Load Baseline

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- Goal: To establish a load baseline profile prediction for demand response event that is accurate, functional, and generates quick results.

Factors Affecting SDH Building Loads

- HVAC
  - Occupancy
  - Outside Air Temperature
  - Radiant Effects
  - Relative Humidity
- Plug Loads
  - Occupancy
  - Academic Calendar
- Lighting
  - Occupancy
  - Time of Year (Radiant effects)

Data Sets for Determining Baseline Load Profile

- To determine an accurate Baseline Load Profile, a method in which the set of data needed to predict the load was used:
  - Actual Load at 10 AM (al(d,10))
  - Actual Load at 11 AM (al(d,11))
  - Average Load of 3 hottest days of previous 10 days
  - Average Load of 3 hottest days of same 10 day period one year ago
  - Occupancy (no dynamic data available yet)

Data Restrictions

- Days of elevated conditions are desired to run the data given the project goal.
- "Static" occupancy data (employment numbers for the time of year) available. Dynamic occupancy data is obtainable, but requires the use of motion sensors, or access to card reader data, or a survey of occupants.
- Trend data is only trended back so far due to the newness of the building.

Methods to Determining Baseline Load Profile

- Using a Morning Correction factor with the loads measured the morning of DR event.
- Using an Occupation Correction factor with the averages of the hottest three loads measured from last year (this month), taking into account, occupancy differences.
- Using an HVAC Correction factor for HVAC efficiency.

Morning Correction Factor

- Method used for Morning Correction factor is derived from LBNL's Best Method. The correction factor is as follows:

$$c(d) = \frac{al(d, h = 10) + al(d, h = 11)}{pl(d, h = 10) + pl(d, h = 11)}$$

al(d,h) – the actual load for the day and the hour
pl(d,h) –the average of the 3 highest actual loads at this hour over the 10 previous days.

Previous Year Correction Factors

- The previous year, functions as a safeguard for situations where there are not elevated temperatures for 10 days prior to a demand response day.
- The efficiency of HVAC systems will deteriorate by a small amount over a year. There is code, for implementation, to correct for changes in the HVAC system. The changes that will be determined are the kW/ton rating and COP.
- The occupancy will change with each year or season raising the need for Occupancy Correction Factor.

Occupancy Correction Factor

- A preliminary Occupancy Correction Factor was used for calculating baseline load.

HVAC Correction Factor

For electric (Centrifugal) system:

$$Net\ refrigeration\ capacity\ (TR) = \frac{mcp(T_{in} - T_{out})}{3024}$$

$$Power\ (kW) = \sqrt{3}\ x\ V\ x\ I\ x\ cos\varphi$$

$$kW/ton\ rating = \frac{Measured\ compressor\ power(kW)}{Net\ refrigeration\ capacity\ (TR)}$$

Where:
m : mass flow rate of chilled water, kg/hr
C_p : Specific heat, kcal/kg °C
T_{in} : Chilled water temperature at evaporator inlet, °C
T_{out}: Chilled water temperature at evaporator outlet, °C

$$COP = \frac{3.516}{kW/ton}$$

$$c(COP) = \frac{COP_{TY}}{COP_{LY}}$$

- For steam (absorption) system: There is no correction factor that has been implemented.
- **We can factor this in, once we add additional submeters on HVAC system.**

Test Data

- Data was used from months of October 2010, February 2011, and April 2011. Data was limited due to system setup and outages (September 2010 not available)
- Previous year data from February was used (October 2009 data not available)
- Weather data from sMap
- “Static” Employment/Office Occupancy data used for preliminary Occupancy Correction Factor until further occupancy measurement is possible.

Time Steps for Prediction

- Due to limited weather data, the time step was limited to 1 hour for preliminary calculations. But with temperature monitoring on sMap server, time steps have been reduced to 5 minutes or less if needed.
- Smaller time steps will allow for greater knowledge of further steps in demand response.

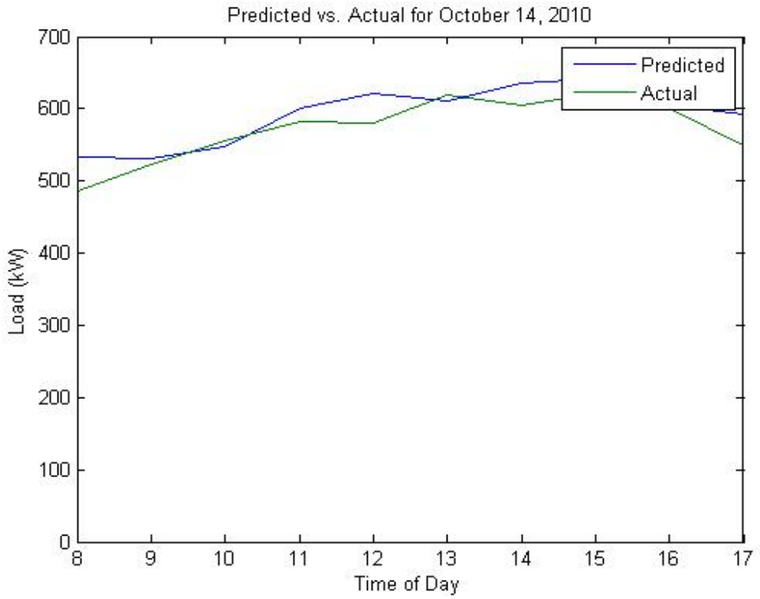
Results

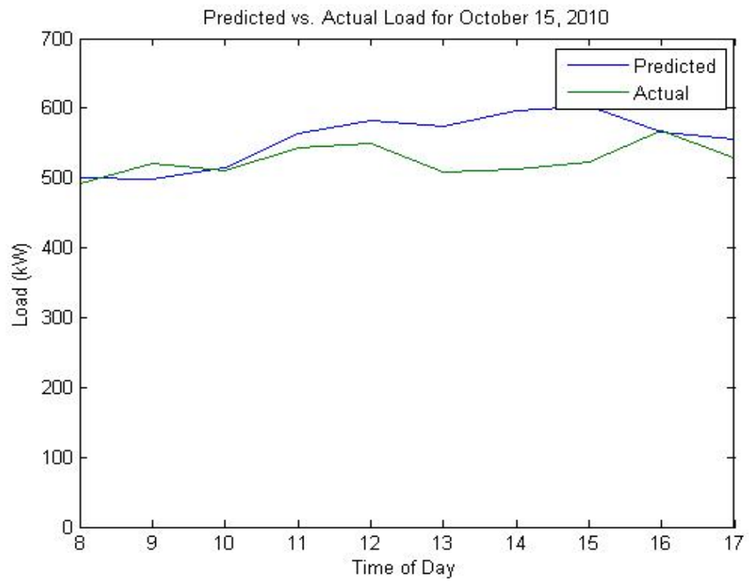
- Prediction Results tested for October 14 & 15, 2010 with Morning Correction factor*. Algorithm made predictions for these two days and the predictions were compared to the actual data received.

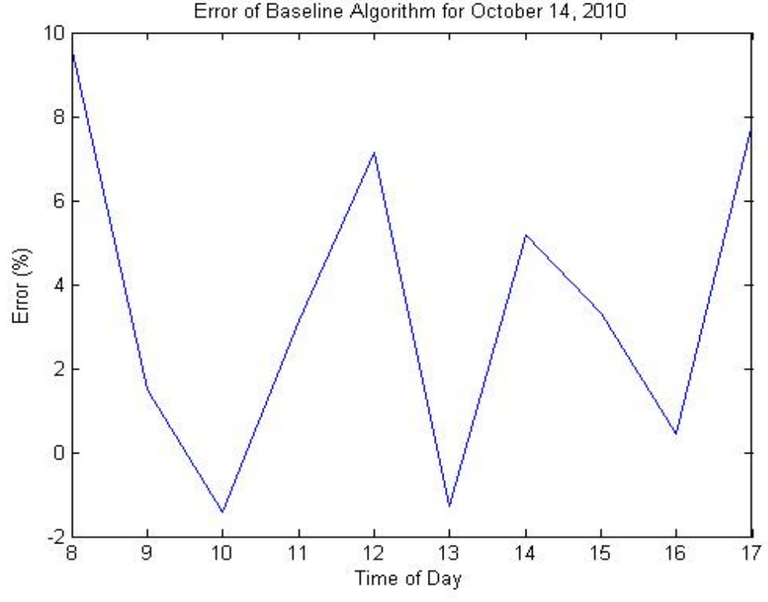
- Prediction Results also tested for February 4, 2011, with Morning Correction Factor, and with a preliminary Occupancy Correction Factor that will be refined with more data.

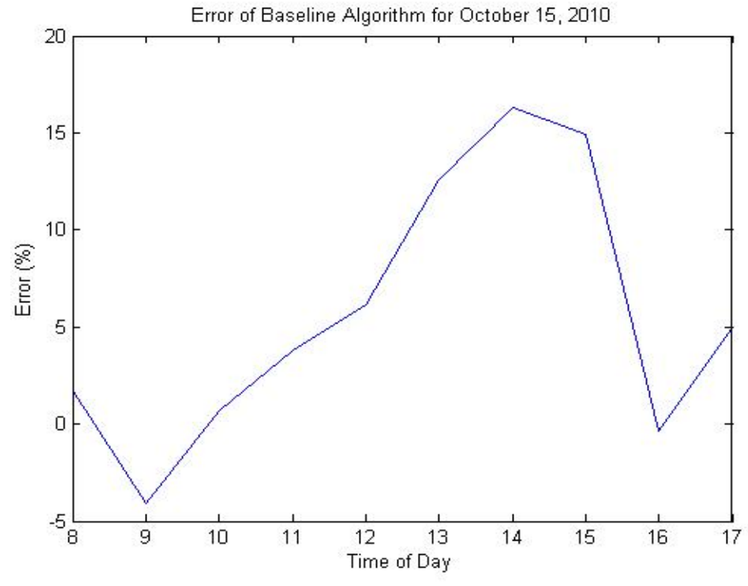
*other two correction factors not available for time period.

October Results

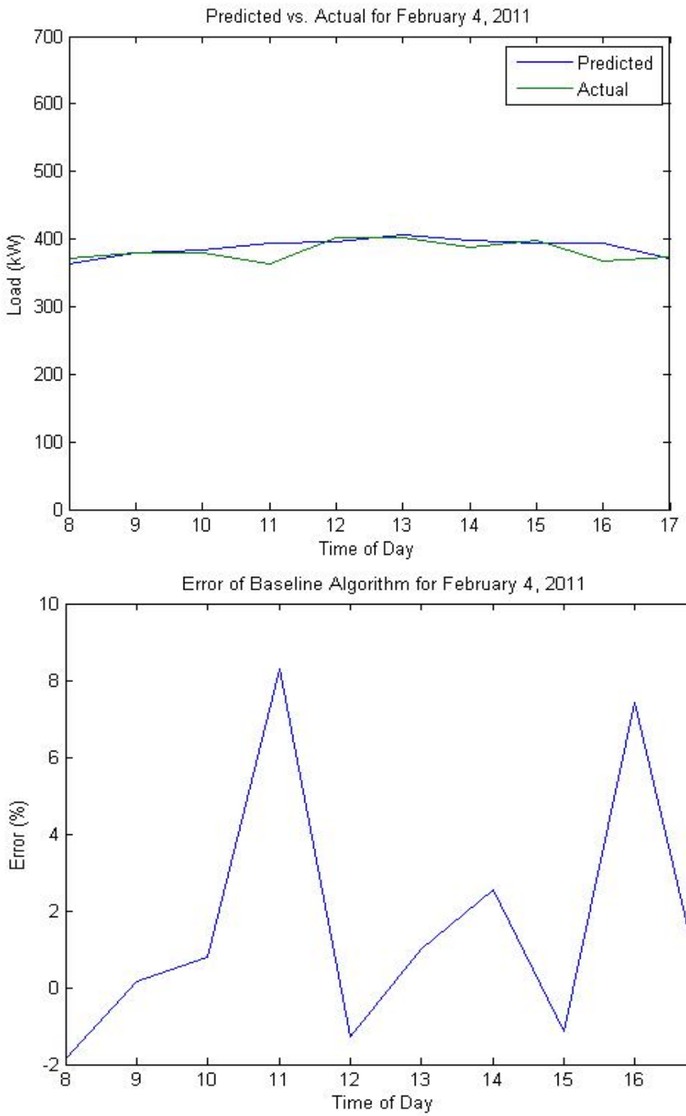


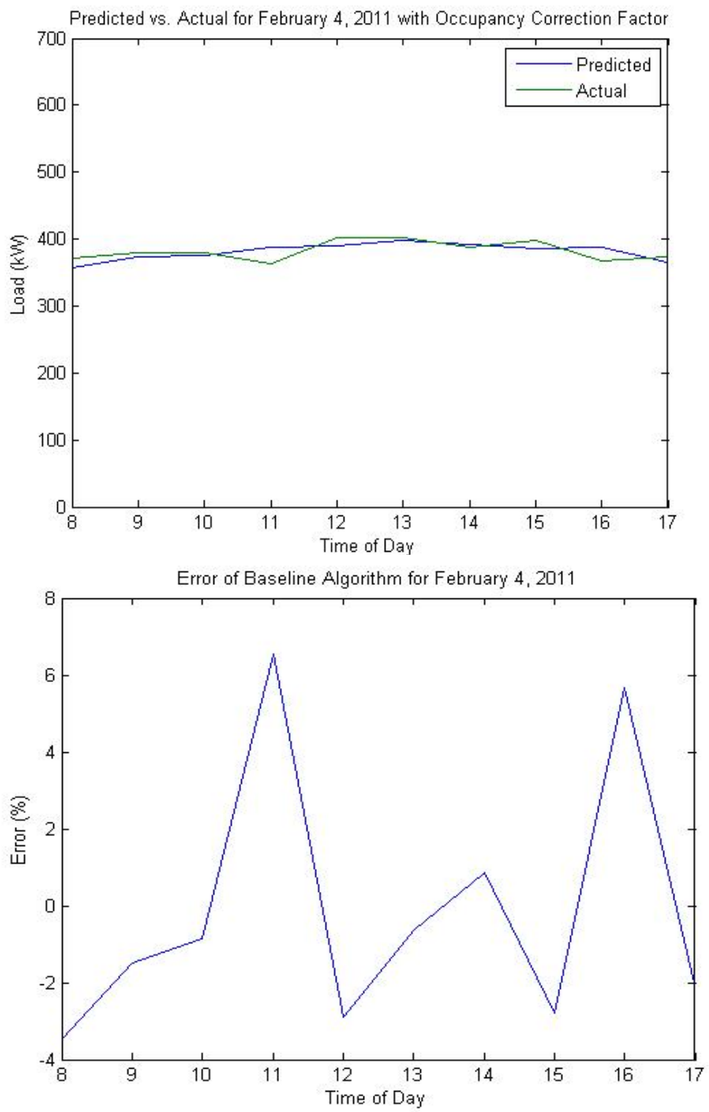




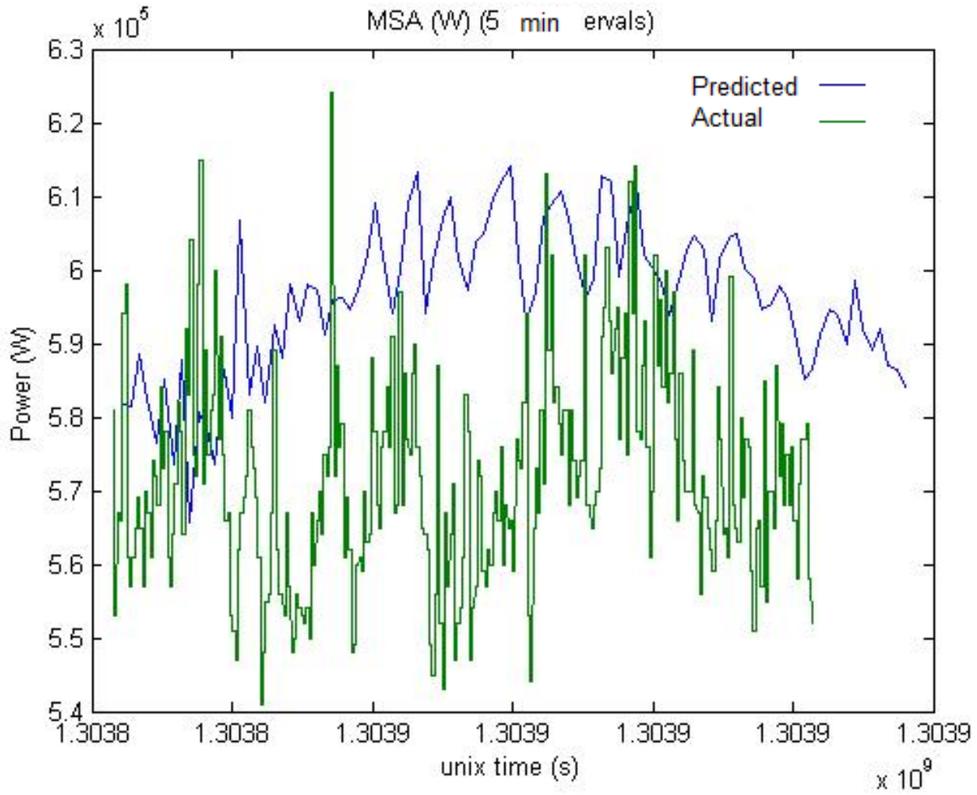


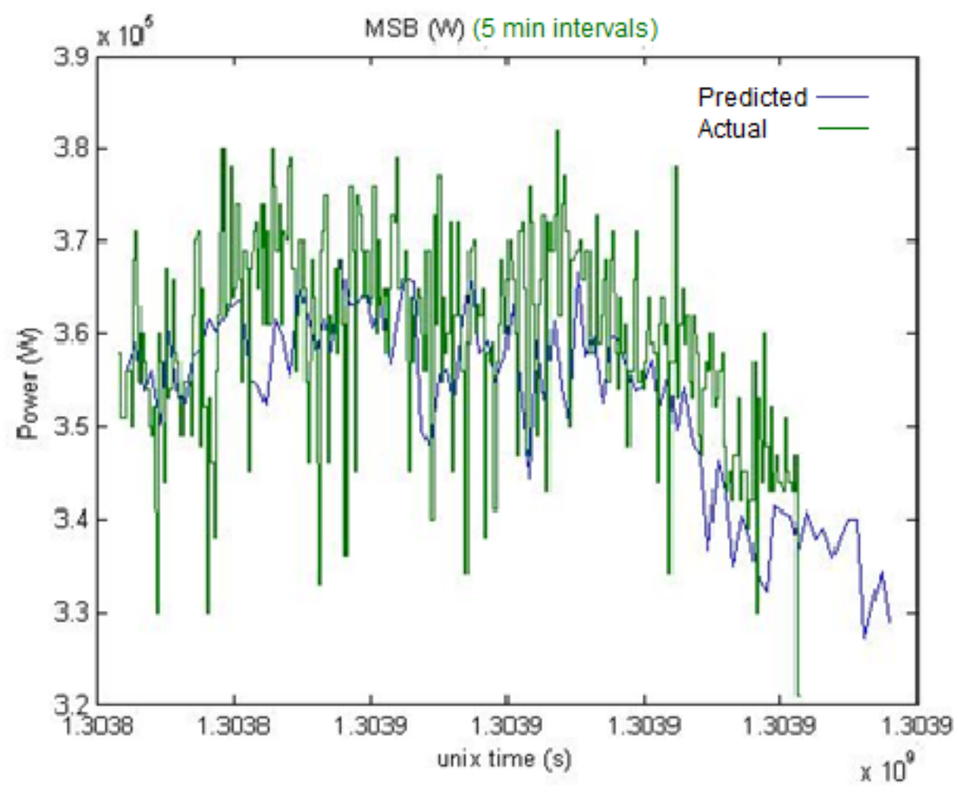
February Results With and Without Occupancy Correction Factor





April Results





- Results for April 26, 2011 from 12 PM until 6 PM
- Largest region of error is 6% from 2 PM to 3 PM for MSA

Future Work

- A refined Occupancy Correction factor to be developed with more dynamic occupancy data that is to be determined in the coming weeks
- Implementation of HVAC Correction factor with the installation of flow submeters on the Sutardja Dai Hall HVAC system.

Questions

Acknowledgement

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