shapes and energy consumption by end-use.
- Weather-normal energy consumption by end-use will add up to weather-normal residential rate class total.

General Service >50 KW Customers

- General service >50 kW customers are grouped by industry classification excluding interval metered customers.
- Allocation of weather correction is undertaken for industry classifications that are weather sensitive.
- Analysis takes into consideration number of work shifts for each industry classification.
- Weather-normal hourly load shapes are estimated using generic load shapes and energy consumption for each industry classification.
- Weather-normal energy consumption by industry classification will add up to weather-normal general service >50 kW rate class total.