A General Discussion of the Forecast Model Structures of the ISO New England Long Run Energy and Seasonal Peak Forecasts for the 2012 CELT Report and 2012 Regional System Plan

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Section 1
General Description of Forecast Model Structures

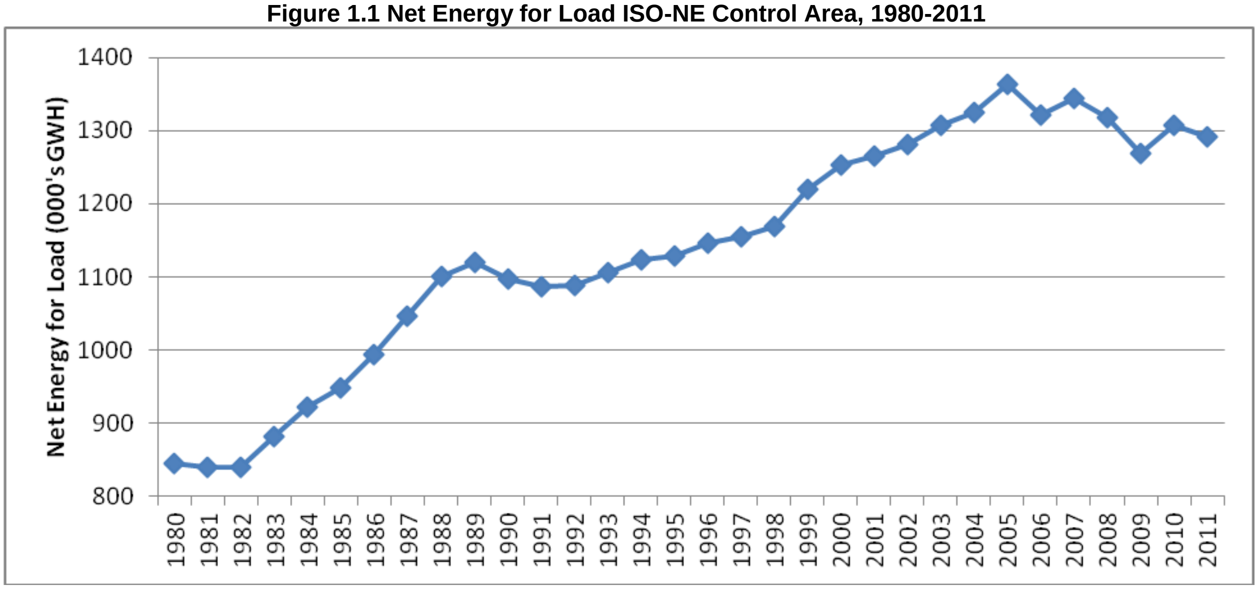
In the 2006-2008 timeframe, in anticipation of the upcoming implementation of the Forward Capacity Market, ISO-NE and NEPOOL initiated a review of the ISO-NE load forecast methodology. Since the load forecast would play an important role in establishing the Installed Capacity and Local Sourcing Requirements that would used in the new Forward Capacity Market it was felt that independent review of the forecast methodology was warranted.

Though the larger reviews process, two independent forecasting experts were hired to review and comment on the ISO-NE load forecast methodology Benchmark Forecasts completed its review in 2006, and Dr. Tim Mount completed his review in 2007. A summary of their recommendations may be found in Appendix A of this report. The current structure of the forecast models for both energy and peak load include the implementation of the recommendations suggested by these two reviewers.

The forecast for 2012 continues being challenging as the recent economic recession still creates a great deal of uncertainty about the speed of economic recovery. In addition, increased demand response and energy efficiency resources, and public policy related to these resources, exacerbate volatility and amplify the uncertainty around the energy and peak load forecast.

Figure 1-1 depicts the long-run trend of Net Energy for New England Control Area. It clearly shows the increased volatility of energy demand since 2005

Figure 1.1 Net Energy for Load ISO-NE Control Area, 1980-2011



1.1 Energy Forecast Model

The 2011 energy forecast is produced by an annual model of projected total energy consumption within the ISO-NE control area. The goal is to specify a forecast model with a sound economic structure that captures the underlying relationships among the input variables to predict electric consumption as accurately as possible. Thus, an autoregressive model is estimated, with lags on the dependent variable for New England, Connecticut, Massachusetts, New Hampshire, Rhode Island and Maine. RGSP and trend were used in Vermont model. This dynamic specification allows for the gradual adjustment of energy consumption to changes in the explanatory variables over time. For example, rising energy prices might spur consumers to purchase more efficient appliances as existing appliances wear out or are scrapped. These purchases are stimulated by higher energy prices, but do not occur immediately when prices begin to rise.

Specifically, the load forecasting model for New England Control area is structured as follows:

$$E_t = \alpha_0 + \alpha_1 E_{t-1} + \alpha_2 rp_t + \alpha_3 rgsp_t + \alpha_4 cdd_t + \alpha_5 hdd_t + e_t \quad (1)$$

The autoregressive structured is kept for each of the states models except for Vermont. The model for Vermont is specified as follows:

$$E_t = \alpha_0 + \alpha_2 trend_t + \alpha_3 rgsp_t + e_t \quad (2)$$

Where:

t :is the year
E :is the energy for load plus "other demand resource" participating in the FCA
rp :is the real average retail electricity price
rpi :is the real personal income (Connecticut)
rgsp :is real gross state (or region) product
cdd :is the cooling degree days
hdd :is the heating degree days
e :is the stochastic residual

In addition, the New England model incorporate a Cooling Degree Day weather elasticity to better account for structural changes over the historical period (e.g., impact of greater penetration of air conditioners).[1] The forecast includes estimates of the impact of new Federal Electric Appliance Standards that would not be captured by econometric models (2013 going forward).

1.2 Peak Forecast Model

The ISO-NE peak load model[2] uses daily peak loads to forecast weekly, monthly and seasonal peak loads. A separate model is estimated for each region for each month over a 10-year time horizon. Daily peak loads are modeled as a function of energy consumption, weather, and slope shifters for weekends, holidays, and other relevant factors. For the summer months, a trend-weather variable is included in the regression equation to capture the increasing sensitivity of peak loads to weather arising from a growing cooling load. Specifically:

$$PeakLoad_{t,d} = \gamma_0 + \gamma_1 E_t + \gamma_2 (wthi_{t,d} - 55)^2 + \gamma_3 trend_t * (wthi_{t,d} - 55)^2 + e_{t,d} \quad (3)$$

Where:

PeakLoad :is the daily peak load

[1] For the specifics on each of the states models, please see http://www.iso-ne.com/trans/celt/fsct_detail/index.html
[2] A background of the current peak load model structure is explained in the paper "A General Discussion of the Forecast Model Structures of the ISO New England Short and Long Run Energy and Seasonal Peak Forecasts for the 2009 CELT Report and 2009 Regional System Plan" (see http://www.iso-ne.com/trans/celt/fsct_detail/2009/index.html).

E	:is the annual energy for load plus “other demand resources” in the FCA
wthi	:is the weighted average temperature humidity index at the time of peak
e	:is the stochastic residual

Consistent with the 2011 peak load model, the 2012 version distinguishes the contributions of the “Non-weather sensitive load” (N-WSL) and weather sensitive load (WSL) to the peak load. Specifically, the model includes:

A) N-WSL is linked to energy, which reflects the influence of electricity price and economic variables.

B) WSL is linked to wthi at the time of the peak.

C) Estimates of the impact of new Federal Electric Appliance Standards (2013 going forward).

1.3 Key Model Inputs and Drivers

The economic drivers used in the regional energy and peak forecast models are:

- New England real Gross Domestic (State) Product (rgsp) from Moody’s Economy.com.[3] Gross domestic product is adjusted for inflation by Moody’s price deflator.

- New England Real Retail Price of Electricity, derived from the Energy Information Administration’s Current and Historical Monthly Sales, Revenue and Average Revenue per Kilowatt hour

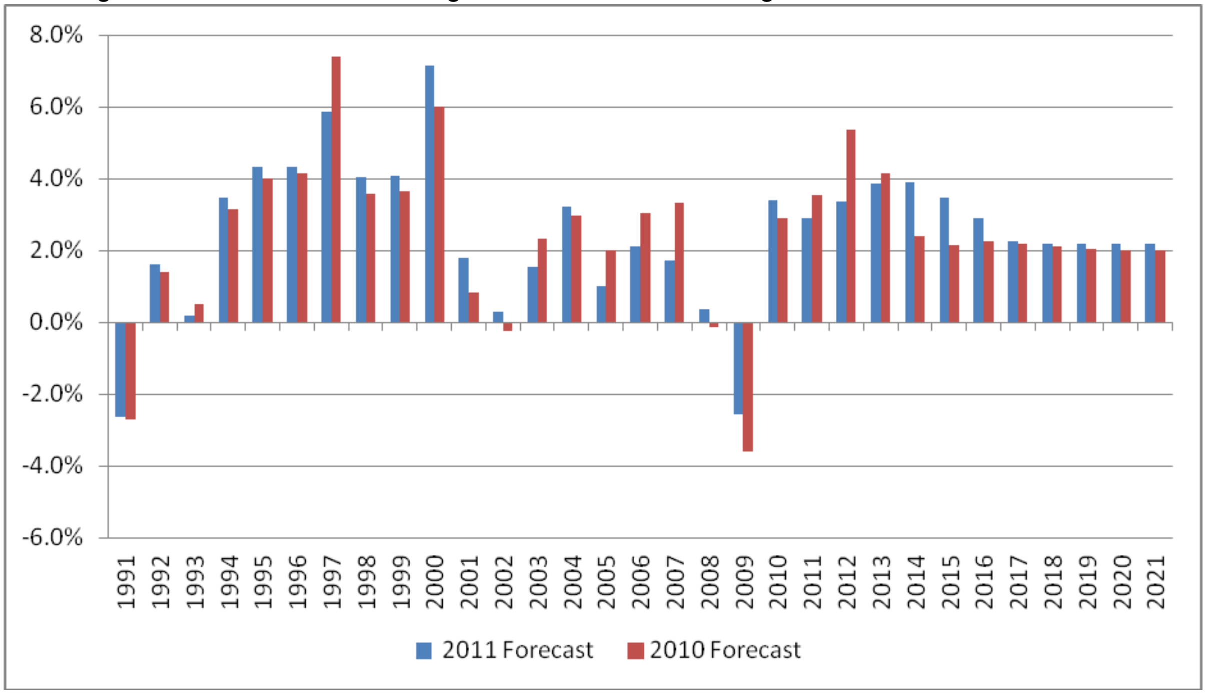
- The weather concepts used in the energy model are: New England 8-city weighted annual heating degree days (HDD) representing winter weather, and an annual temperature-humidity index cooling degree days (CDD), constructed from both dry bulb and dew point temperatures for summer weather. The weather concepts used in the peak models are the New England 8-city weighted daily dry bulb for the winter and shoulder months and the New England 3-day weighted temperature-humidity index (WTHI) for the summer months. The forecasts assume normal weather.

1.4 Economic Input Data – Real Gross Domestic (State) Product

Real gross domestic product serves as a surrogate for overall economic activity in the models. Figure 1-2 presents forecasted annual growth of the real gross domestic product for New England used in the current energy and peak load forecasts, as compared to last year. The economic activity started to slow in 2007, bottomed out in 2009, and began to recover in 2010.

[3] Real personal income is used as the economic driver in the Connecticut model.

Figure 1–2: Forecasts of New England Annual Percent Change in Real Gross Domerstic Product.

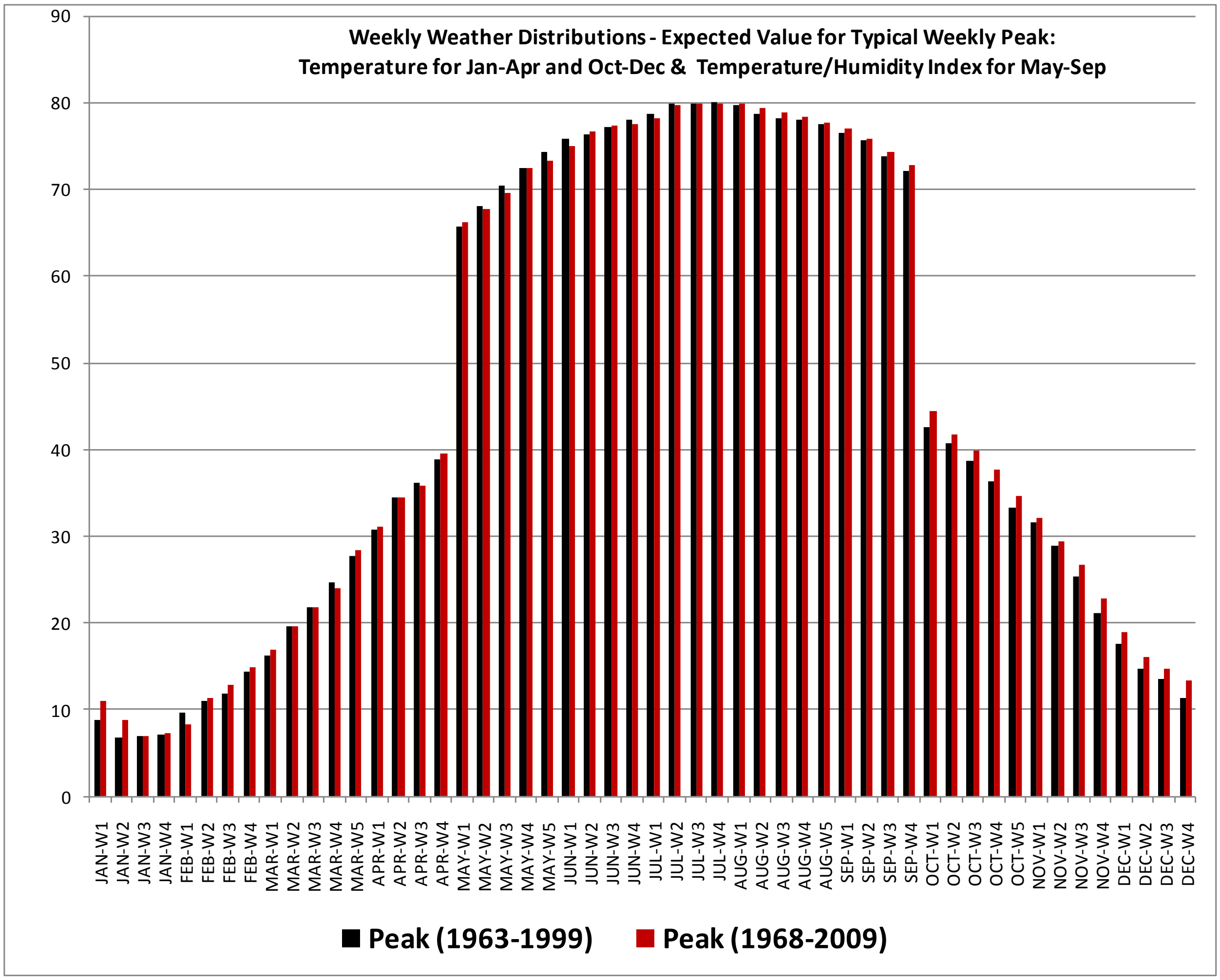


Source: Economy.com

1.5 Weather Distribution

ISO-NE updated the historical weather used to forecast weekly peak load distributions, and seasonal peak loads in 2010. As in 2011, the 2012 forecast uses the new historical weather sample which covers the period from 1969 through 2008, while the 2009forecast used the historical weather sample from 1963 through 1999.

In summary, the new weather distribution results in somewhat cooler normal weather in the months of June and July than does the previous distribution, and the month of August is slightly hotter than before. With respect to the winter months, the new weather distributions results in slightly warmer weather in December and January.


Weekly Weather Distributions - Expected Value for Typical Weekly Peak:
Temperature for Jan-Apr and Oct-Dec & Temperature/Humidity Index for May-Sep
90
80
70
60
50
40
30
20
10
0
JAN-W1
JAN-W2
JAN-W3
JAN-W4
FEB-W1
FEB-W2
FEB-W3
FEB-W4
MAR-W1
MAR-W2
MAR-W3
MAR-W4
MAR-W5
APR-W1
APR-W2
APR-W3
APR-W4
MAY-W1
MAY-W2
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JUN-W1
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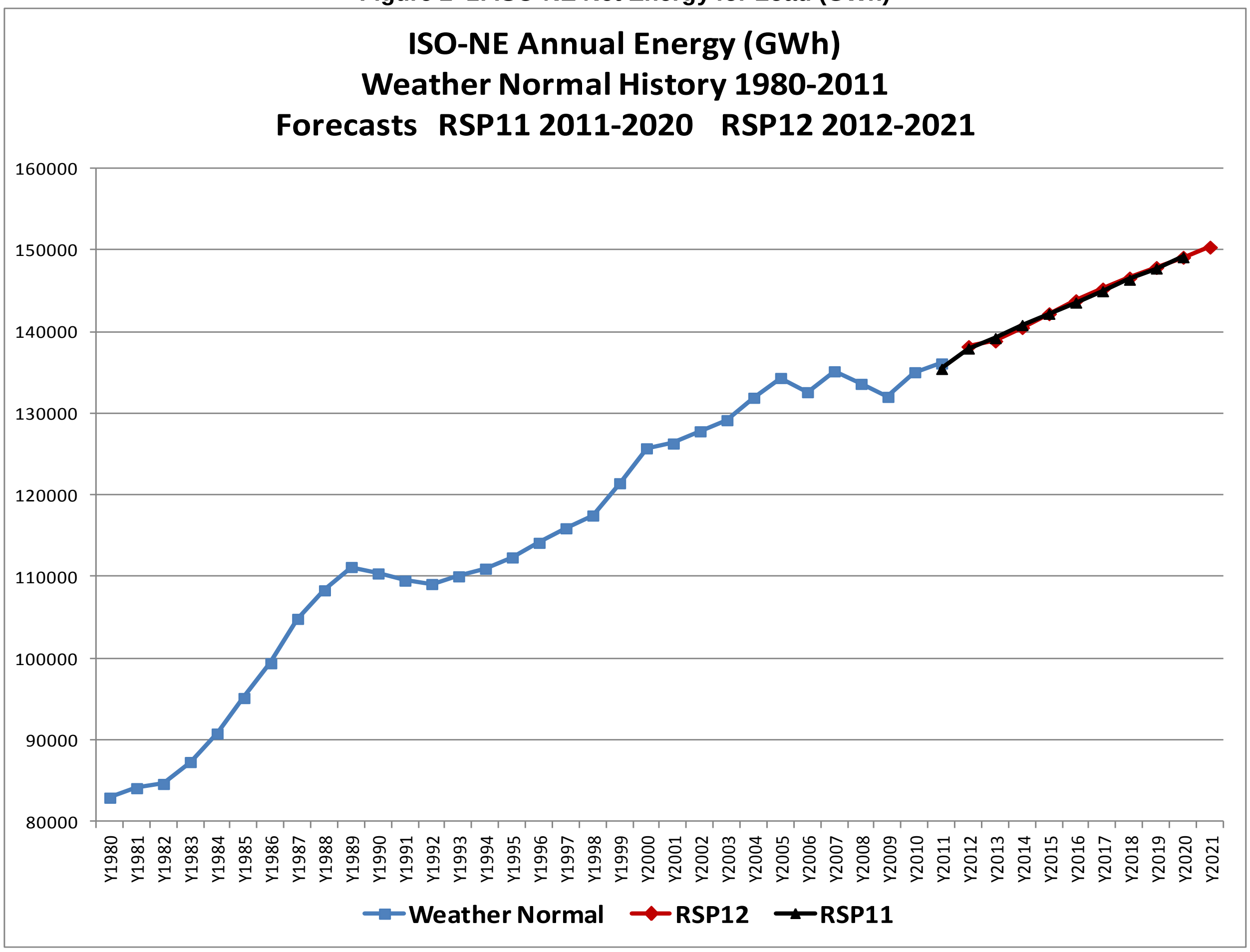
JUL-W1
JUL-W2
JUL-W3
JUL-W4
AUG-W1
AUG-W2
AUG-W3
AUG-W4
AUG-W5
SEP-W1
SEP-W2
SEP-W3
SEP-W4
OCT-W1
OCT-W2
OCT-W3
OCT-W4
OCT-W5
NOV-W1
NOV-W2
NOV-W3
NOV-W4
DEC-W1
DEC-W2
DEC-W3
DEC-W4
Peak (1963-1999)
Peak (1968-2009)

Section 2
Observations Regarding Projected Energy Consumption

The 2012 projected weather normalized annual energy demand is depicted in figure 2-1, the 2012 forecast projects that weather-normalized annual energy demand in New England will grow slightly slower than expected in the 2011 forecast. The long–run energy growth rate is forecasted to be just over 0.9%. The 2012 energy forecast incorporates the annual energy saving expected from the introduction of the Federal Appliance Efficiency Standards in 2013. The forecast of electricity demand was depressed 0.92% in 2013. The impact of the Federal Appliance Efficiency Standards are projected to increase gradually and amount about 1.56% .

Figure 2–1: ISO-NE Net Energy for Load (GWh)



Section 3
Observations Regarding the Projected Winter Peak

The 2012 forecast projects a modest growth over the next 10-year period. The long-run winter peak load growth rate is projected to be 0.6%. Major changes in the winter peak load methodology were implemented in 2009, and no further changes were necessary for the 2011 winter peak load forecast.

The economic downturn had a less severe impact on the winter peak load than on the summer peak load. The winter peak is determined mainly by residential load. As such, it occurs late in the afternoon (6 PM) and has less exposure to deteriorating industrial and commercial demand.

The primary factors driving the current winter peak load forecast include:

A) Economic activity, represented by the energy forecast, is the major driver of the winter peak load forecast, since the non-weather-sensitive part of the load accounts for 85% of the winter peak.

B) The impacts of Federal Electric Appliance Standards on peak demand have been incorporated into the model.

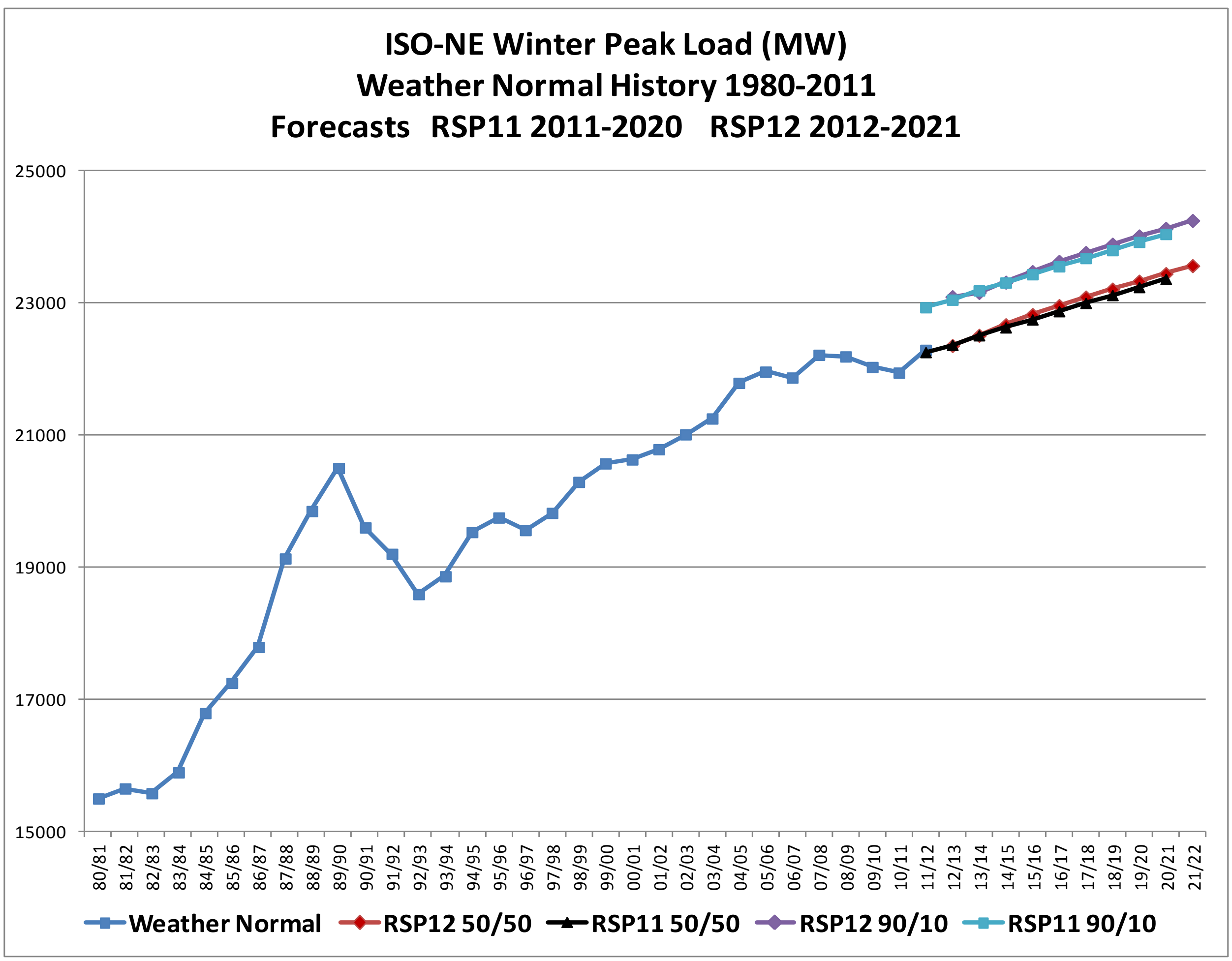


Figure 3-1: ISO-NE Winter Peak Loads

Section 4
Observations Regarding the Projected Summer Peak

Figure 4-1 shows that the 2012 summer peak load forecast is very similar to the 2011 forecast. The 2012 forecast cycle projects an average growth rate of 1.5% over the next 10-year period, slightly above the 2011 forecast of summer peak growth (1.4%). The trajectories of both forecasts are mainly influenced by the energy driver, which in turn is heavily dependent on its economic drivers, and an increasing penetration of air-conditioning.

The economy began a sluggish recovery from the recession in 2010. After a disappointing 2011, the economy is projected to show a modest growth during 2012 and 2013 and speed up after 2014. The summer peak load long run forecast trend is very closely aligned with the long-run forecast of the economy. Dampening the growth in the summer peak load forecast is the impacts of Federal Energy Appliance Standards, which become effective in 2013.

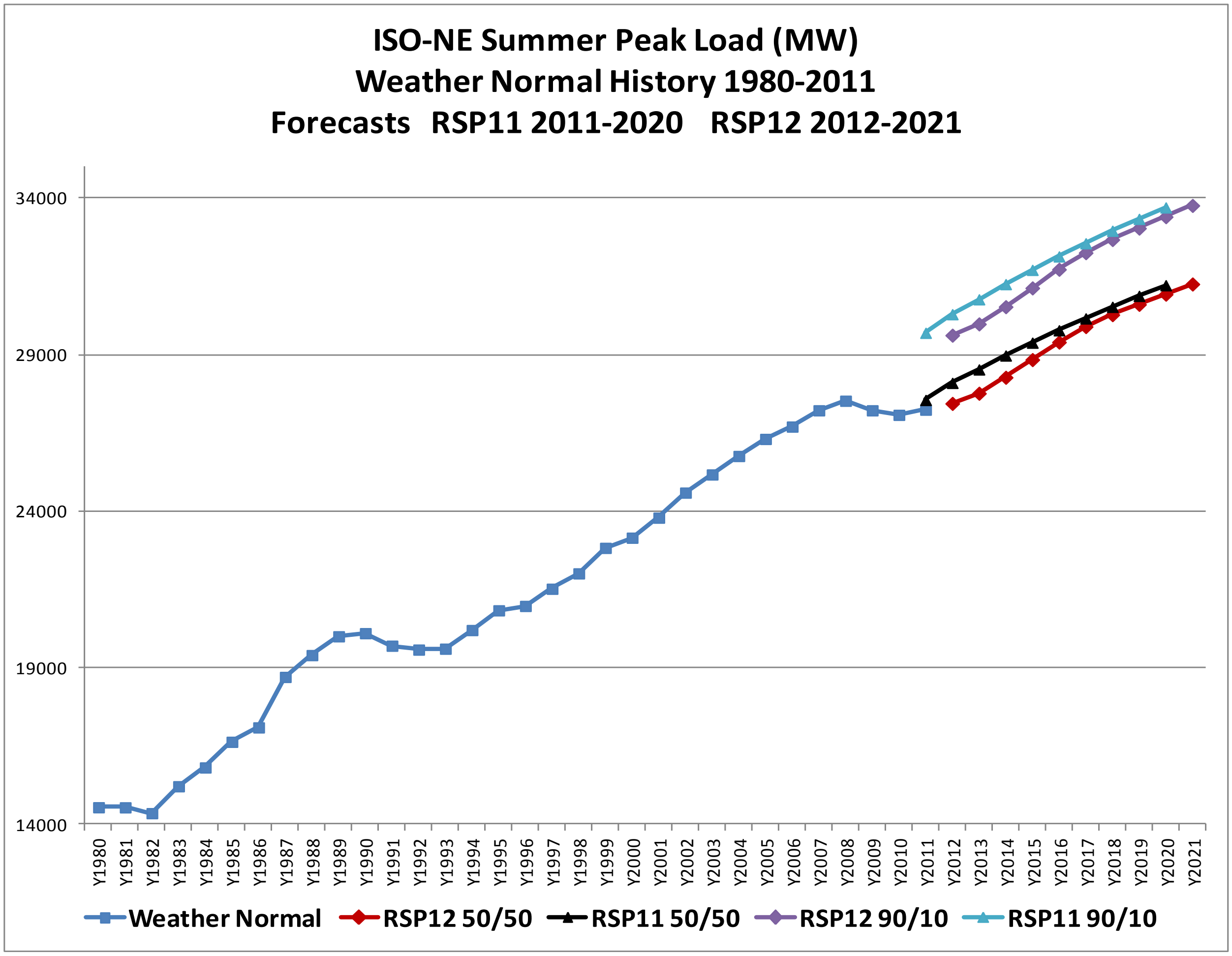


Figure 4–1: ISO-NE Summer Peak Loads.

Appendix A: Summary of Enhancements Recommended by Benchmark Forecasts and Dr. Tim Mount (2010)

To the extent feasible, ISO-NE incorporated the following recommendations into its 2010 forecasting effort. This appendix outlines the recommendations and briefly describes the ISO's response.

Recommendation 1: Keep the current linear structure of the model of peak load so that the ability to distinguish explicitly between temperature sensitive and non-temperature sensitive load is maintained. The linear specification did not change in the 2010 or 2011 peak load forecasting models.

Recommendation 2: Use a model specification for peak load that makes it feasible to estimate the short-run and long-run effects of economic (price and income) and physical (weather) factors simultaneously. Such a change requires a major research effort, and earlier studies found that the energy and peak load models are recursive and do not need to be estimated simultaneously.[4]

Recommendation 3: Statistical evidence should be presented in public reports to demonstrate that all time-series models are consistent with the basic econometric specifications such as white noise, homoskedastic, and non-stationarity of the residuals. These tests have been incorporated into the model documentation.

Recommendation 4: Use a statistical package that estimates time-series models correctly when there are gaps in the sequence of the observations. These gaps from one year to the next and from one state to another state are inevitable. Research into the current software used to estimate the forecasting models (eViews) confirms that it can handle gaps correctly.

Recommendation 5: Incorporate weekend effects into the model to make it feasible to add weekend observations for estimation and eliminate many of the gaps in the time-series data. Weekend and holiday effects were incorporated into the model in 2010; thus, few gaps remain in the data.

[4] See the documentation for the 1987-1988 original model development.

Appendix B: Statistical Tests

Eviews econometric software was used to estimate and forecast energy and system peak load. Linear Least Square, Non-linear Least Square or Restricted Least Square Estimation techniques were used to estimate the majority of the models.

This appendix discusses the overall results of the statistical tests conducted for the model specification. Details can be found in the individual model documentation.

Overall, the energy and system peak load models exhibit very good statistical properties. The estimates of the explanatory variables have the expected signs and most are statistically significant at the 1% critical level or better. “Goodness of fit” is represented by the adjusted R-squared values. In most of the models, the adjusted R-squared values were over 0.90. The R-squared values are especially consistent across the energy models.

Following the recommendations of Benchmark Forecasts and Dr. Tim Mount (Appendix A – Recommendation 3), ISO-NE has paid particular attention to the statistical properties of each of the models used in the forecast process, to make sure that the standard statistical assumptions are not violated, and therefore to help ensure that the forecasts are unbiased and as efficient as possible.

Since ISO-NE deals with time series data, the most typical statistical problem the model may have is serial autocorrelation of order 1 or higher in the residuals. Residuals that are correlated across time suggest that the model does not explain the patterns in the data adequately. In this case, the standard warning is that the regression coefficients estimated with ordinary least squares (OLS) regression remain unbiased, but the standard errors and confidence intervals will be too narrow, giving a false sense of precision.

Peak Load Models

ISO-NE modeled energy and system peak load so that the residuals exhibit no pattern (white noise). Further, ISO-NE used the Breusch-Godfrey Lagrange multiplier test to test for serial correlation of order one. The correlogram of the residuals and the associated Ljung-Box Q-statistics models were used to test for “n” order serial correlation (or “white noise”). P-values greater than 0.05 indicate failure to reject the null hypothesis of no serial autocorrelation at the 1% critical level for each of the forecast models used. Many of the p-values were greater than 0.05, especially in the winter models.

Homoskasticity (versus heteroscedasticity) of the residuals is another standard assumption that OLS models should fulfill. Homoscdasticity is a statistical term which describes a modeling or measurement result where the residuals are independent of the magnitude of the predicted in-sample dependent variable. By contrast, if the results of the model exhibit heteroskedasticity, the error of the prediction is correlated with the magnitude of the predicted value.

Homoskedasticity is important for forecasting purposes, and in particular, for forecasting system summer peak. For example, violation of the homoscedasticity assumption might imply that as temperature and humidity levels increase, the model’s errors become larger. Thus, ISO-NE tested for heteroskedasticity using the White test. The p-value for each model is larger than 0.05; therefore, the tests fail to reject the null hypothesis of homokedasticity at the 1% critical level.

Since the White Heteroskedasticity test assumes that the errors are both homoscedastic and independent of the explanatory variables, this statistic is generally used to test for model misspecification as well. Failure of any one of these conditions could lead to a significant test statistic. Thus, the results of the test also imply that the misspecification assumption was violated.

In addition, ISO-NE tested for autoregressive conditional heteroskedasticity in the residuals using the ARCH Lagrange multiplier test. P-values above 0.05 mean that the ARCH test fails to reject the null hypothesis of homokedasticity at the 1% critical level. This was the result for many of the models.

However, the estimated coefficients for the independent variables are generally fairly significant, and the resulting biases in the standard errors caused by heteroskedasticity likely would have little effect on the resulting significance of the coefficients.

Energy, income and prices are variables that tend to show definite trends, while weather variables are stationary. In an equation containing different non-stationary explanatory variables, the residuals must be stationary. If they are not, the equation is "spurious." Thus, ISO-NE tested the residuals for non-stationarity (also called "unit roots") in the series using the Augmented Dickey-Fuller test. In each of the models, the Augmented Dickey-Fuller test rejected the null hypothesis of unit root at the 1% critical level.