Weather Normalization for Total Utility Load

Hydro One's weather correction methodology was developed jointly by forecasting and meteorology staff of the former Ontario Hydro. This weather correction method was used for the total system load since 1988 and for local electric utilities since 1994. The weather correction methodology used by Hydro One is a proven technique that has performed well in the past years. Many electric utilities in the province have used this weather normalization methodology: London Hydro, Markham Hydro, Scarborough Hydro and Ottawa Hydro.

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. The weather correction method is applicable to the total utility load as well as by rate class.

Hydro One's weather correction methodology uses four years of daily load and weather data to establish a sound statistical relationship between weather and load. Weather variables used in the analysis include temperature, wind speed, cloud cover and humidity. The weather correction estimates 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.

Hydro One's weather normalization methodology for total utility load is summarised 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.

Weather Normalization by Rate Class

Weather correction by rate class can be 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 can be 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 can be 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 can be estimated for each rate class. The weather correction for each rate class can be 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 can be developed using the generic load shapes (cooling, space heating, electric water heating, etc.) from the joint load research project. Based on these generic load shapes and specific appliance saturation estimates for the utility and the region, total residential space heating and cooling load can be 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 joint load research project (or available load shapes from Hydro One for load shapes not covered by the joint project) can be 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 can be 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 can be calculated.

- Weather correction by rate-class: For each rate class, the cooling and heating weather correction amount can be 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 can be estimated by adding the weather correction estimates by rate class to the corresponding (actual) load for each rate class.