The following report outlines the data utilized and specific insights to determine energy usage based upon sub metering for a residential subdivision. This report will outline data resources, analysis, and recommendations to better address more efficient energy usage.

Energy Data

The data used for the analysis consisted of nearly 2 million residents energy data points over a four year period from December 2006 until November 2010. Consisting of one-minute samples, the submetering data contains nine different variables: date, time, global active power, global reactive power, voltage, global intensity, submetering one (kitchen), submetering two (laundry and refrigerator), and submetering three (AC and water heater). Given the focus on submetering usage, this analysis focuses primarily on submetering usage within submeter 2 which address laundry and kitchen usage.

Analysis

In analyzing the energy data, three different models focusing on the various submeters were created for the different seasons to better address the seasonal trends in energy usage. There seasonal models were also aligned with three different sub metering systems to understand how different areas of the home use energy. The sample of energy usage was analyzed for a 31 day period for each month with the corresponding month and compressed to one hour intervals. Therefore, a sample was taken from three different years which include the month of August for 2007 (Summer 2007), the month of December for 2008 (Winter 2008), and the month of March for 2009 (Spring 2009).

Consumer Energy Patterns

Spring 2007

For the month of March 2007, the energy data illustrated significant energy usage at the beginning of the month and toward the end of the month as well. The actual specific increases occur on March 5th and March 28th. In addition, the average wattage usage for sub-meter 2 for the Spring 2007 was 2.9 watts with the most frequent expenditure of zero watt usage. The frequency of the zero usage were a result of overnight lack of usage. However, the highest of watt usage occurred with 74 watts on March 28th at 2pm and 73 watts on March 5th at 5pm.
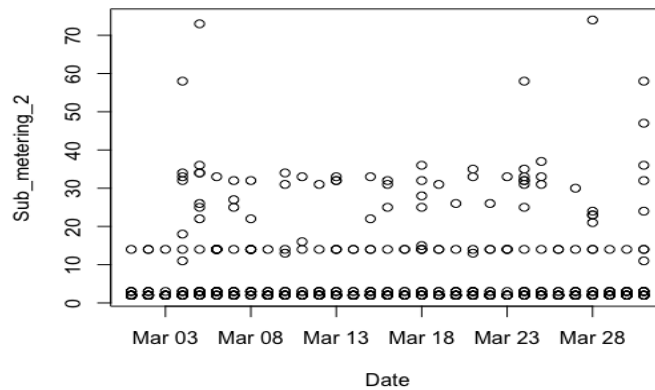
Summer 2008

For the month of Summer 2008, the energy data illustrated significant power usage for sub-meter two on August 4th at 6pm (71 watts) and August 31st at 3pm (39 watts).There was an average usage of .5 watts for the month of August 2008 and a frequency of zero watt usage given the large number of overnight hours.
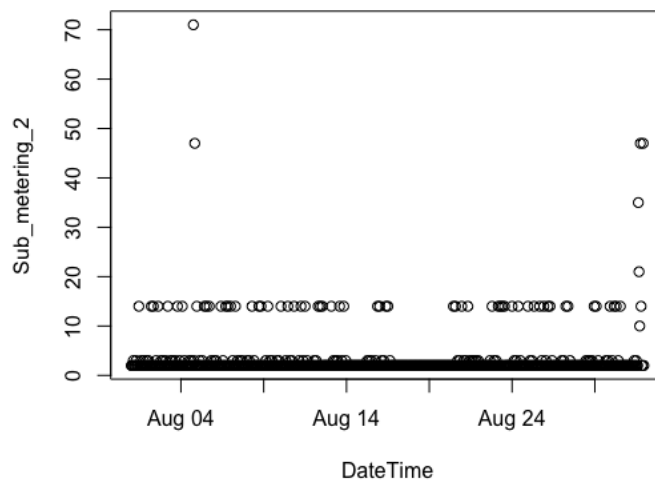
Winter 2009

For the analysis of Winter 2009, we utilized a sample from December 2009 for the entire month. For this analysis of customer usage, we found that the average usage for the winter month for sub-meter 2 was 1.4 watts per hour and with the highest rate of usage occurring on December 12th at 5pm (71 watts/hour) and December 24th at 4pm (70 watts/hour). Similar to the other months, the most frequent watt usage was zero watts.
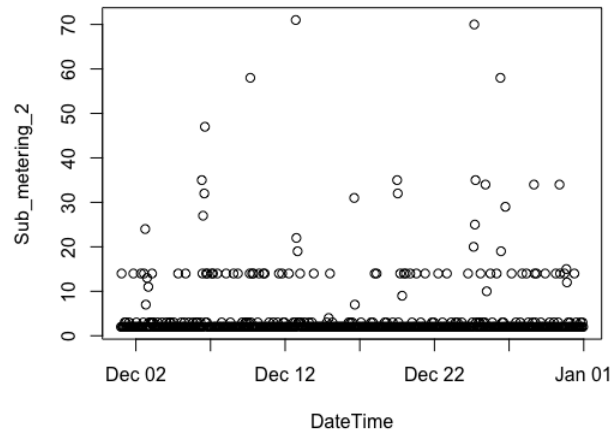
Time Series Usage and Forecasting

In order to gain a better understanding of energy usages for submeter usage, a time series analysis which look at the various time energy usage patterns to forecast/predict how consumers will typically use their energy in the future. Based upon the time parameters listed above for the Spring 2007, Summer 2008, and Winter 2009, the following conclusions were determined by season:
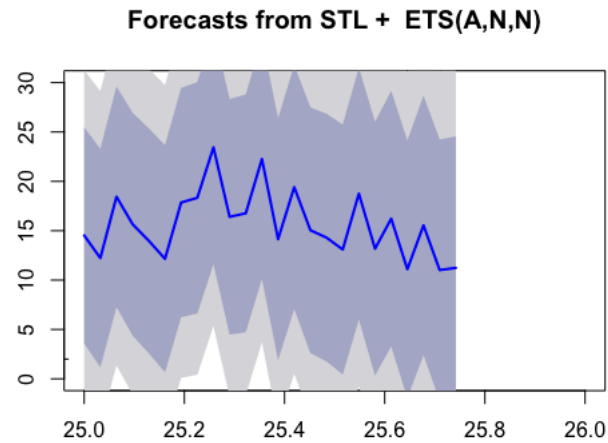
Spring 2007

The graph below shows a time series for Spring 2007 and the fluctuations over the month of March 2007 with the watt usage and date. As illustrated in the forecast, the prediction for energy usage for submeter 2 ranges around 10 to 25 watts.
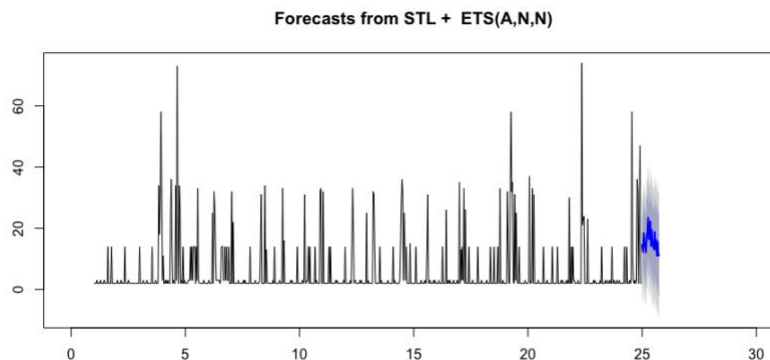
In order to get a more specific insight as to the forecast for Submeter 2 usages, the line chart below indicates for the prediction of usage the ranges of 10 to 25 watts and their

corresponding time frames. Therefore from this analysis, the highest predicted spikes in energy usage in the beginning part of the day.

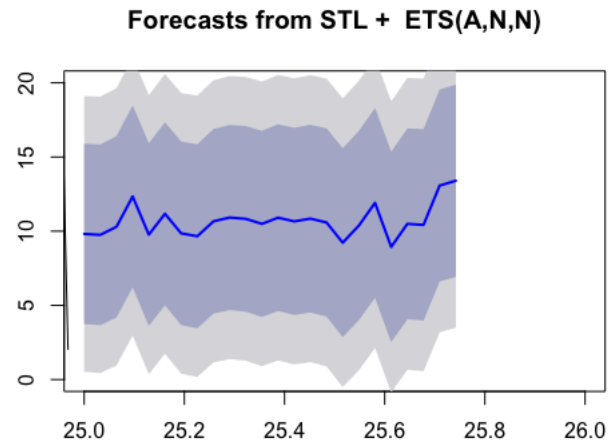**Forecasts from STL + ETS(A,N,N)**

Summer 2008
The graph below shows a time series for Summer 2008 and the fluctuations over the month of August 2008 with the watt usage and date. The chart below shows the spike in submetering usage at the beginning and end of month with the forecast ranging near the 10 watt area.

Forecasts from STL + ETS(A,N,N)
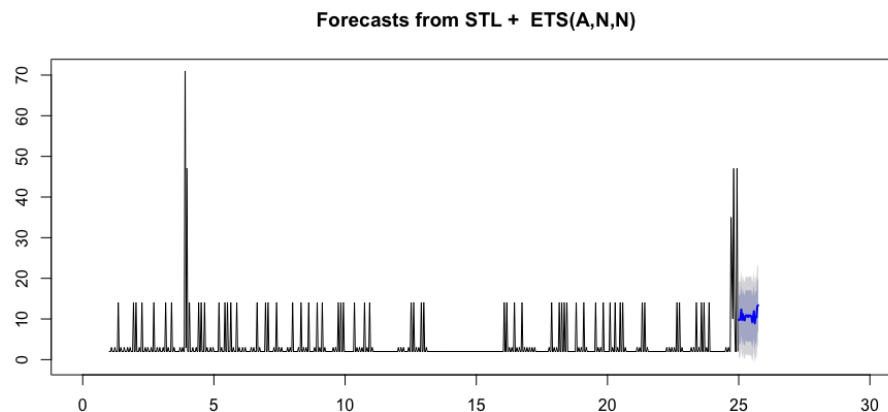
In the chart below, the prediction for energy usage in submeter two follows a similar patterns to customer usages in that the increase in usages occur in the beginning and end of day. In comparison to the Spring 2007 data, the Summer 2008 data illustrate a more consistent range of energy usage (around 10-12 watts) and lower overall energy usage.

Forecasts from STL + ETS(A,N,N)

<u>Winter 2009</u>

The graph below shows a time series for Winter 2009 and the fluctuations over the month of December 2009 with the watt usage and date. The chart below shows the spike in submetering usage around the 5th, 8th, 10th, 18th, and 22nd days of the month.

Forecasts from STL + ETS(A,N,N)
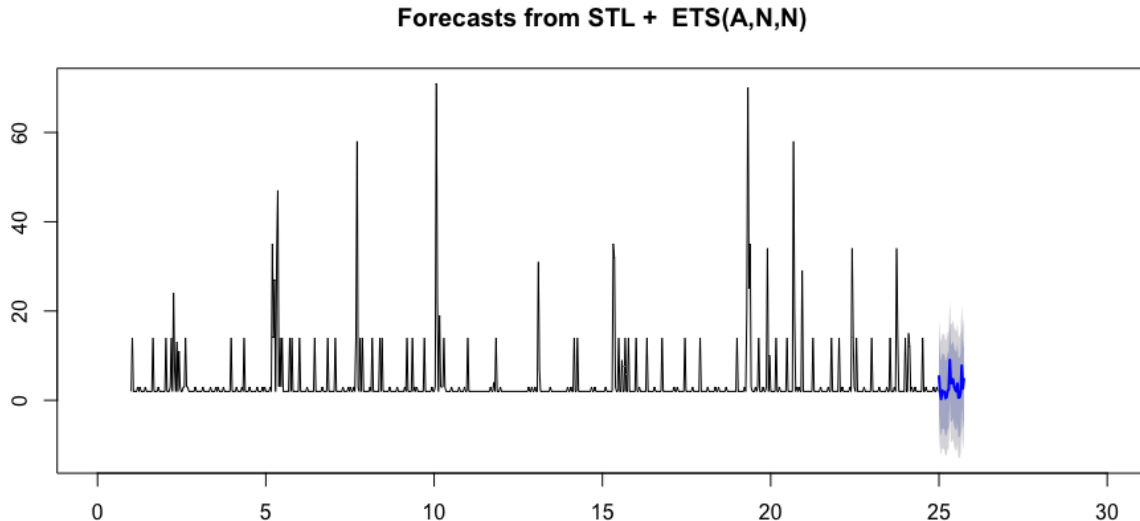
The following chart provides a more specific example of data usage for future prediction. In this forecast for Winter 2008, there are several low energy usage points as compared to the other seasonal times and higher spikes in usage from the middle of the day and end of day with an overall lower energy usage.

Forecasts from STL + ETS(A,N,N)
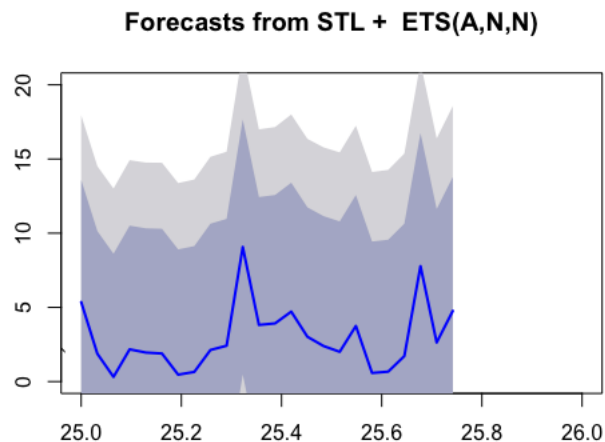
Business Recommendations

The following are five business recommendations that can be determined from the analysis of customer residential energy usage for submeter 2 (Laundry and Refrigerator):

- Energy usage increase for at the beginning and end of month for Spring and Summer research ways and therefore it may be wise to research ways to reduce costs during these times.
- Recommend correlating usage with other submeters to determine if use of laundry would be better at different time to save energy usage.
- Energy usage increase later in the afternoon when people return from work and look for ways to automate appliances for convenient energy use.
- Further analysis on different usage between washer and dryer and different appliance types.
- Provide price comparison of submetering to regular energy usage.
- Provide educational material for more effective usage for consumers.
- Some causes of energy expenditure are poor insulation, inefficient windows, old or inefficient appliances, and inefficient AC. In order to better determine energy usage, it would be important to review these problem areas.
- Provide description of data privacy protocol for energy usage.