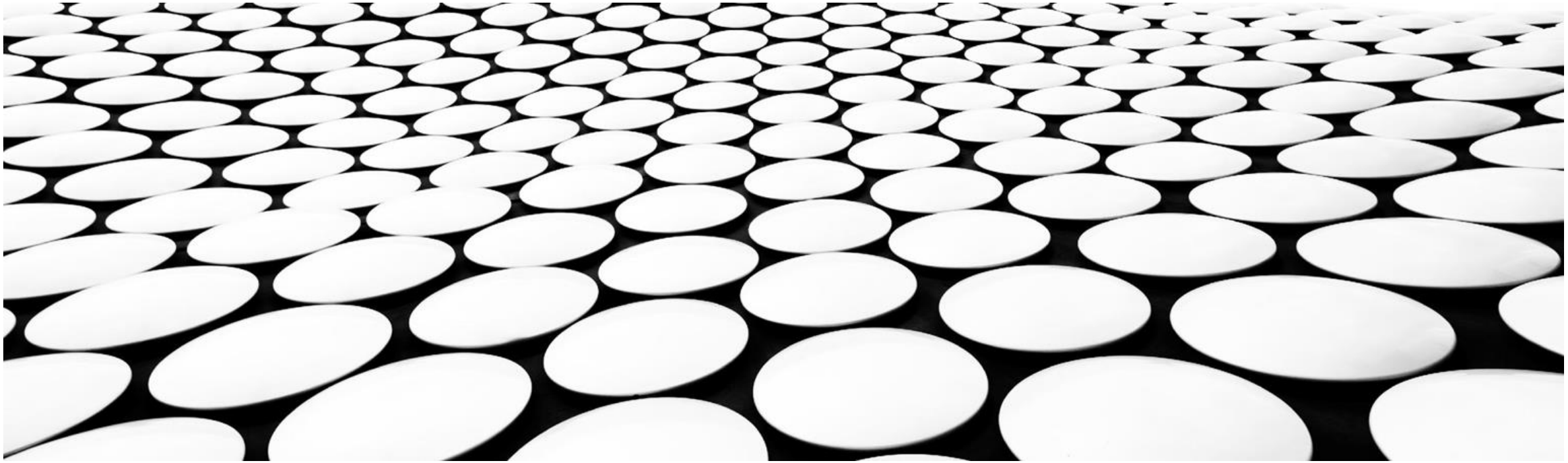
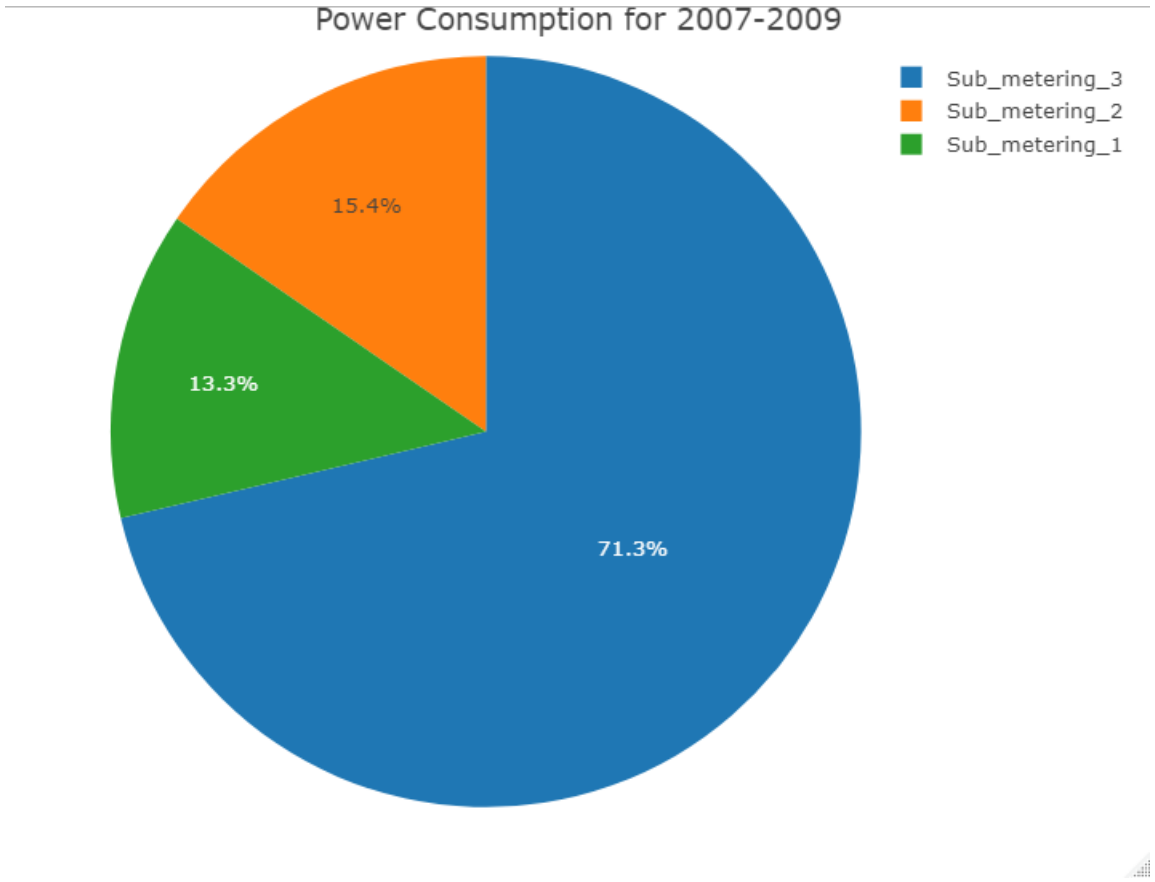
IOT Analytics

Electricity Usage Patterns

Brian Mattis



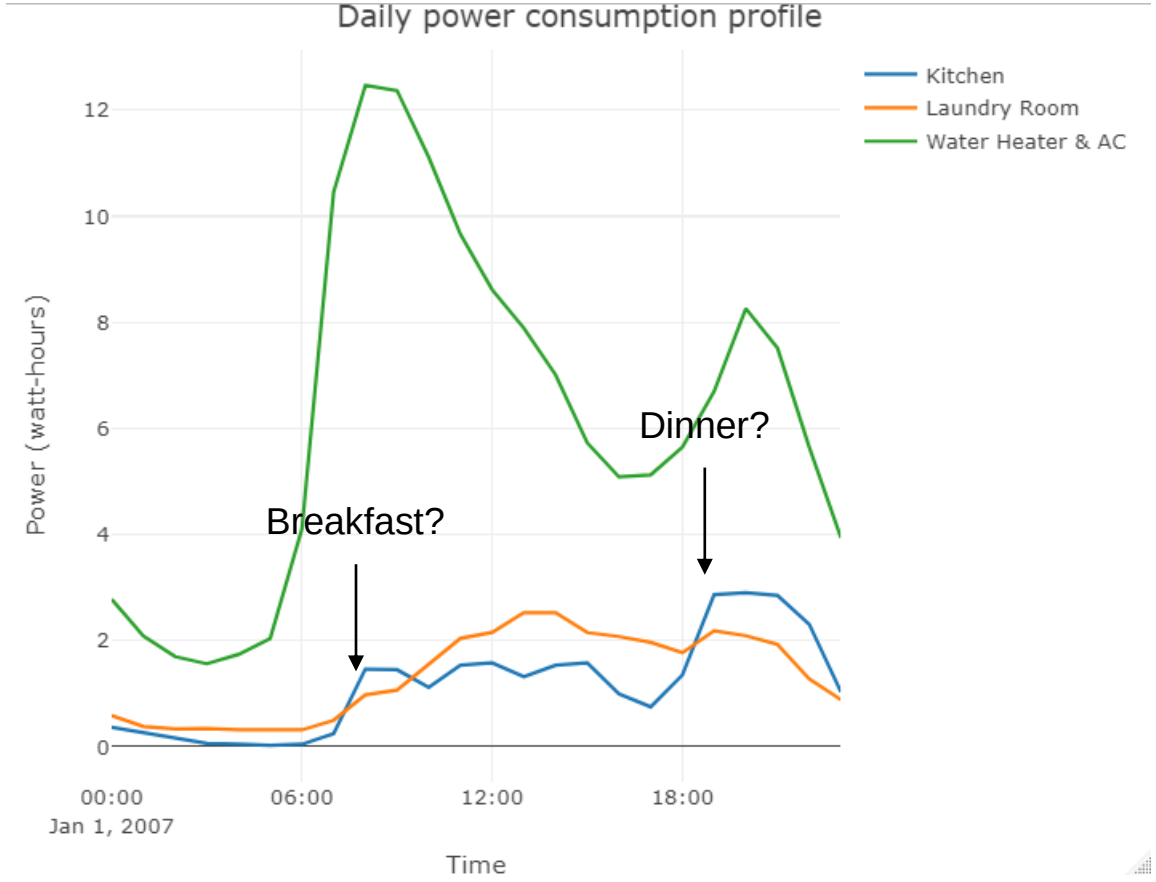
Overall Power Consumption by Submeter (2007-2009)



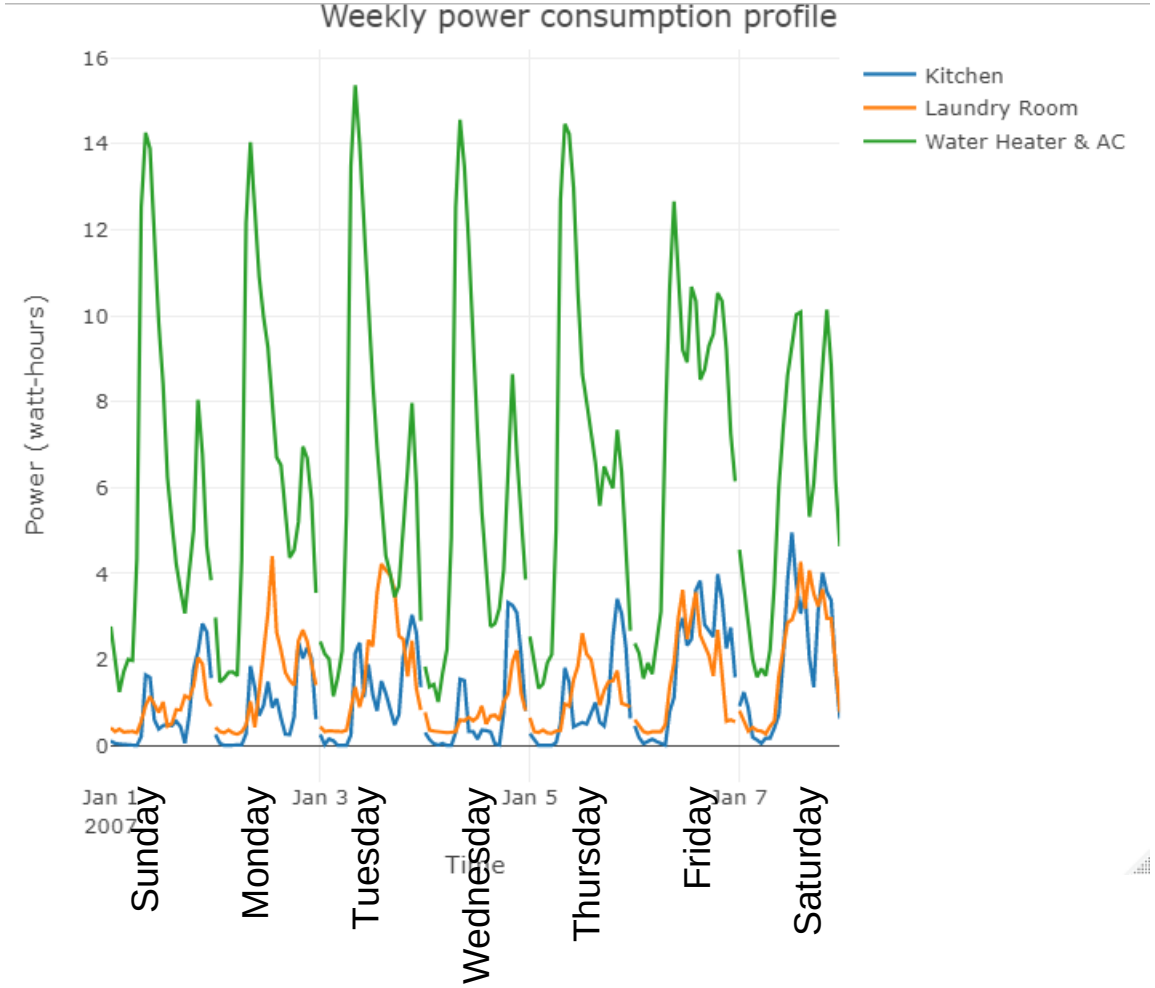
Residence circuit allocations

- Submeter 1: Kitchen
  - Dishwasher
  - Oven
  - Microwave
- Submeter 2: Laundry Room
  - Washing Machine
  - Dryer
  - Refrigerator
  - Light
- Submeter 3: Heating/cooling
  - Water heater
  - Air Conditioner

Daily and Weekly Power Usage Profiles



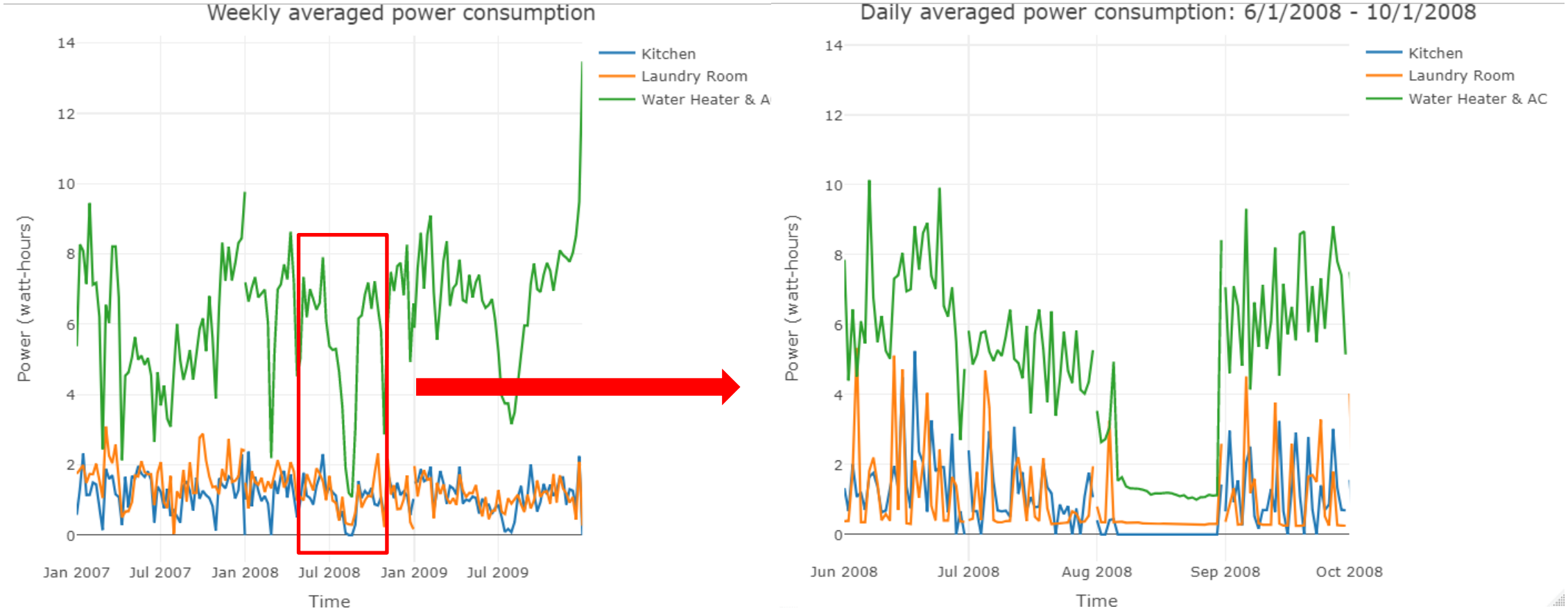
** Power data averaged hourly for all days from 2007-2009*



** Power data averaged hourly for all days from 2007-2009, by day-of-week*

- Client daily and weekly behavior patterns can be observed

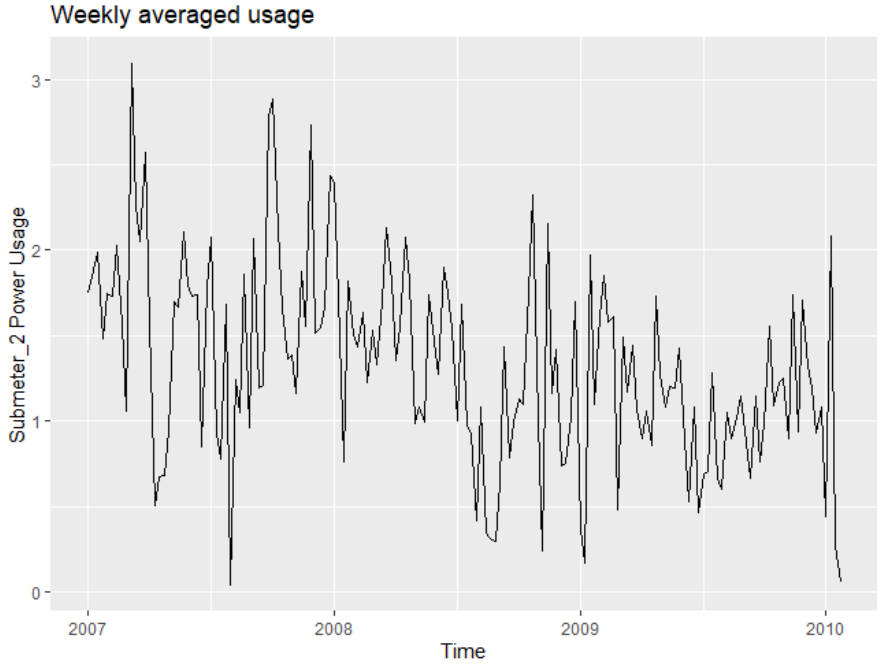
Summer 2008 Investigation

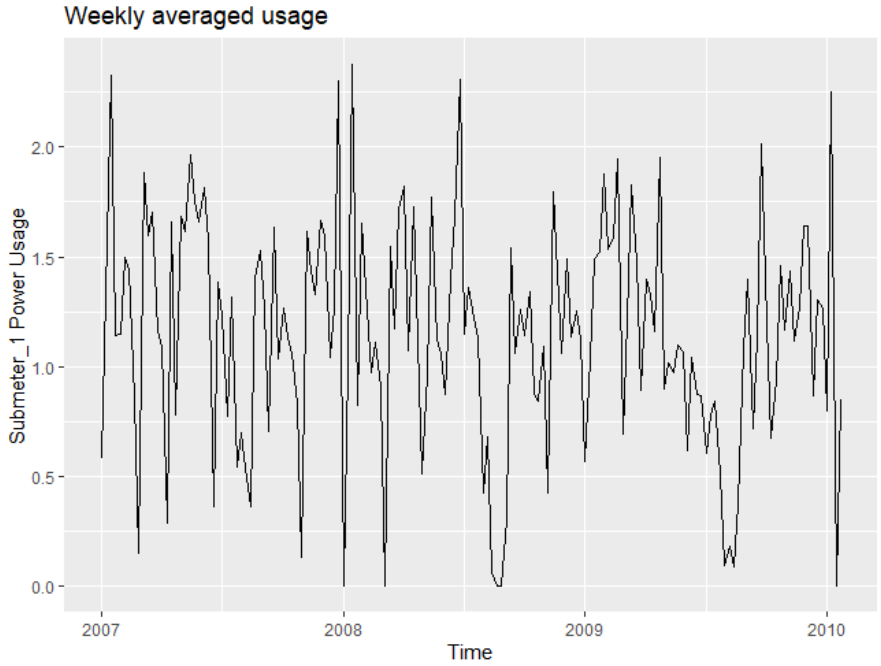


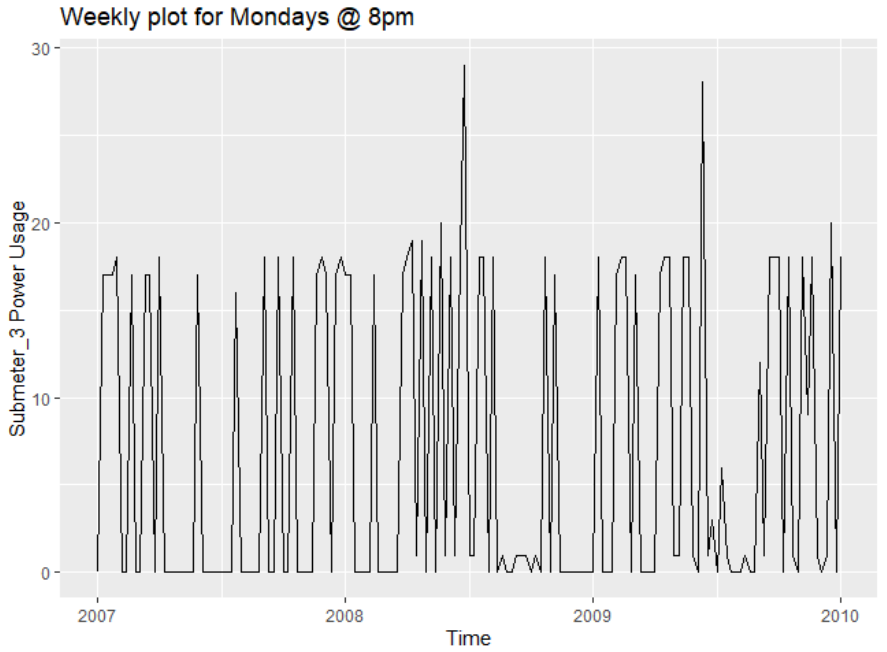
- Clear data showing minimal power usage Aug 7th – Aug 30th 2008
  - Reasonable to conclude client was not living in residence at this time

Usage data

- SM1 and SM2 plotted as weekly mean usage from 2007-2010
- SM3 plotted as weekly sample of the data taken at 8pm on Mondays (*per project roadmap*)

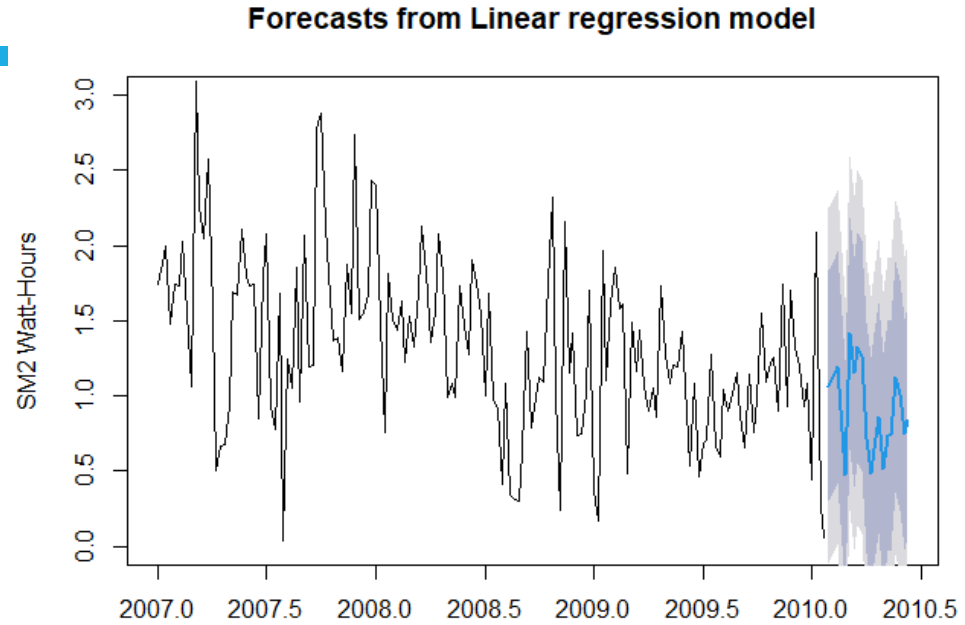


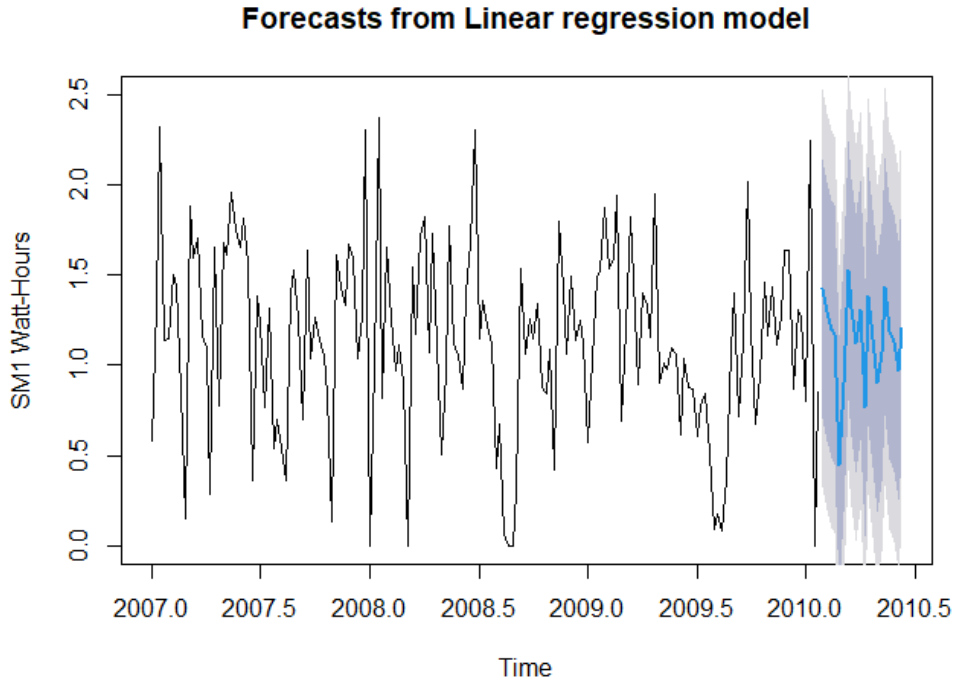


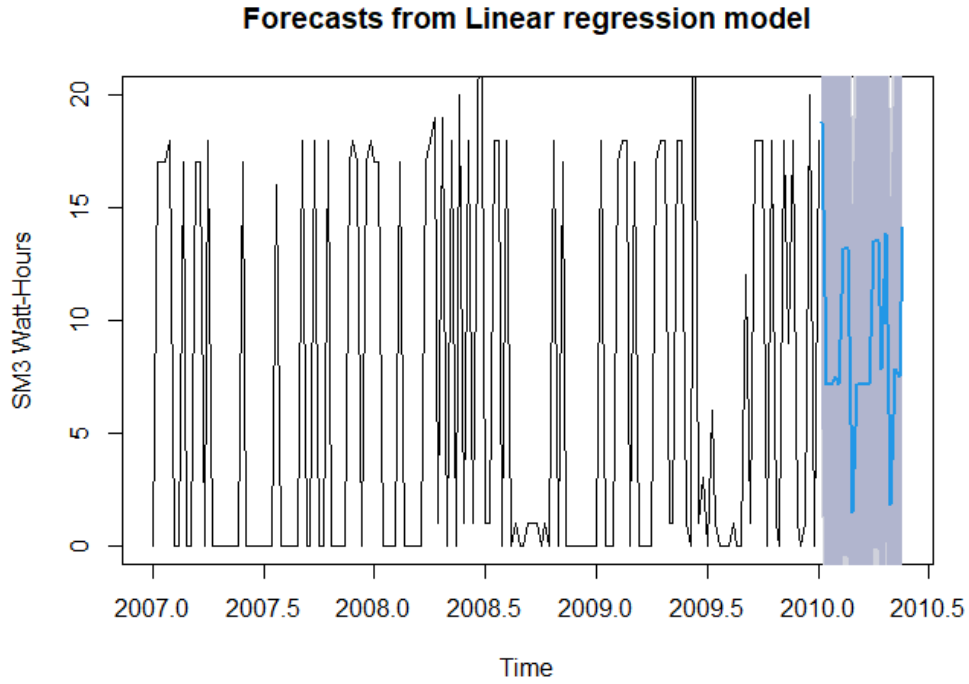


Linear Regression Forecasting

	RSE	Multiple R2	Adjusted R2
SM1	0.4753	0.4411	0.1694
SM2	0.5085	0.4851	0.2349
SM3	9.046	0.263	-0.1055

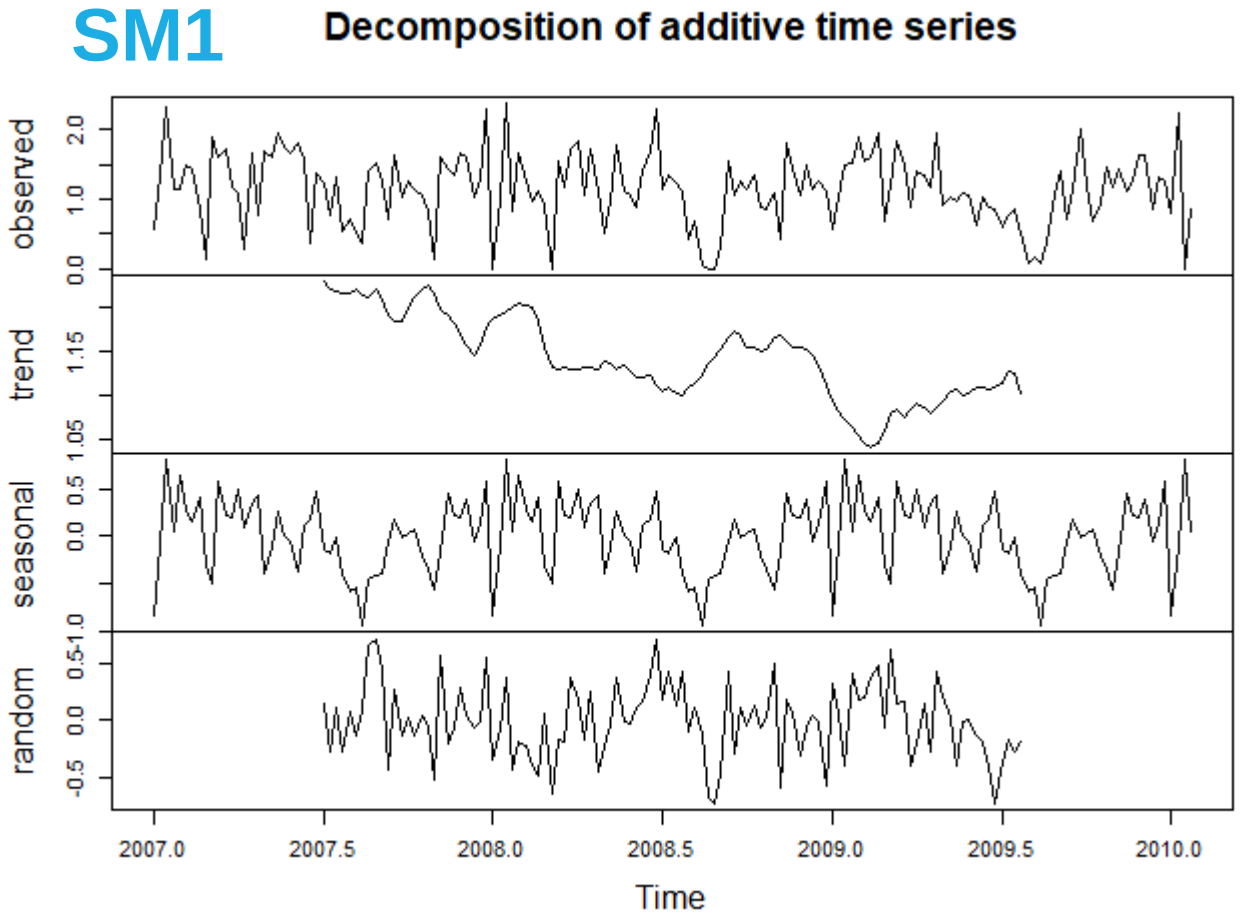




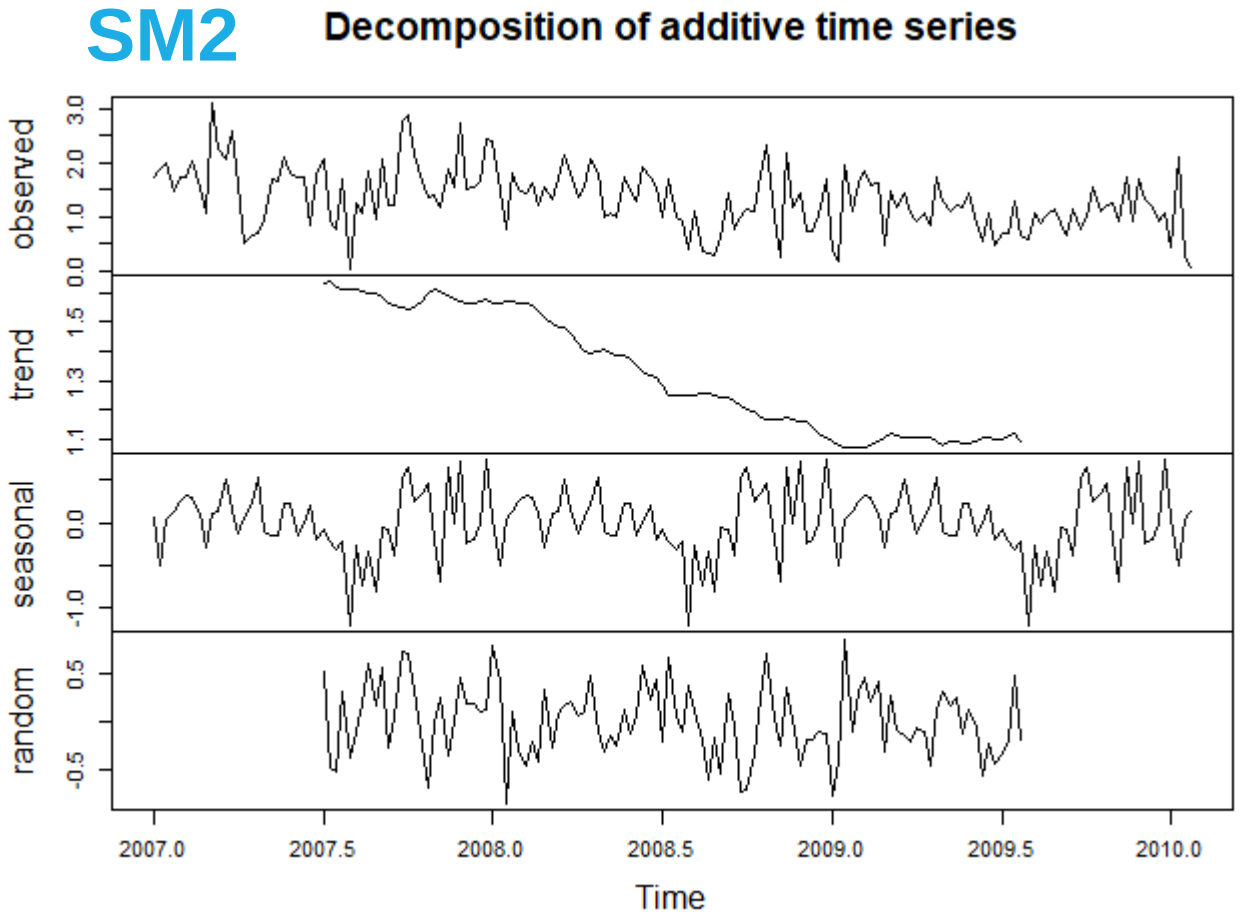


Component Decompositions

SM1

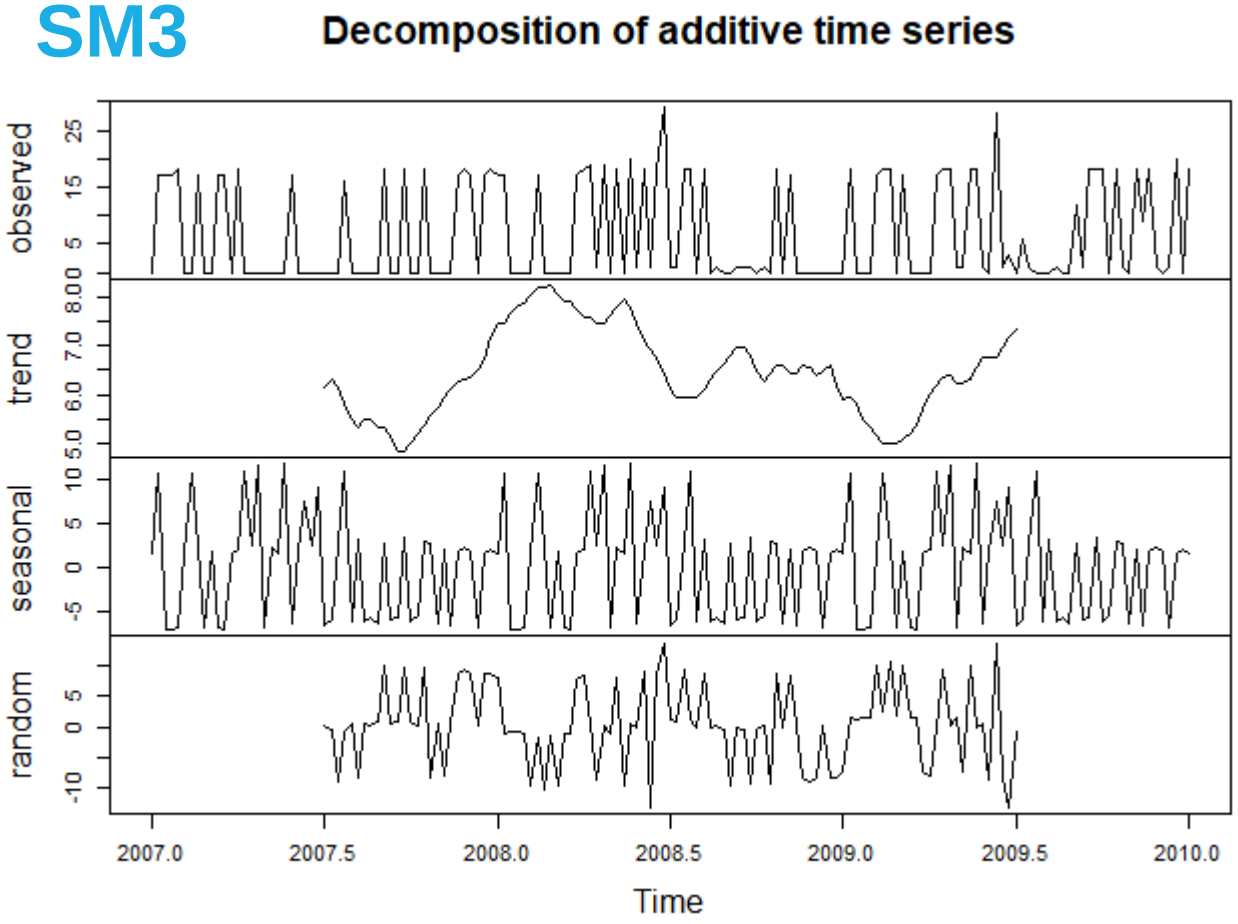


SM2



Component Decompositions

SM3



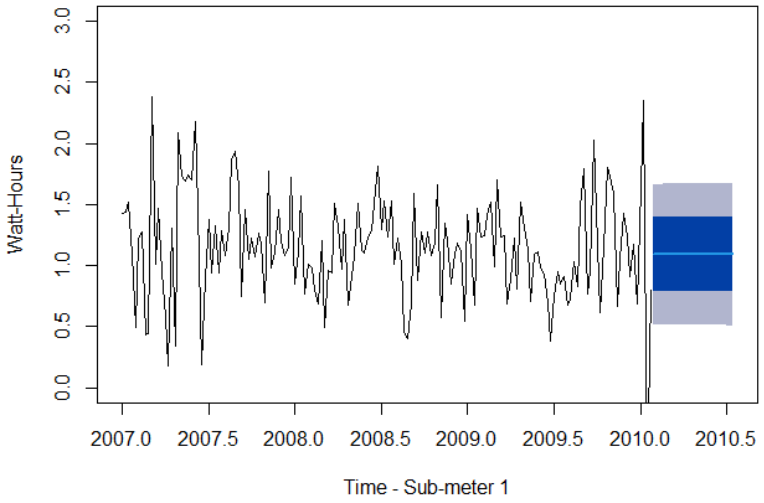
		Min.	1st Qu	Median	Mean	3rd Qu.	Max
SM1	Seasonal	-0.946	-0.309	0.021	-0.001	0.240	0.808
	Trend	1.042	1.109	1.135	1.142	1.184	1.228
	Random	-0.737	-0.211	-0.010	-0.010	0.184	0.717
SM2	Seasonal	-1.204	-0.211	-0.001	-0.002	0.228	0.725
	Trend	1.073	1.111	1.257	1.327	1.563	1.638
	Random	-0.855	-0.246	-0.020	-0.001	0.246	0.853
SM3	Seasonal	-6.969	-6.118	1.680	0.010	2.699	11.598
	Trend	4.837	5.913	6.404	6.456	6.981	8.231
	Random	-13.358	-1.401	0.229	0.224	1.849	13.806

- SM2 showed a clear trend decrease with time
  - Client perhaps reduced usage of washer/dryer
- SM3 shows surprisingly weak/noisy seasonal trend
  - Improved if we use weekly averaging instead of sampling

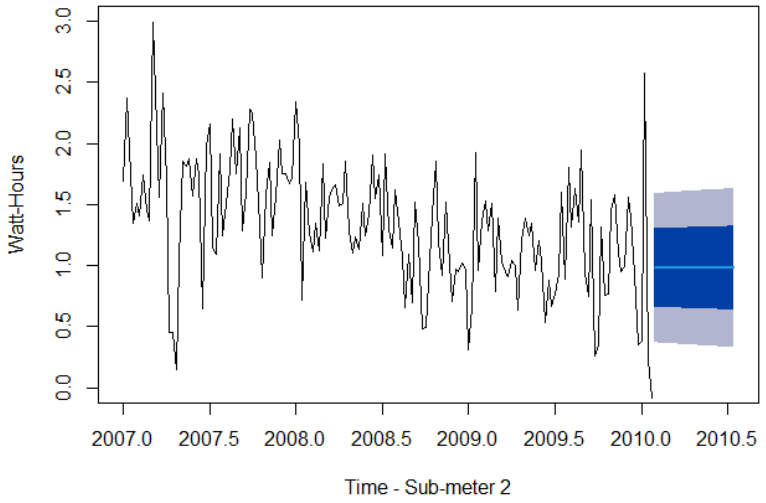
Holt-Winters Forecasting

50% and 80% Confidence Levels plotted

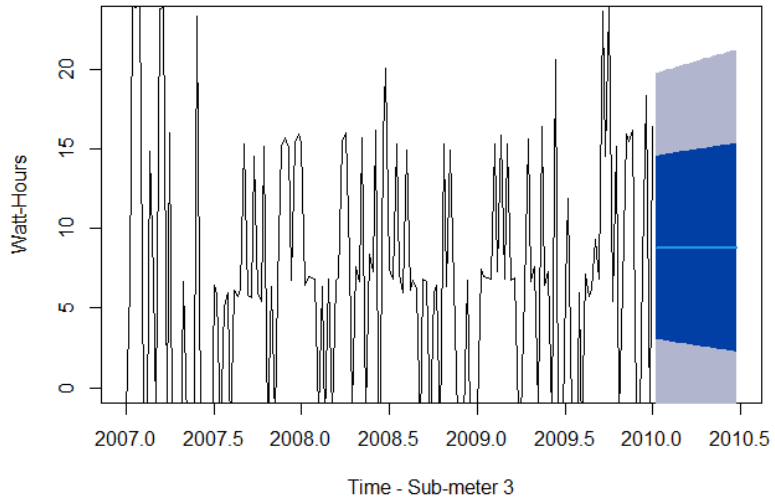
SM1



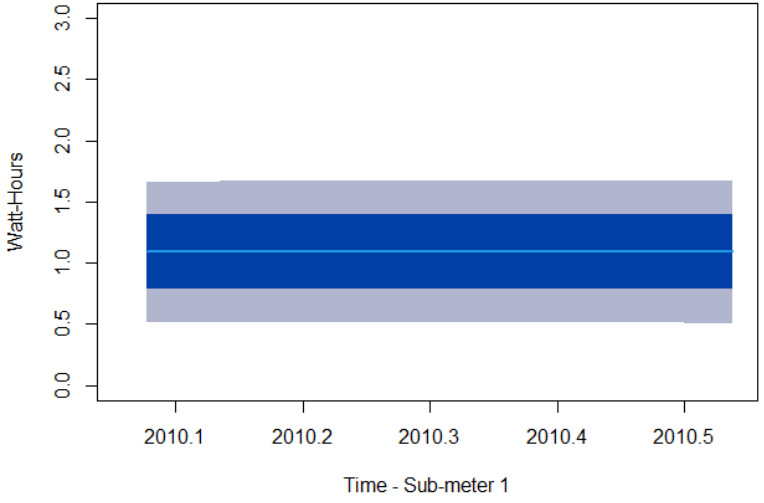
SM2



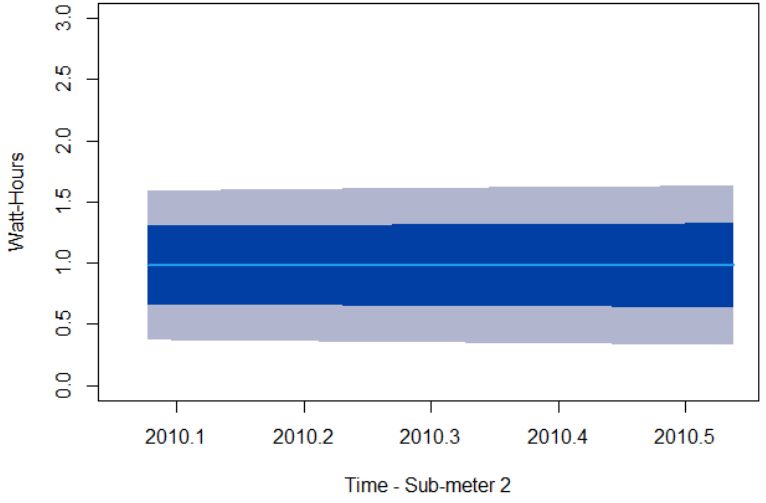
SM3



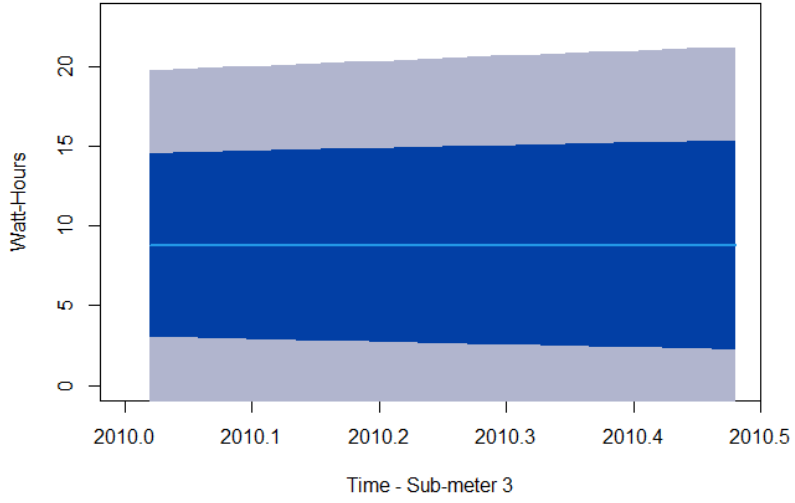
SM1



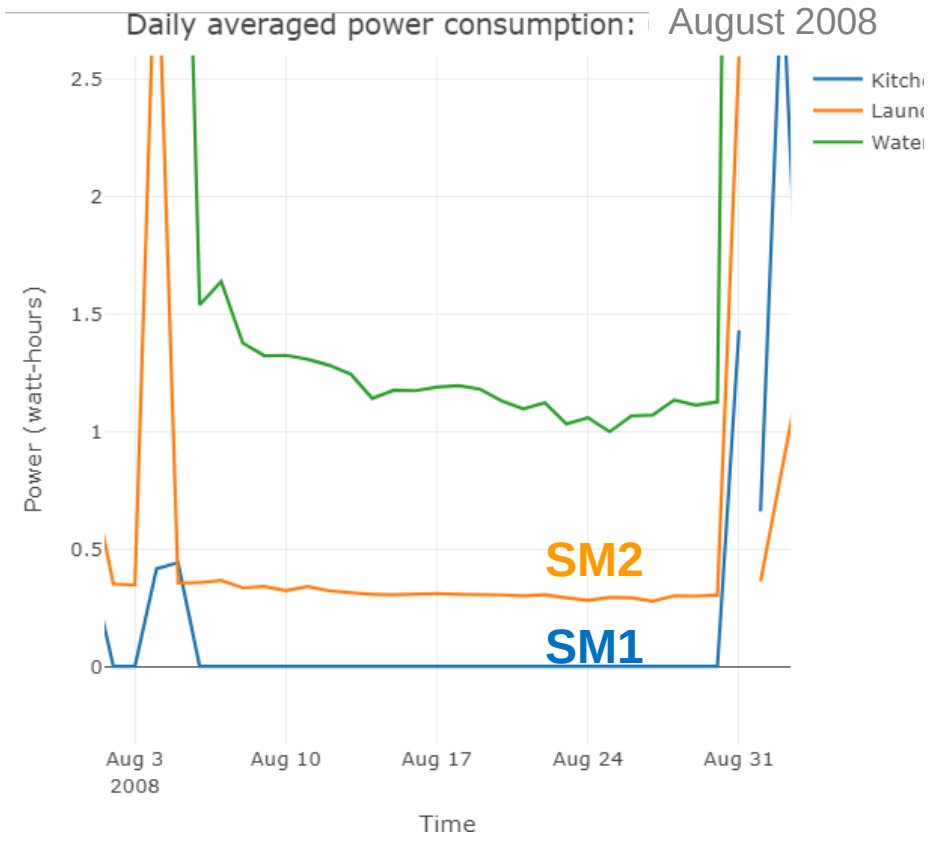
SM2

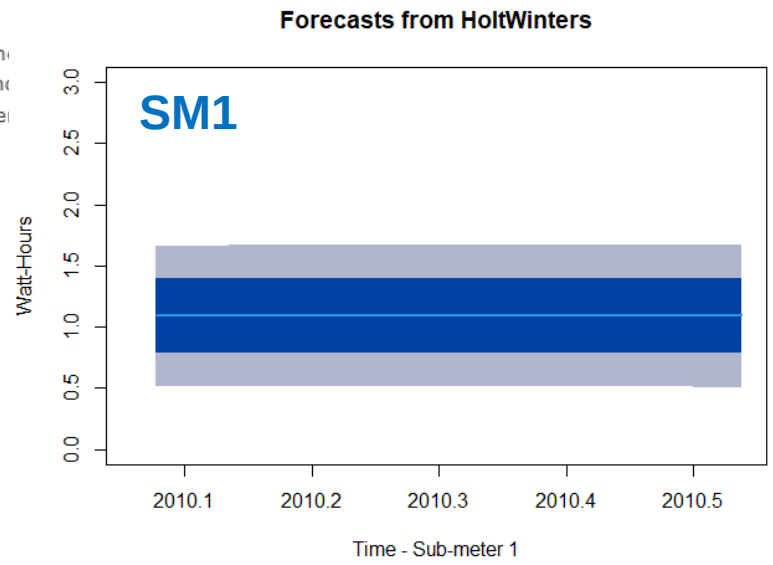


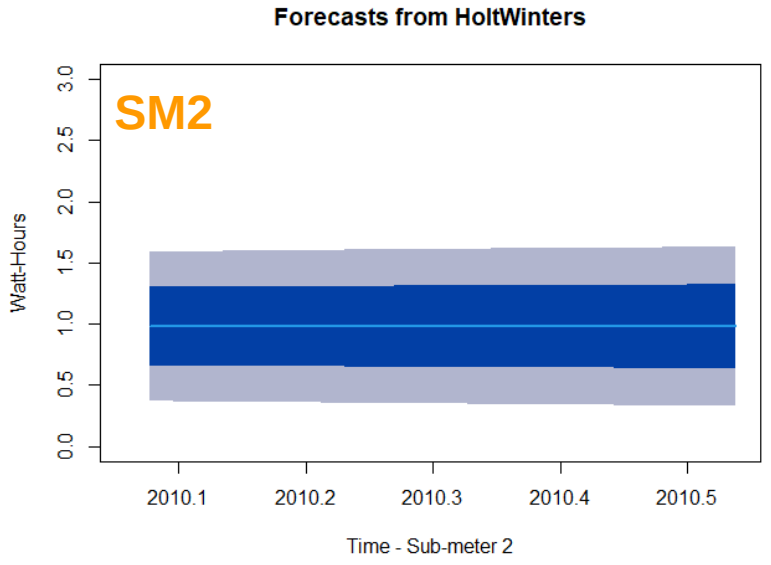
SM3



Modeled vs. actual usage in August 2008



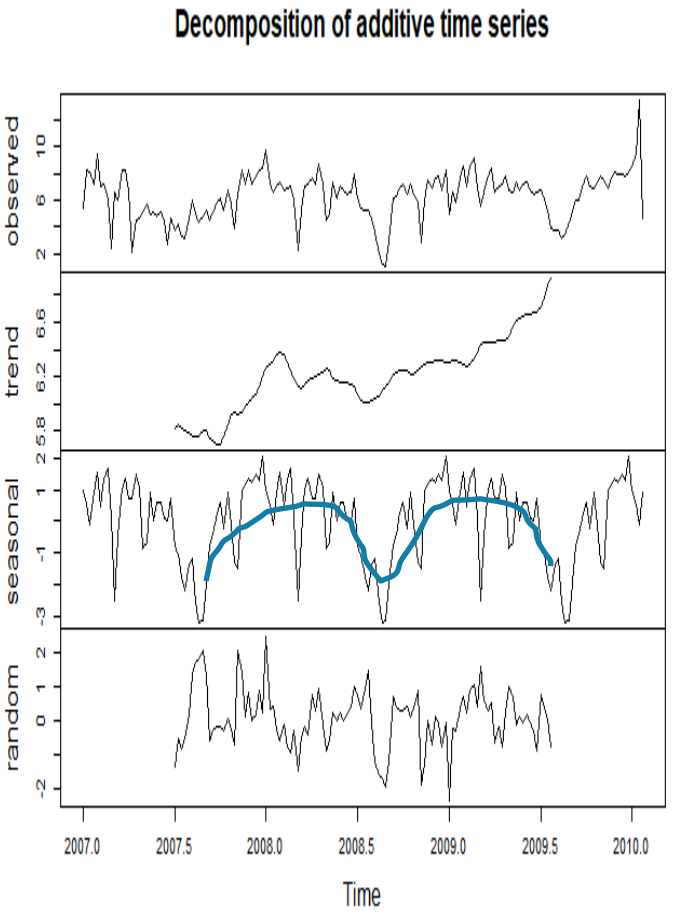




- During Aug2008, SM1 and SM2 usages are well outside the 80% confidence ranges, indicating a significant deviation from previous trends
- Further supports the client was not in the residence during this time frame

Business Recommendations

- Combining weather and sunrise/sunset data could help in analyzing the seasonality and trend components of the AC/heater related data
  - SM3 decomposition shows lower seasonal usage in summer (plot on right)
- Increasing the number of submeters in a residence would offer further insight into the details of a resident's behavior
- Sub-meters offer fine granularity, and future cases with tighter timelines in question could benefit
- AC/Water heater consume significantly more energy annually than other appliances, and could be an opportunity for savings with more efficient units
- Access to broad submeter usage data across a city could be useful in other data mining markets, such as targeted advertising
  - Identify meal times, bed times, and work schedules



Lessons Learned

- Sampled data is noisier than averaged grouped data for consumption data sets
- Holt-Winters fails to integrate the SM2 downward trend in future forecasts
  - Manually adjusting parameters results in overfitting and a poor model
- Using a weekly-averaged sample set produces much more controlled forecasts for SM3, as seen on right
  - Random sampling has negatively impacted our prediction capabilities
  - SM3 with this forecast would have supported the out-of-range claims for Aug2008