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ERCOT Growth Index Evaluation

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ERCOT Growth Index Evaluation

In December 2013, ERCOT engaged Itron to evaluate a new long-term forecasting framework. The framework includes a neural network (NN) model for each ERCOT zone (Zone) estimated over multiple historic periods and forecasted with a range of historic weather patterns. Within the NN, the key growth driver is a single index created by weighting together three premise count forecasts.

Itron's evaluation addresses the following three issues.

1. **<u>Premise Forecast.</u>** Underlying ERCOT's Growth Index is a forecast of premise counts. Itron's evaluation examines potential economic drivers to forecast the premise counts relative to ERCOT's initial proposal of using a historic five year average growth rate.

2. **<u>Growth Index.</u>** The key growth driver in the NN model is a growth index created as a weighted average of ERCOT's residential, business, and industrial class premise forecast. Itron's evaluation examines the weighting scheme and identifies issues and potential improvements.

3. **<u>Multiple NN Models.</u>** ERCOT's framework uses a NN model which is used to obtain multiple sets of parameters based on different historical time periods. The estimated parameters are applied to multiple historic weather scenarios to create a distribution of forecast. Itron's evaluation discusses the NN model, multiple sets of parameters, and the historic scenarios.

On January 10, 2014, Itron released its Review of ERCOT Premise Forecast report. The report addresses the Premise Forecast and presents a preliminary discussion on the Multiple NN Models.

In this Summary, Itron addresses the Growth Index and presents an updated recommendation on the Multiple NN Models.

1. Growth Index

The key growth driver in the NN model is an index created as a weighted average of ERCOT's residential, business, and industrial class premise forecast. The weighted average is derived from the average annual use per premise (UPP) values for each class computed from 8/1/2012 – 7/31/2013.

The index equation is formally shown below.

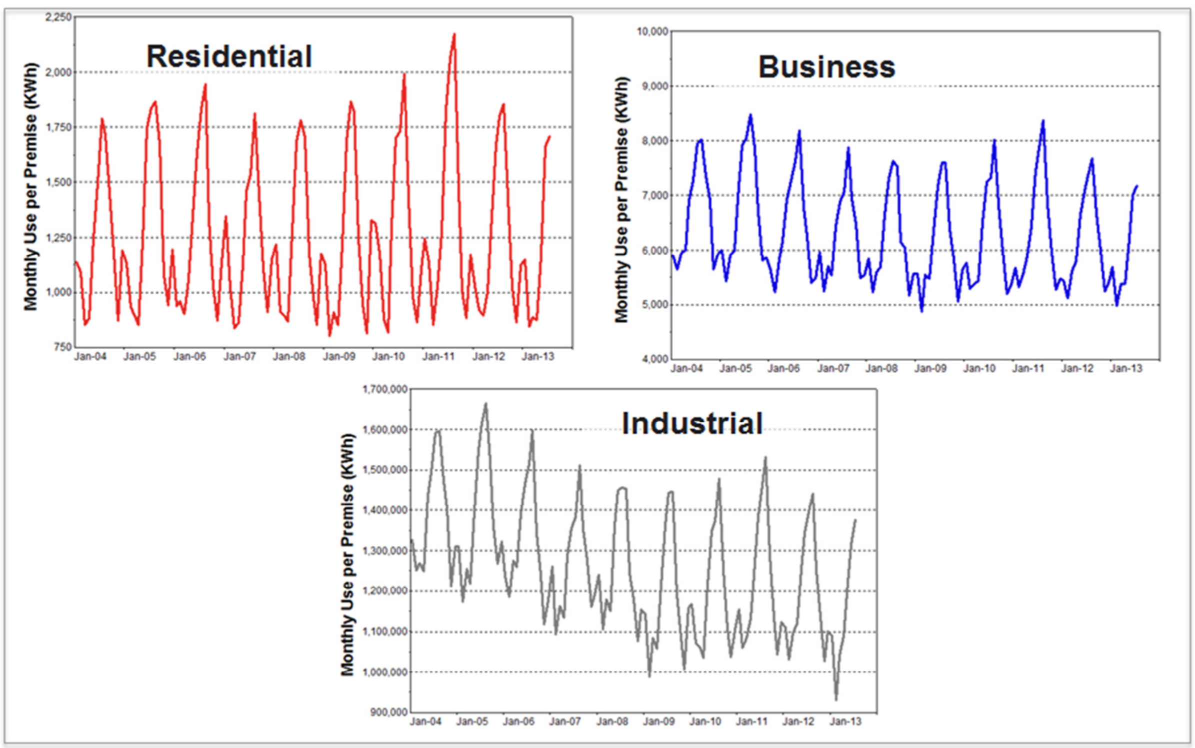
$$\begin{aligned} Growth\ Index_{y,m,d} = \quad & ResPremiseFcst_{y,m,d} \times ResWgt_{y,m,d} \\ + \quad & BusPremiseFcst_{y,m,d} \times BusWgt_{y,m,d} \\ + \quad & IndPremiseFcst_{y,m,d} \times IndWgt_{y,m,d} \end{aligned}$$

Itron's evaluation examines the weighting scheme and identifies issues and potential improvements. The evaluation consists of two parts. First, Itron weather normalizes historic UPP levels to remove weather-driven variation. Second, Itron examines whether ERCOT's existing weighting scheme is representative of the weather normalized UPP levels.

Weather Normalization Process

Because historic UPP data contains significant variations driven by changing weather conditions, UPP trends are difficult to identify. An example of these variations is shown in Figure 1 for the Coast Zone. The weather normalization process is designed to remove the weather variation and clarify the underlying growth trends. This section discusses Itron's weather normalization process using Coast Zone data from 2004-2013 to demonstrate the process.

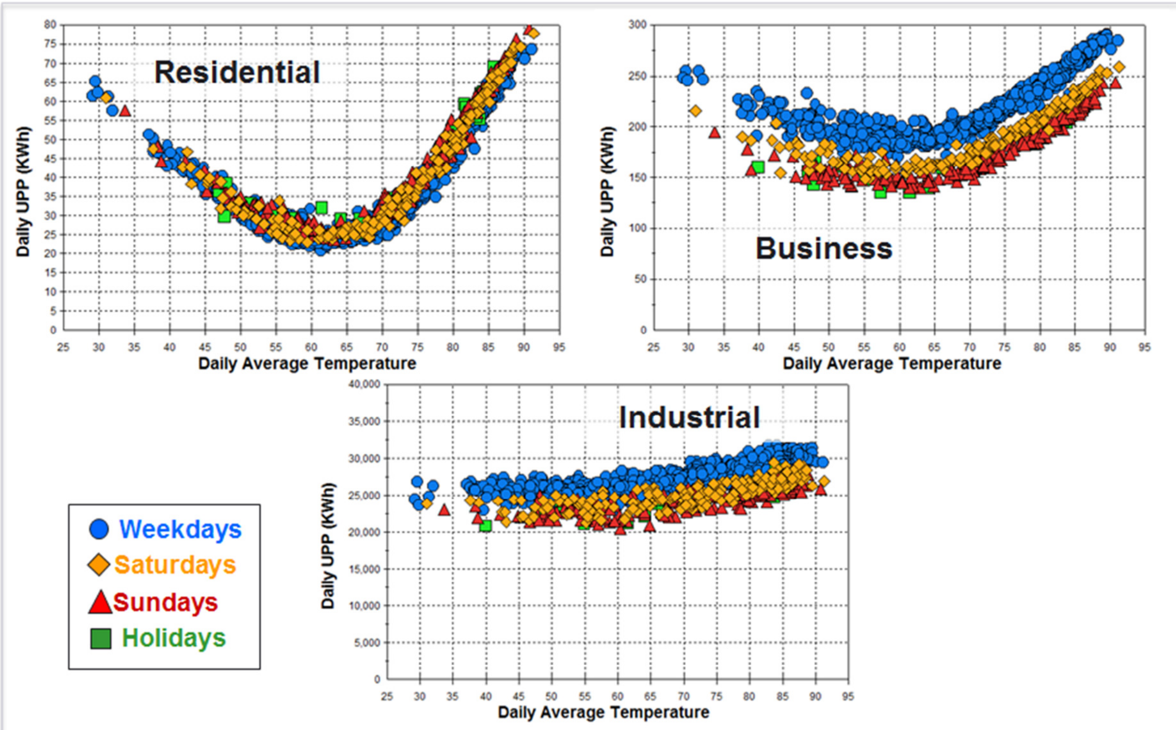
Figure 1: Coast Zone Monthly Use per Premise (2004-2013)



Weather Relationships

The first step in the weather normalization process is to visually inspect the load-weather relationship. Figure 2 depicts the daily load-weather relationship for each class in the Coast zone. On each scatter plot, daily class-level use per premise is shown on the vertical axis and daily average temperature on the horizontal axis. Each point is one day and the points are color coded by day-type.

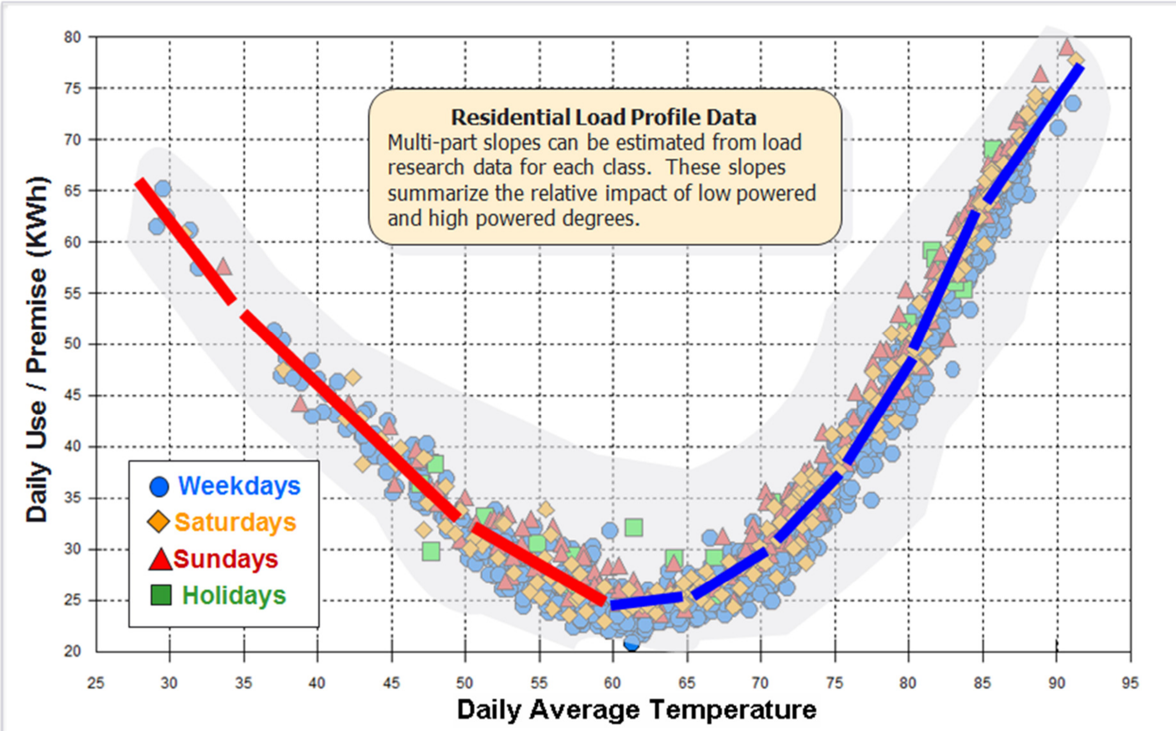
Figure 2: Class Weather Relationship (Coast Zone Daily UPP vs. Temperature)



Weather Response Functions

The daily data reveal a unique, non-linear relationship by class, which can each be closely approximated by a well-defined weather response function. Figure 3 illustrates the weather response function for Coast Residential, which is constructed using a series of multi-part slopes.

Figure 3: Weather Response Function (Coast Residential)



In this figure, the balance point is set at 60 degrees. This is the point at which the slope is close to 0. Cooling Degree Day (CDD) variables are constructed to the right of the balance point and Heating Degree Day (HDD) variables to the left.

The blue lines on the right side of the scatter plot illustrate the Cooling Weather Response function. To the immediate right of the balance point the response per degree is relatively low. At higher temperatures, the response per degree increases, until the 85 degree threshold is reached. The response per degree slowly reduces at temperatures greater than 85 degrees.

The red lines to the left of the scatter plot illustrate the Heating Weather Response function. Like the Cooling Weather Response function the response per degree is relatively low close to the balance point. The response gradually increases until the maximum powered heating response is reached at 35 degrees.

For each zone and class, auxiliary regression models including CDD and HDD variable composites are estimated to identify the appropriate cutpoints and relative weighting scheme. The result is a unique weather response function by zone and class

Weather Normalization Model. Once the weather response functions are defined, they are implemented in the weather normalization models. The purpose of the weather normalization models is to isolate the impact of weather on the historical UPP values. Itron developed the UPP models using a linear regression framework that utilized the weather response function developed above.

Normal Weather Calculation. The isolation of weather impacts requires a set of normal weather variables.

Itron developed the normal weather variables by zone using a 10 year historical period (2003-2012), incorporating the 10 complete years of historical weather data provided by ERCOT. The calculation of the normal weather variables uses a two-step process:

1. **Average By Date**. In this step, each daily degree day variable is averaged by date across years. For example, the Jan 1 HDD 65 values are averaged across the 10 year period, next, the Jan 2 HDD 65 values are averaged across years. The process is repeated for each day of the year. The result is a series of 366 values for each degree day variable.

2. **Smooth.** In this step, the Average by Date values from Step 1 are smoothed using a 30 day centered moving average. The purpose of this step is to smooth through data irregularities. The result is a smoothed series of 366 values which is repeated in each year.

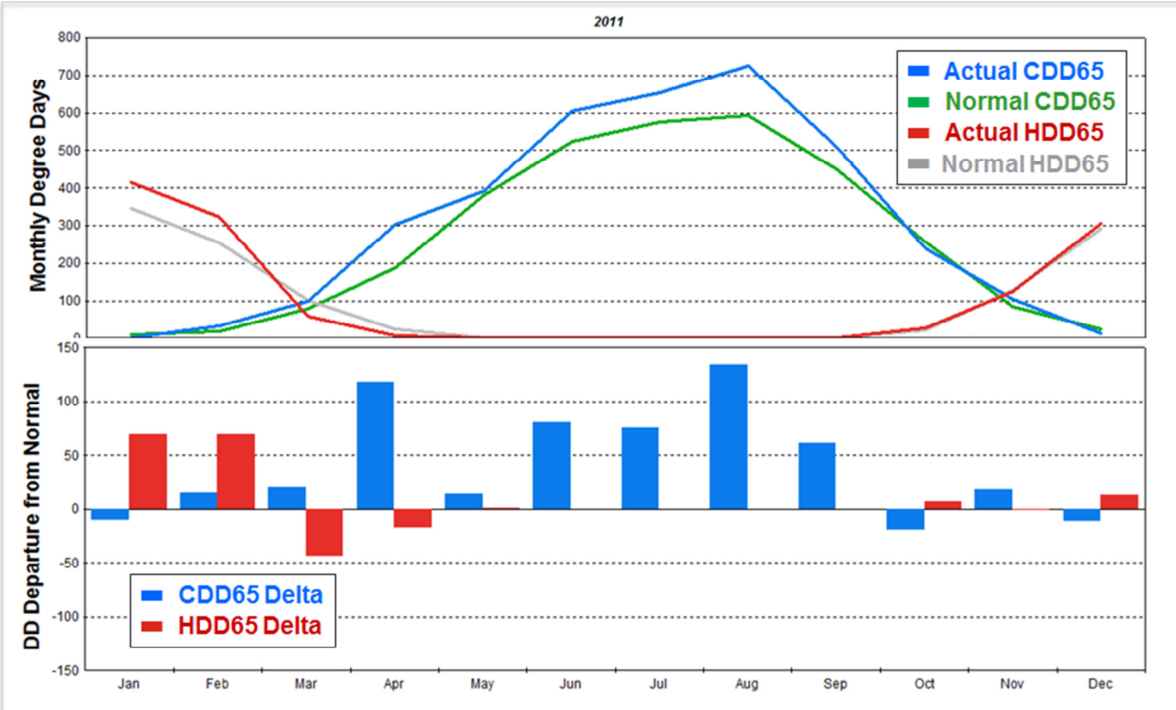
The smooth normal weather variables are used to obtain the model simulated values given normal weather.

Focus on 2011.

In Texas, the year 2011 produced some of the most extreme weather on record. A cold winter coupled with a hot summer combined to drive an increase in annual electricity sales. Given its extreme nature, 2011 is chosen for a conceptual discussion on weather normalization.

Figure 4 presents a monthly weather summary for 2011. The top pane displays a comparison of monthly CDDs and HDDs, both with base 65. The bottom pane illustrates departures from normal, where the blue bars indicate CDD departures from normal, and the red bars HDD departures from normal.

Figure 4: 2011 Coast Zone Weather Summary



The bars in the bottom pane consistently fall above the origin, indicating a steady stream of extreme weather swept through Texas throughout 2011. February, April and August stand out as being the most extreme months. These are the months in which the most significant weather adjustments are expected when the weather normalization process is performed for 2011.

Weather Normalization Calculation. Using the weather normalization models and the normal weather calculation, the historical UPP series is adjusted to represent weather normalized loads. The weather normalization calculation requires two sets of model outputs:

- First, a predicted value given actual weather (UPP_PredActual),
- Second a simulated value given normal weather (UPP_PredNormal).

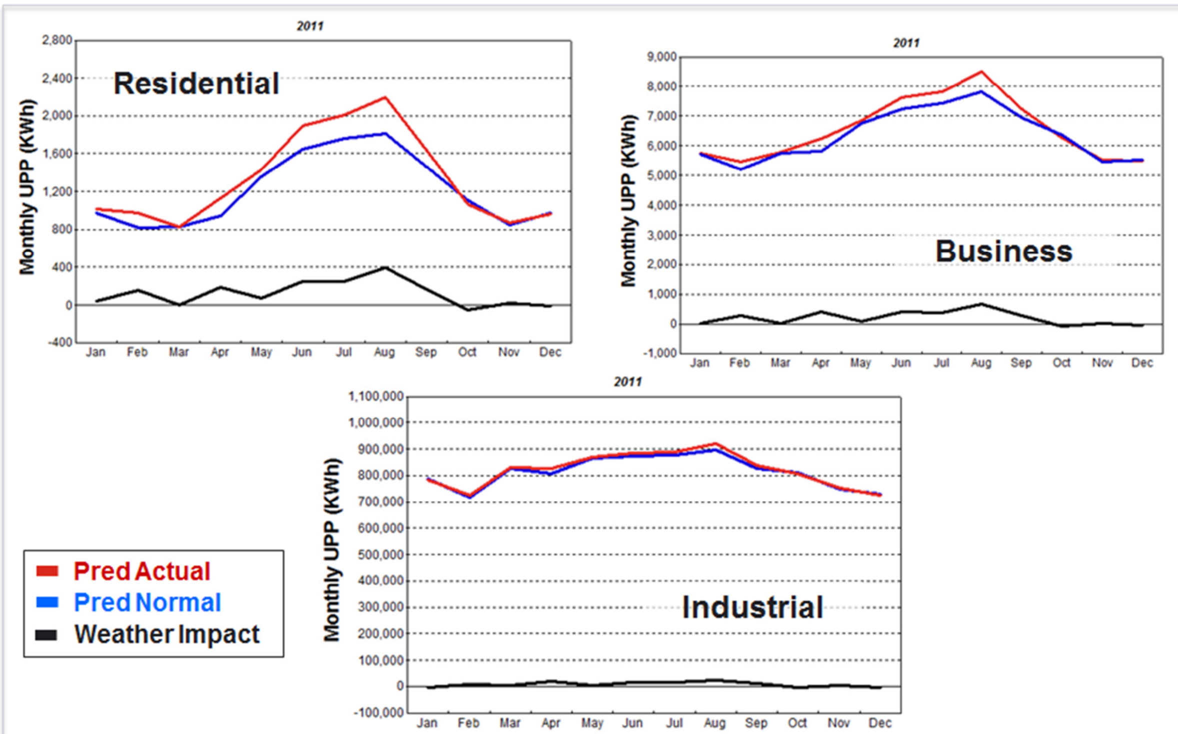
The difference between the predicted value given actual weather and the simulated value given normal weather represents the use per premise weather impacts.

The weather normalization calculation is shown below.

$$UPP\_WeatherImpacts_{y,m,d} = UPP\_PredActual_{y,m,d} - UPP\_PredNormal_{y,m,d}$$

Figure 5 displays the monthly 2011 weather normalization model outputs for the Coast Zone. The red lines depict the predicted value given actual weather, the blue lines the simulated value given normal weather, and the black lines, the use per premise weather impacts.

Figure 5: 2011 Coast Zone Weather Normalization Model Outputs



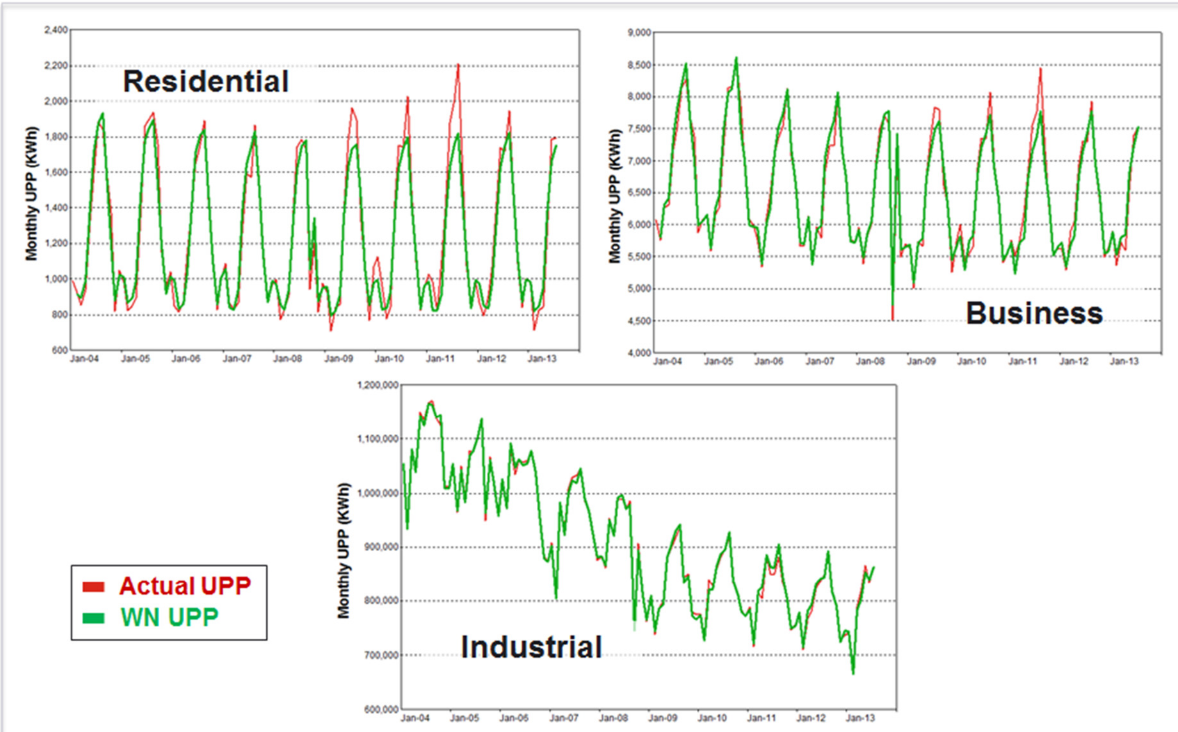
As 2011 was extreme throughout the year, the UPP weather impacts are consistently positive and the black line lies consistently above the origin, especially in the residential and business classes. The largest positive monthly impacts are consistent with the largest degree-day departures from normal shown in Figure 4, most notably February in the winter, April in the shoulder, and August in the summer.

Once the use per premise weather impacts are computed, Itron computed the weather normalized use per premise series. This series is computed by taking the difference between the actual use per premise values and the weather impacts as shown below.

$$Weather\ Normalized\ UPP_{y,m,d} = ActualUPP_{y,m,d} - UPPWeatherImpacts_{y,m,d}$$

Figure 6 displays the monthly actual and weather normalized use per premise values. The red lines indicate the actual monthly use per premise values, and the green lines their weather normalized counterparts.

Figure 6: Coast Monthly UPP (Actual and Weather Normalized)

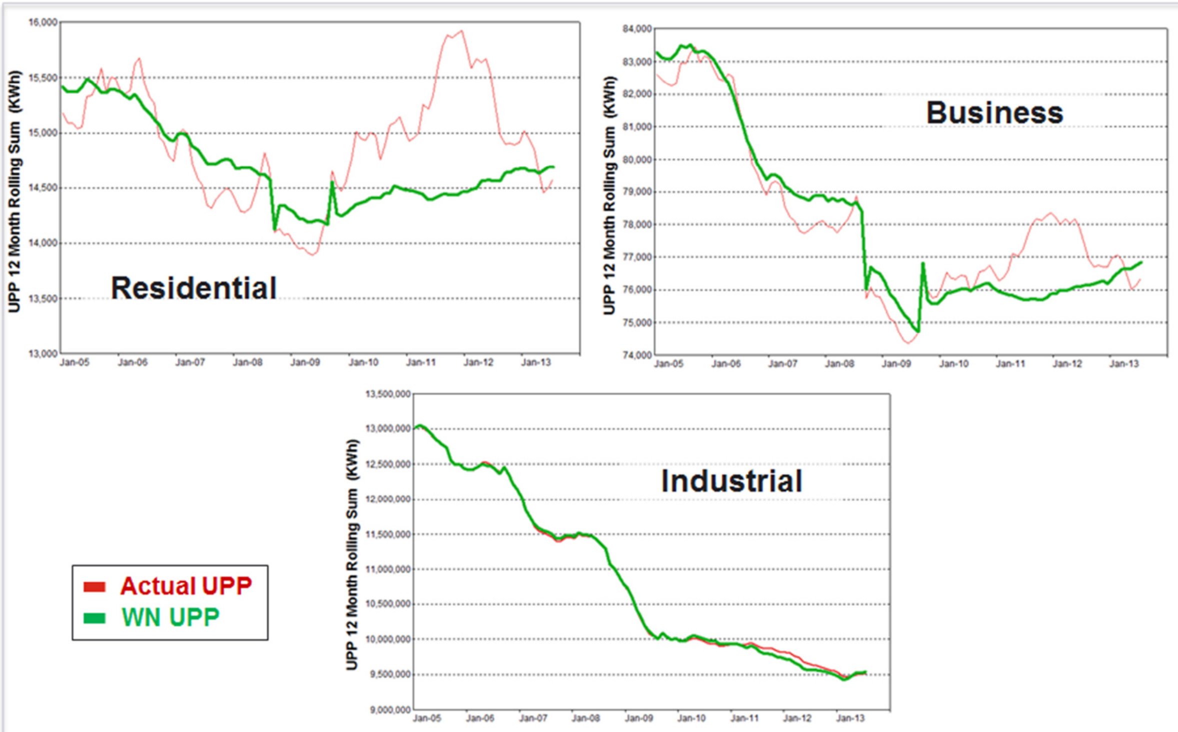


As the Residential class is the most weather sensitive, it contains the largest differences between the red and green lines, followed by the Business and Industrial classes, respectively. As expected, the year 2011 contains the largest adjustment from actual to normal.

Once the weather variation is removed from the historical data through the weather normalization process, the underlying use per premise trends can analyzed. To increase the clarity of the historical trends and remove non-weather-related seasonal variations, Itron computed a 12-month rolling sum of the actual and normalized UPP. The 12-month rolling sum is a moving representation of annual sales levels through time. Figure 7 is analogous to Figure 6, but displays 12-month rolling sums.

In this figure, the annual UPP trends are easily seen. In the Residential class, the actual UPP values have increased from 2009 through 2011 with a decrease in 2012 and 2013. However, examination of the weather normalized series reveals a much flatter growth trend, implying the recent variation in actual UPP was weather driven. A similar pattern can be seen in the Business class.

Figure 7: Coast 12 Month Rolling UPP (Actual and Weather Normalized)



ERCOT Use per Premise Results

This section presents an evaluation of the ERCOT UPP trends for the Residential, Business, and Industrial classes based on the zone level weather normalization process. To compute the ERCOT-level use per premise values, Itron performed the following calculations:

- Calculate zone-level weather normalized energy as the product of the number of premises and weather normalized use per premise.
- Compute ERCOT-level weather normalized energy by class as the sum of the Zone-level values across zones.
- Calculate ERCOT-level premises by class as the sum of the Zone-level values across zones.
- Compute ERCOT-level use per premise as the ratio of ERCOT-level weather normalized energy and ERCOT-level premises.

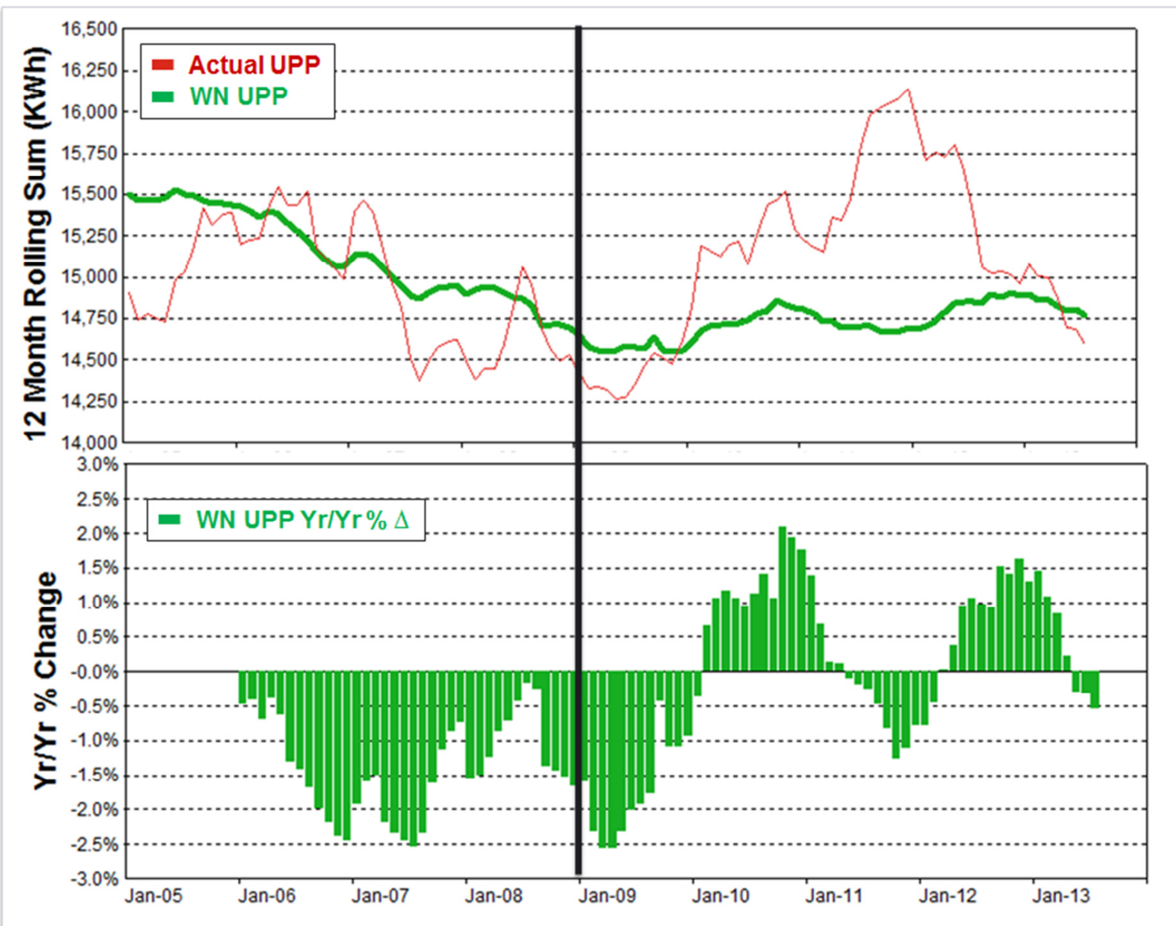
This section is divided into sub-sections by class. Each sub-section contains a figure with two panes. In the top pane, the red line shows a 12-month rolling sum of the Actual UPP values, while the green line shows its weather normalized counterpart. In the bottom pane, the green bars depict the year/year percentage change of the weather normalized 12-month rolling sum. The vertical black bar divides the time series into two sections, with the section to the right representing ERCOT's 5-year estimation range.

Residential Use per Premise Results

Figure 8 shows actual and weather normalized Residential UPP using a 12-month rolling sum for the ERCOT system. In this figure, the Actual Residential UPP trend (shown by the red line) contains significant weather-driven variations, most notably the increase in 2011. The short-term variations drive volatility into the series, making it difficult to identify the underlying trends.

The Weather Normalized Residential UPP series (shown by the green line) clarifies the underlying trend. In the early years (2005 – 2008), the data reflect a consistent downward trend, yielding an average year over year decline of -1.4%. In the ERCOT 5-year estimation window (2009-2013), the trend begins to stabilize and the growth trajectory flattens, with an average year over year increase of 0.2%.

Figure 8: ERCOT Residential Use per Premise Results



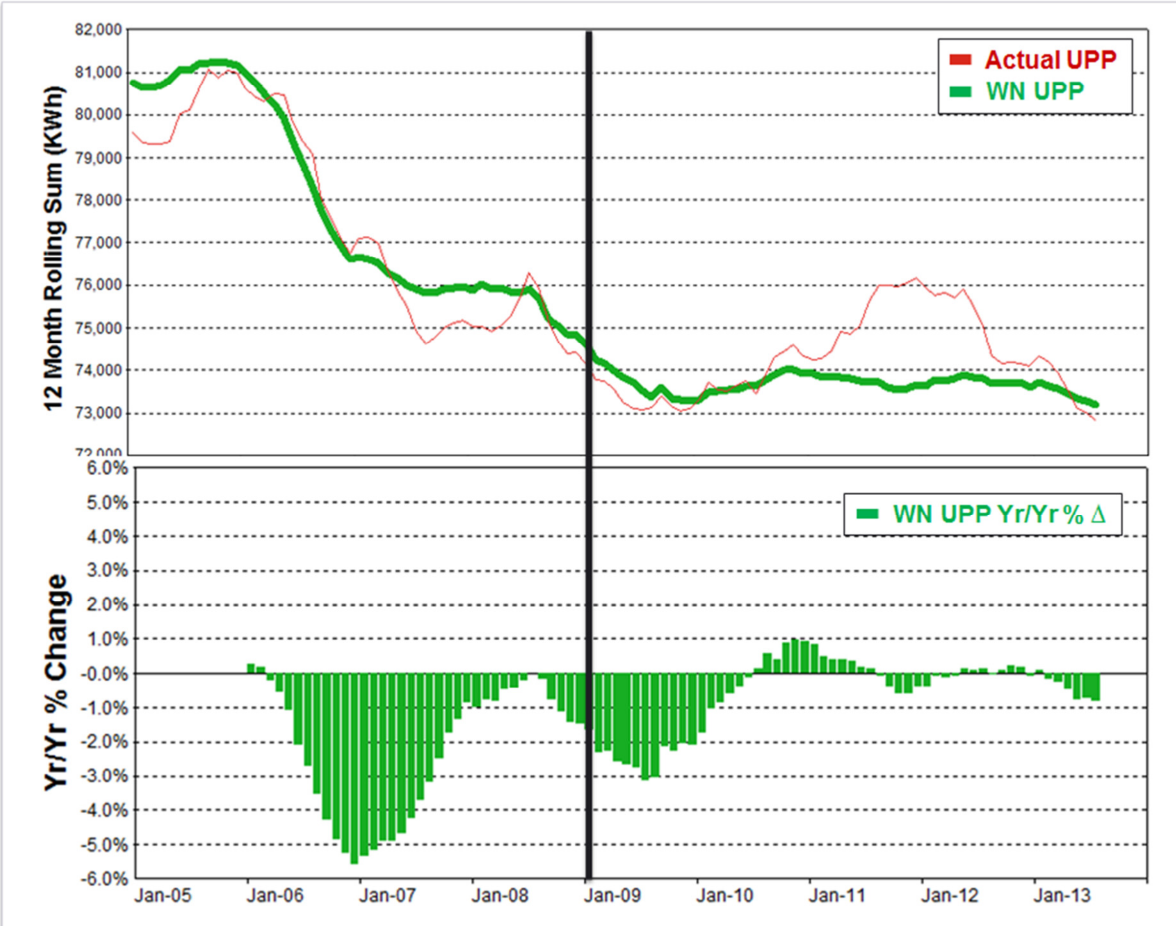
ERCOT's existing method uses the actual annual Residential UPP values from 8/1/2012 – 7/31/2013 (ERCOT's calculation range) to define a static weight to apply to the growth index throughout the five year historical estimation range (2009-2013) and forecast period. Because the weather during ERCOT's calculation range is close to normal and the 5-year historical weather normalized UPP trend is relatively flat, ERCOT's approach yields a weight that aligns closely with the weather normalized UPP.

Business Use per Premise Results

Figure 9 shows actual and weather normalized Business UPP using a 12-month rolling sum for the ERCOT system. In this figure, the Actual Business UPP trend (shown by the red line) demonstrates moderate, short-term, weather-driven variations, most notably the increase in 2011. While the weather impacts are not as severe as the Residential class, they are large enough to confound the underlying trends.

The Weather Normalized UPP trend (shown by the green line) removes the short-term variations. In the early years (2005 – 2009), there are two sharp, downward shifts in the UPP values. The first shift occurs in 2006, as the result of a rate reclassification which moved some of the largest business customers into the industrial class. The second shift occurs in late 2008 through 2009, reflecting a decline of 3.5%. This drop is attributed predominantly to the Great Recession. From 2010-2013, the trend begins to stabilize and the growth trajectory flattens, with an average year over year decrease of -0.1%.

Figure 9: ERCOT Business Use per Premise Results



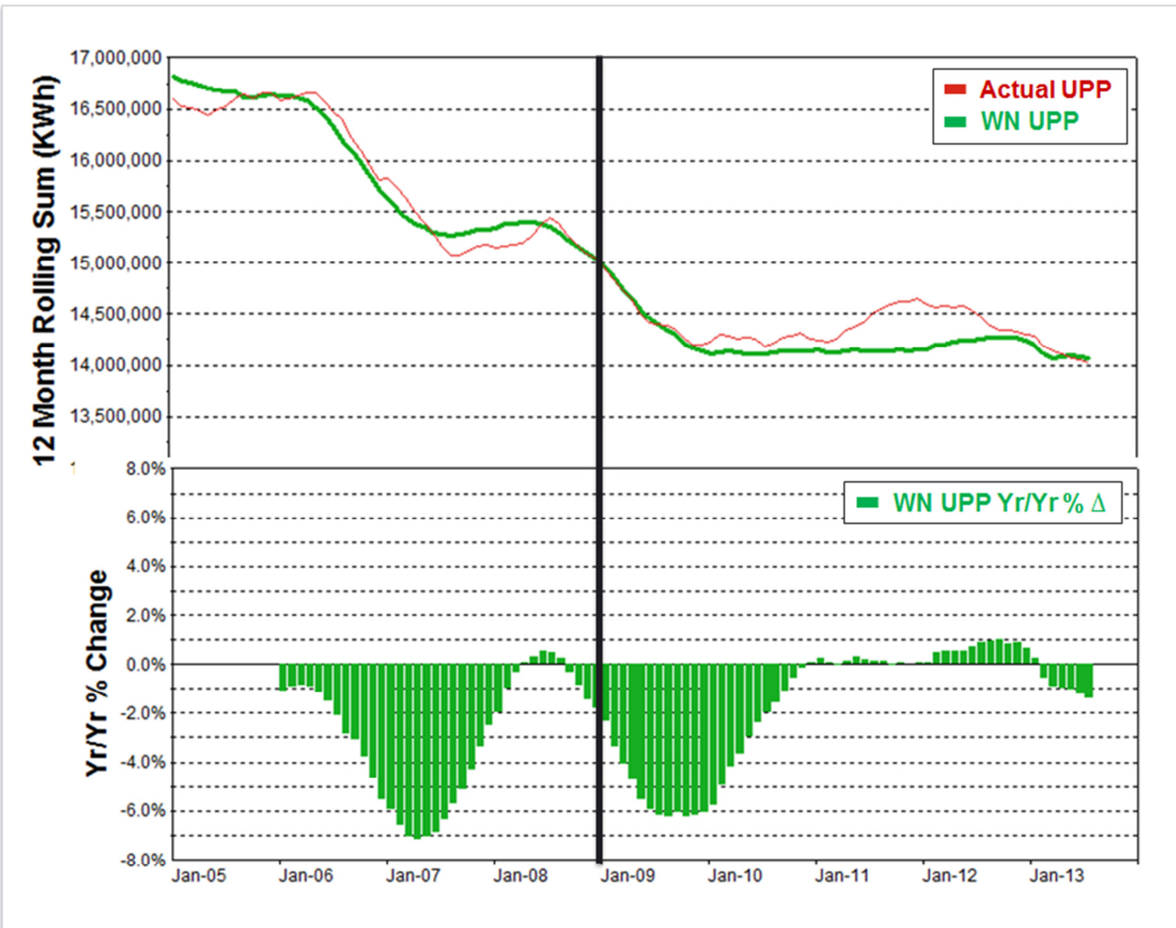
ERCOT's existing method uses the actual annual Business UPP values from 8/1/2012 – 7/31/2013 (ERCOT's calculation range) to define a static weight to apply to the growth index throughout the five year historical estimation range (2009-2013) and forecast period. As the weather during ERCOT's calculation range is close to normal and the 5-year historical weather normalized UPP trend is relatively flat, ERCOT's approach yields a weight that aligns closely with the weather normalized series.

Industrial Use per Premise Results

Figure 10 shows actual and weather normalized Industrial UPP using a 12-month rolling sum for the ERCOT system. In this figure, the Actual Industrial UPP series (shown by the red line) contains only mild short-term variations. However, there are multiple, temporary weather-driven fluctuations, most notably 2011.

The Weather Normalized Industrial UPP series (shown by the green line) removes the short-term variations. The signature of the Industrial Weather Normalized UPP trends is similar to the Business class. In the early years (2005 – 2009), there are two sharp, downward shifts in the UPP values. The first shift occurs in 2006, as the result of a rate reclassification which moves business customers into the industrial class, reducing the average industrial customer size. The second shift occurs in late 2008 through 2009, reflecting a decline of -8.3%. This shift is attributed predominantly to the Great Recession. From 2010-2013, the trend begins to stabilize and the growth trajectory flattens, with an average year over year decrease of -0.2%.

Figure 10: ERCOT Industrial use per Premise Results



ERCOT's existing method uses the actual annual Industrial UPP value from 8/1/2012 – 7/31/2013 (ERCOT's calculation range) to define a static weight to apply to the growth index throughout the five year historical estimation range (2009-2013) and forecast period. As the weather during ERCOT's calculation range is close to normal and the 5-

year historical weather normalized UPP trend is relatively flat, ERCOT's approach yields a weight that aligns closely with the weather normalized series.

Recommendation

While the analysis and discussion presented in class results sections are at the ERCOT system level, Itron performed the analysis for each zone. The zone-level analyses demonstrate the weather normalized UPP trends differ slightly across zones. Based on these results, Itron makes the following recommendations.

1. **Dynamic Weather Normalized Weights (Historical).** The implementation of a dynamic weighting scheme will allow the growth index to bend with the same signature as the underlying UPP trends. Itron recommends that ERCOT implement the weather normalized use per premise values as the class-level weights throughout the 5-year historical estimation range.

2. **Static Weather Normalized Weights (Forecast).** The class UPP trends have begun to stabilize in recent years. Itron recommends that ERCOT implement the 2013 weight throughout the forecast period.

3. **Future Consideration.** While the UPP trends have begun to stabilize at this point in time, Itron recommends ERCOT perform ongoing research to understand the underlying factors driving the trends. Once the factors have been identified, ERCOT should integrate them into the forecasted weighting scheme. For the Residential class, factors may include evaluation of end use-level saturation and efficiency information. For the Business and Industrial classes, given the abrupt shift in the use per premise level that occurred in 2006, ERCOT should consider assessing these classes in aggregate in future analyses.

2. Neural Network (NN) Models

On January 10, 2014, Itron presented its preliminary findings regarding ERCOT's NN Models. That report presented the following recommendations.

1. **Re-specify the NN Model**. Itron recommends that ERCOT re-specify the NN model to isolate the growth index and obtain a stable model.

2. **Regression Model.** Itron recommends that ERCOT explore using a regression model to validate any advantage of a NN model over a traditional approach.

3. **Weather Simulation.** Itron recommends that ERCOT continue to use the historic weather simulations to capture weather uncertainty.

The preliminary nature of the findings depended on whether any new issues would be identified while evaluating the Growth Index. Based on the findings in the report, Itron finalizes recommendations 2 and 3 as no new information would impact the Regression Model and Weather Simulations recommendations.

However, based on the weather normalization process, Itron amends its first recommendation Re-assess the NN Model, to include an examination of the weather response function.

The weather normalization process identifies a nonlinear load response to the weather conditions. An example of this response is shown for the Coast region in Figure 3. Using regression models, the weather response is captured using a multipart spline variable. In a NN framework, the weather response can be managed through the nonlinear functional form of the NN or through multipart splines. While Itron has not reviewed the details of the NN model specification, mis-specfication of the weather variables can lead to instability in the NN model estimation process. As a result, ERCOT should review the model weather response to ensure stability.

1. **Re-specify the NN Model**. Itron recommends that ERCOT re-specify the NN model to isolate the growth index and obtain a stable model. Additionally, Itron recommends that ERCOT examine the weather response to ensure that the NN model accurately capture weather variation for each zone.

3. Summary

ERCOT's forecasting framework includes three key components. The framework begins with a long term forecast of premises by class and zone. Next, the premise forecasts are weighted together into a single growth driver. Finally, a neural network (NN) model is used to create the long term forecast based on multiple model estimation periods and weather scenarios.

In this summary, Itron evaluates the use per premise weighting scheme used in the construction of the single growth driver. Additionally, Itron provides its final recommendation on the NN model. A summary of Itron's recommendations is presented below.

Use per Premise Weighting Recommendations

1. **Dynamic Weather Normalized Weights (Historical).** The implementation of a dynamic weighting scheme will allow the growth index to bend with the same signature as the underlying UPP trends. Itron recommends that ERCOT implement the weather normalized use per premise values as the class-level weights throughout the 5-year historical estimation range.

2. **Static Weather Normalized Weights (Forecast).** The class UPP trends have begun to stabilize in recent years. Itron recommends that ERCOT implement the 2013 weight throughout the forecast period.

3. **Future Consideration.** While the UPP trends have begun to stabilize at this point in time, Itron recommends ERCOT perform ongoing research to understand the underlying factors driving the trends. Once the factors have been identified, ERCOT should integrate them into the forecasted weighting scheme. For the Residential class, factors may include evaluation of end use-level saturation and efficiency information. For the Business and Industrial classes, given the abrupt shift in the use per premise level that occurred in 2006, ERCOT should consider assessing these classes in aggregate in future analyses.

Neural Network (NN) Model Recommendations

1. **Re-specify the NN Model**. Itron recommends that ERCOT re-specify the NN model to isolate the growth index and obtain a stable model. Additionally, Itron recommends that ERCOT examine the weather response to ensure that the NN model accurately capture weather variation for each zone.

2. **Regression Model.** Itron recommends that ERCOT explore using a regression model to validate any advantage of a NN model over a traditional approach.

3. **Weather Simulation.** Itron recommends that ERCOT continue to use the historic weather simulations to capture weather uncertainty.