

Data Visualization of Sub-Metering

Analyzing Household Energy Consumption
Through the Use of Sub-Metering

Tom Snyder 09/27/21



Agenda

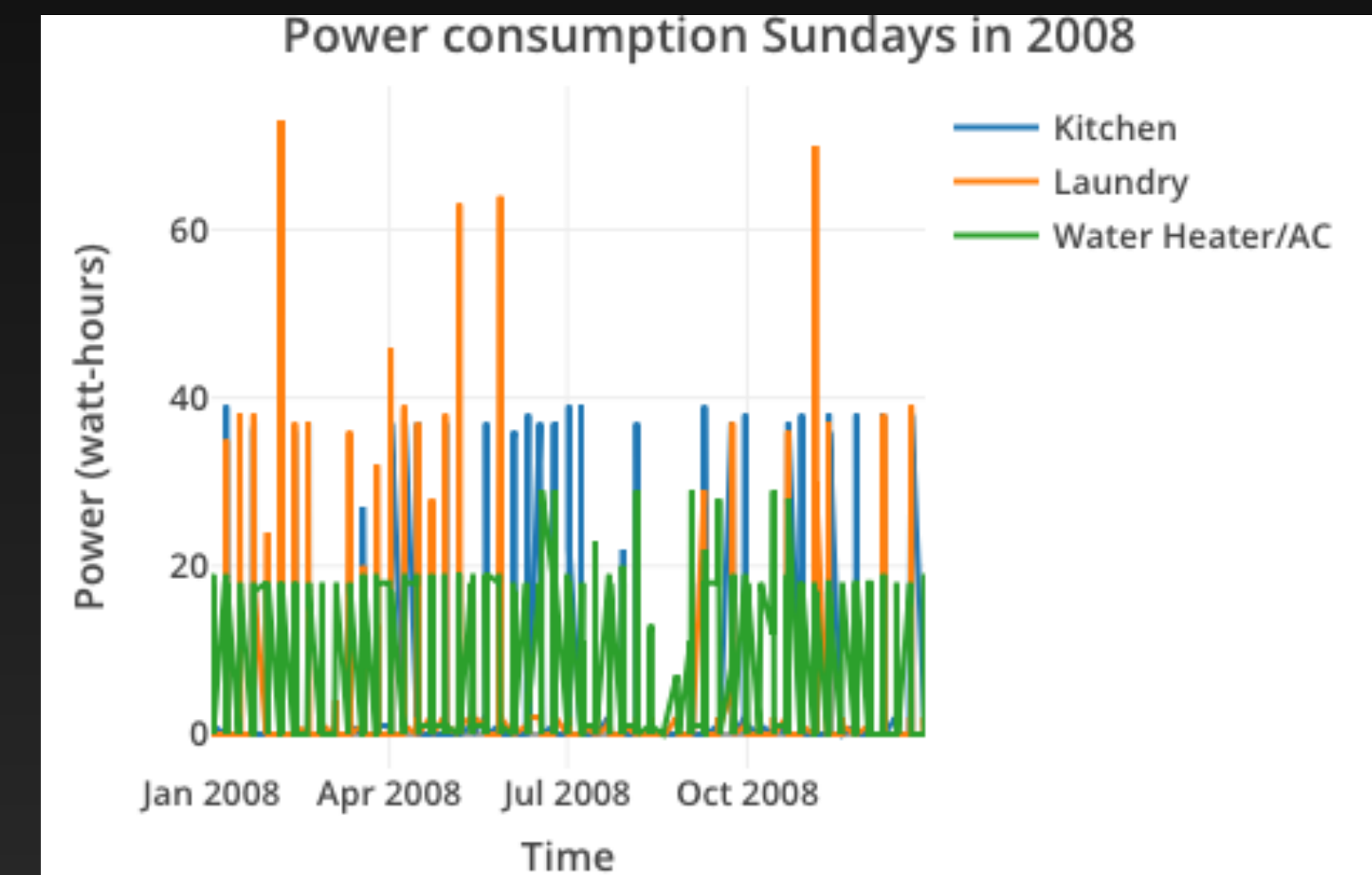
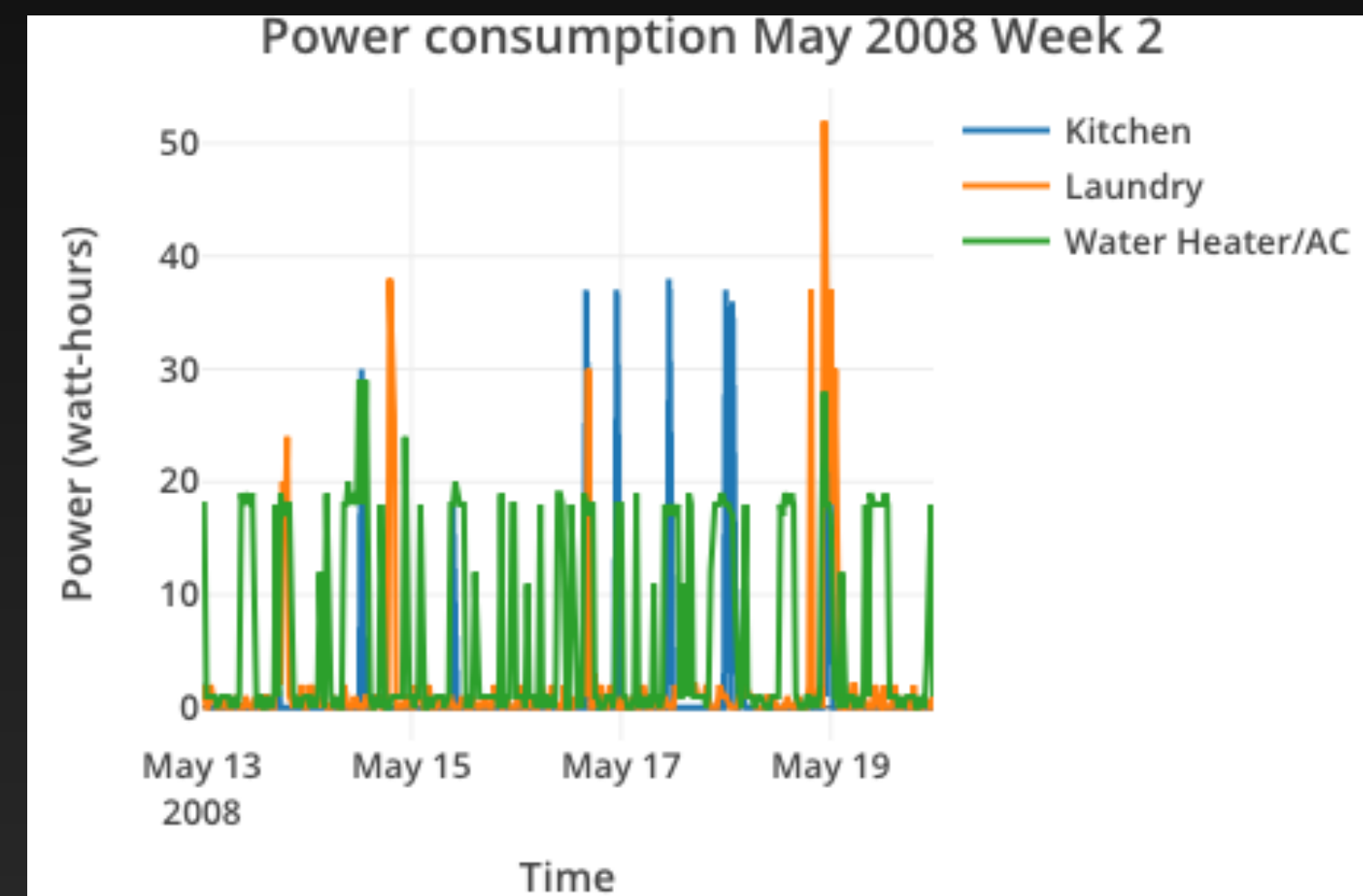
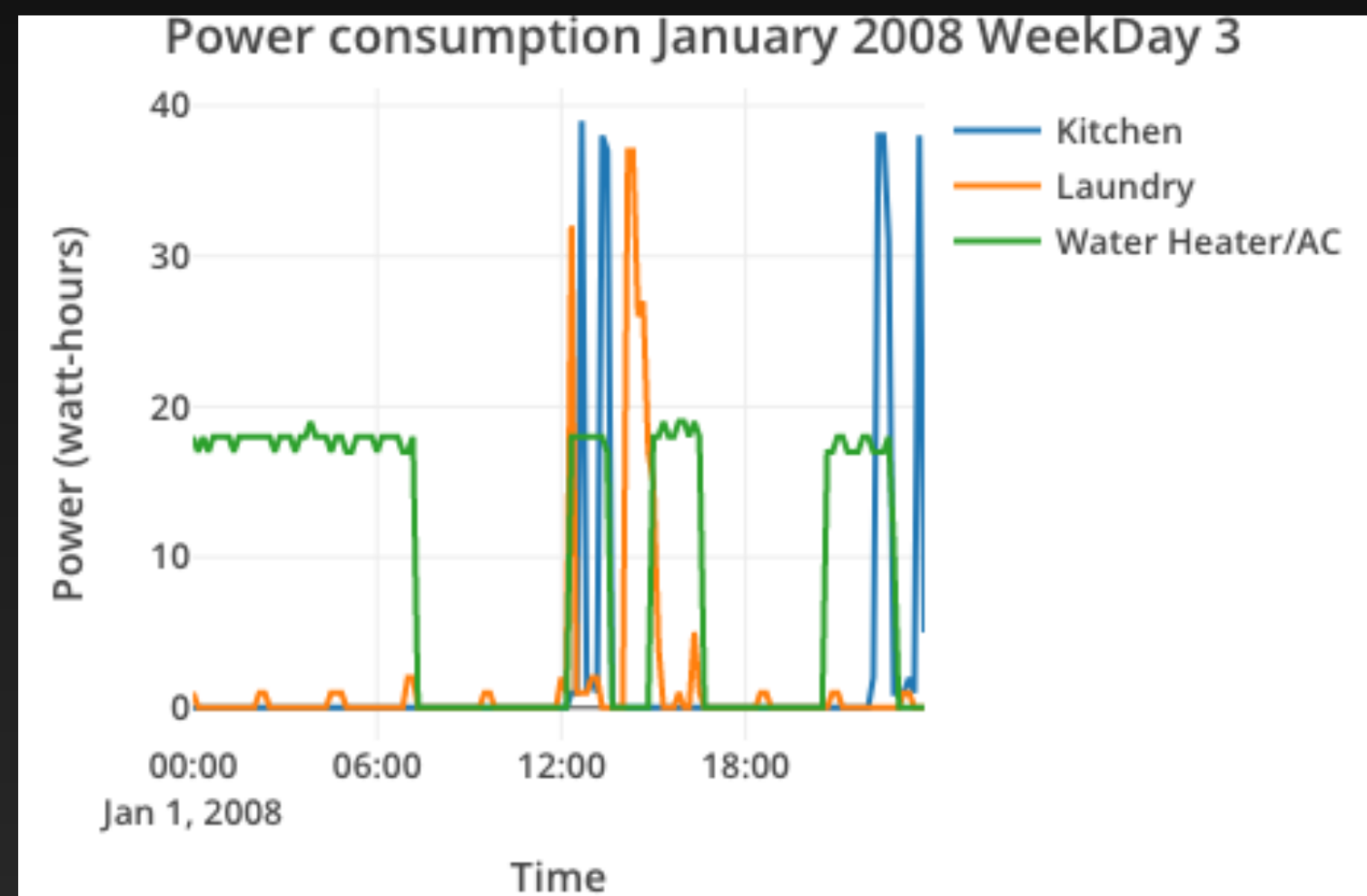
This presentation will cover:

- Visualization of weekly, monthly, and quarterly power consumption measured by sub-meters for the kitchens, laundry rooms, and water heater/AC
- Visualization of forecasting of power consumption, seasonally adjusted
- Business recommendations informed by insights gleaned from data analysis

About the Data

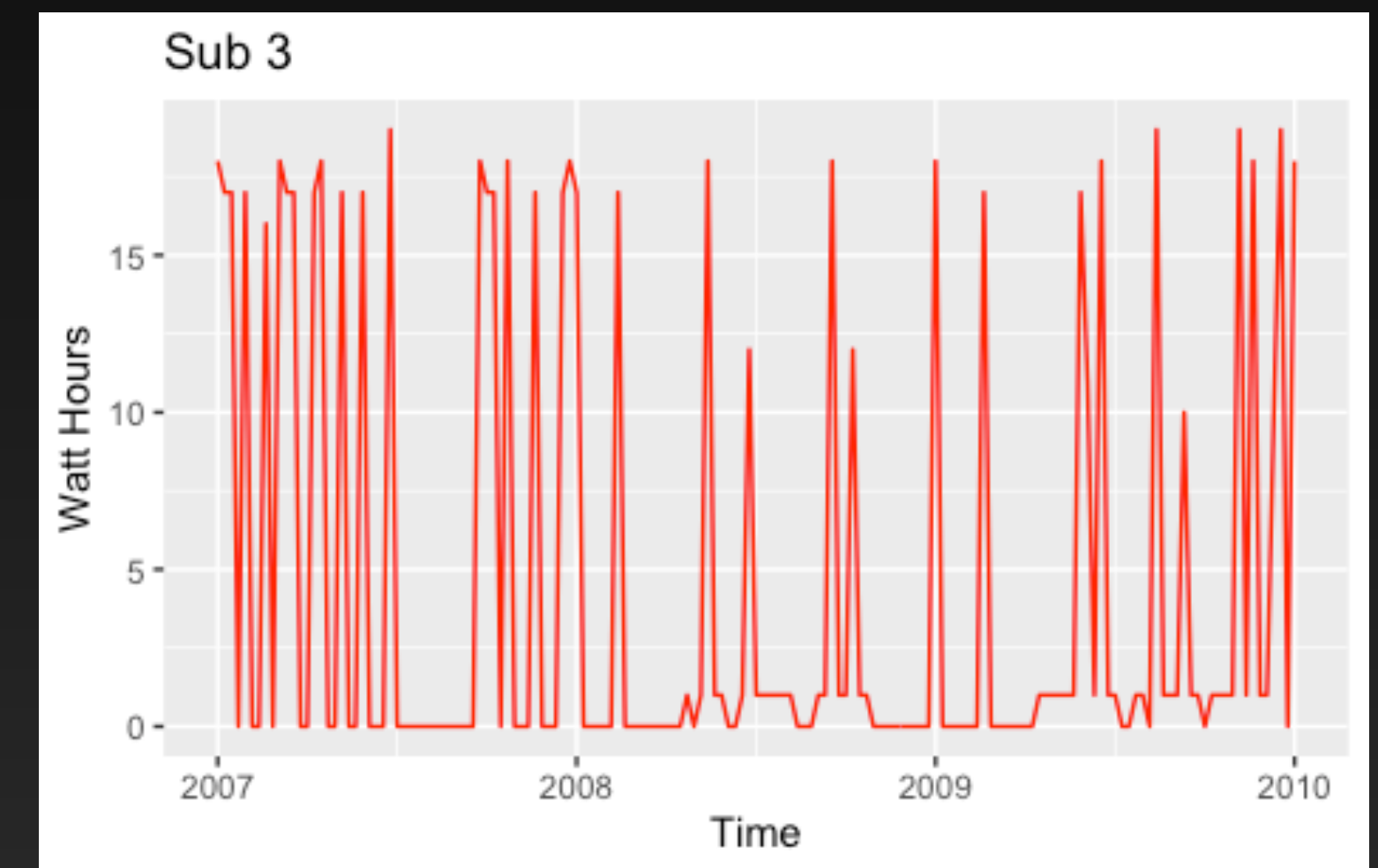
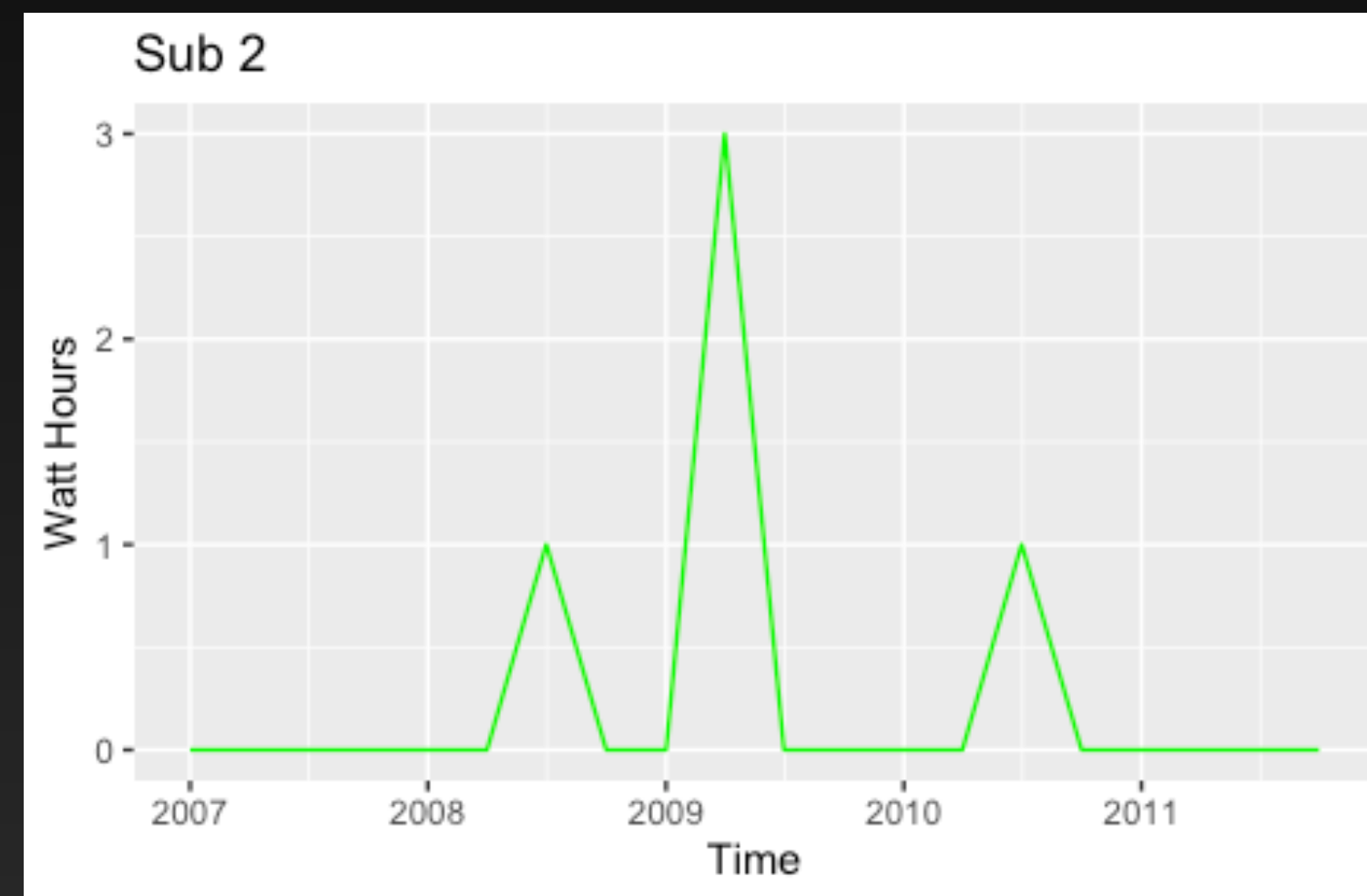
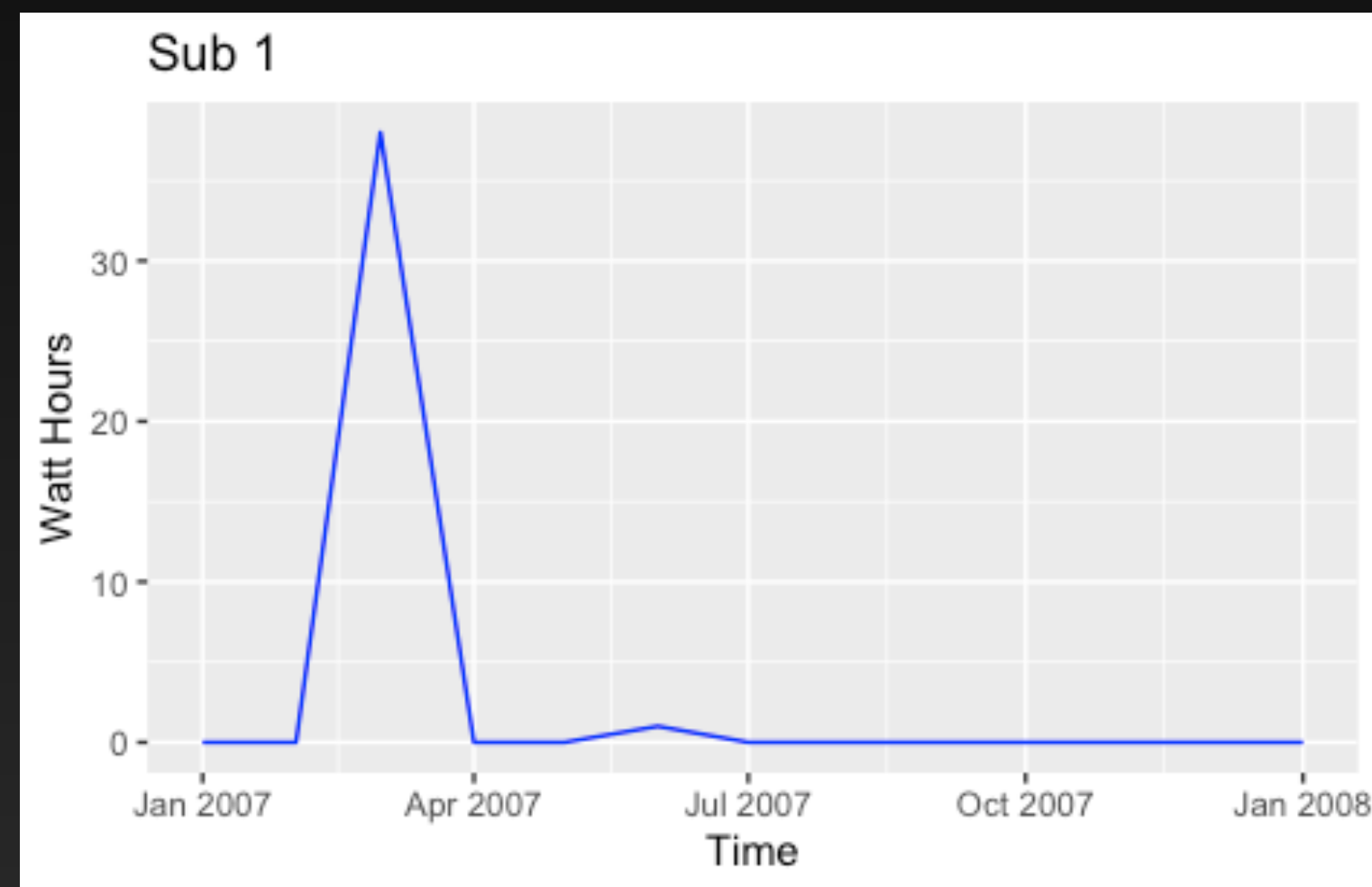
- This data set is a time series data set of power usage of a residential apartment building in Paris. The power usage was divided by a sub-meter - a device that measures power usage at a micro level to better assess where power is used.
- Sub-meter 1 measures power consumption in the kitchen.
- Sub-meter 2 measures power consumption in the laundry room.
- Sub-meter 3 measures power consumption by the water heater and AC.
- The data was compiled from 5 consecutive years: 2006-2010.
- For accurate measurements, data analysis was performed using the complete data from years 2007, 2008, 2009.

Power Consumption



It can be seen at the hourly, daily, and weekly level that the water heater and AC units consume a lower, more consistent rate of energy than the laundry room or kitchen. In the hourly and daily samples, it appears that power consumption by laundry room and kitchen is very similar.

Power Consumption by Sub-Meter



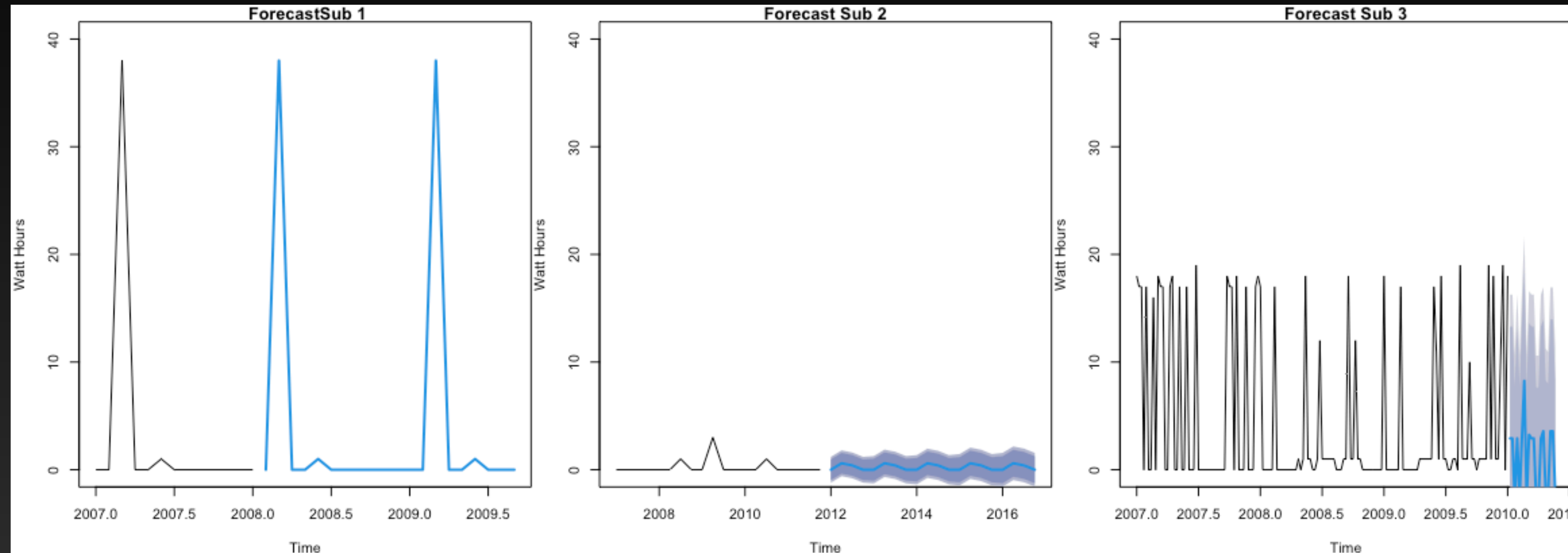
In these three plots, we see the three different sub-meters sampled with three different frequencies over three years.

Sub 1 is monthly sampling of sub-meter 1

Sub 2 is quarterly sampling of sub-meter 2

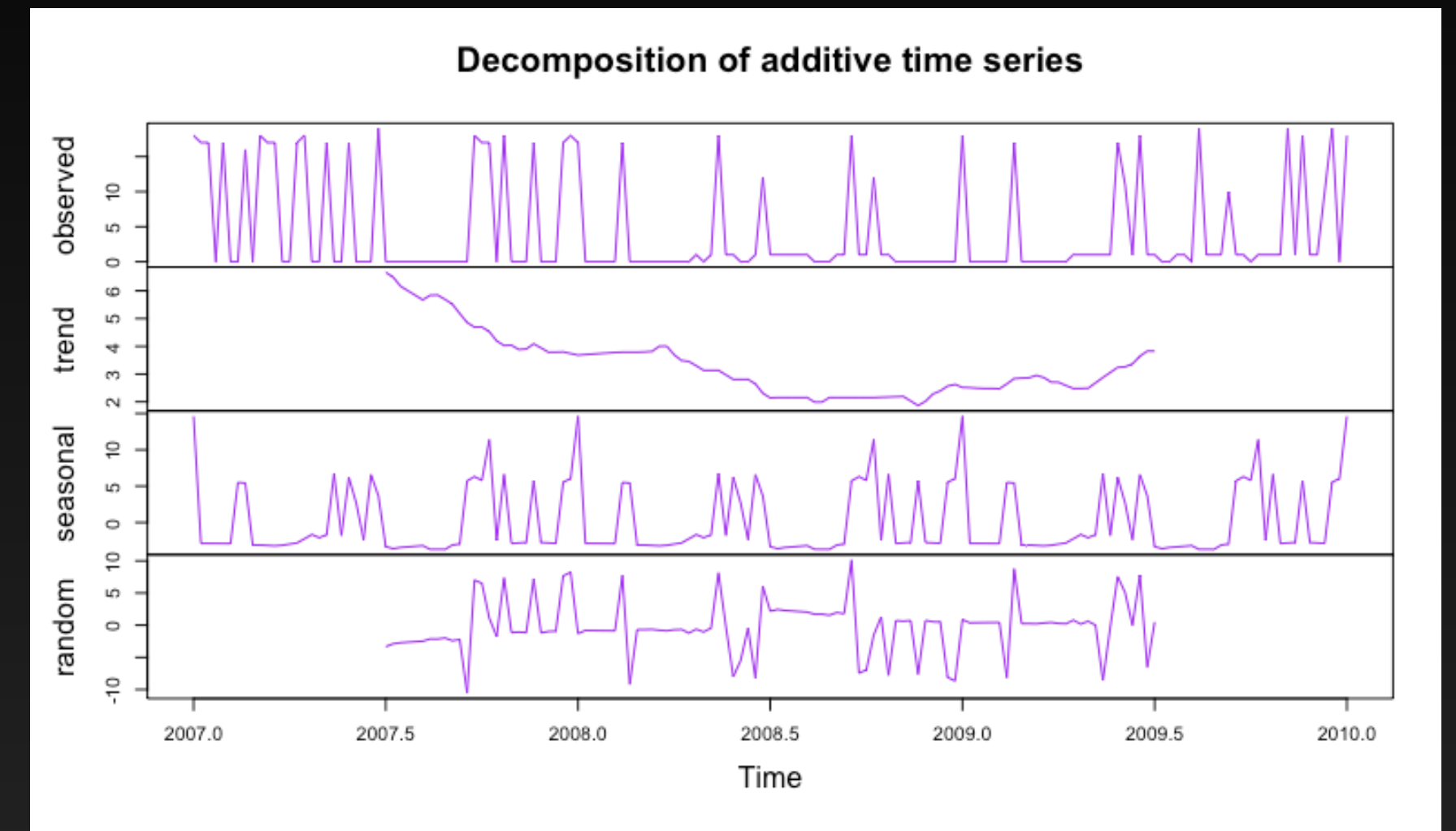
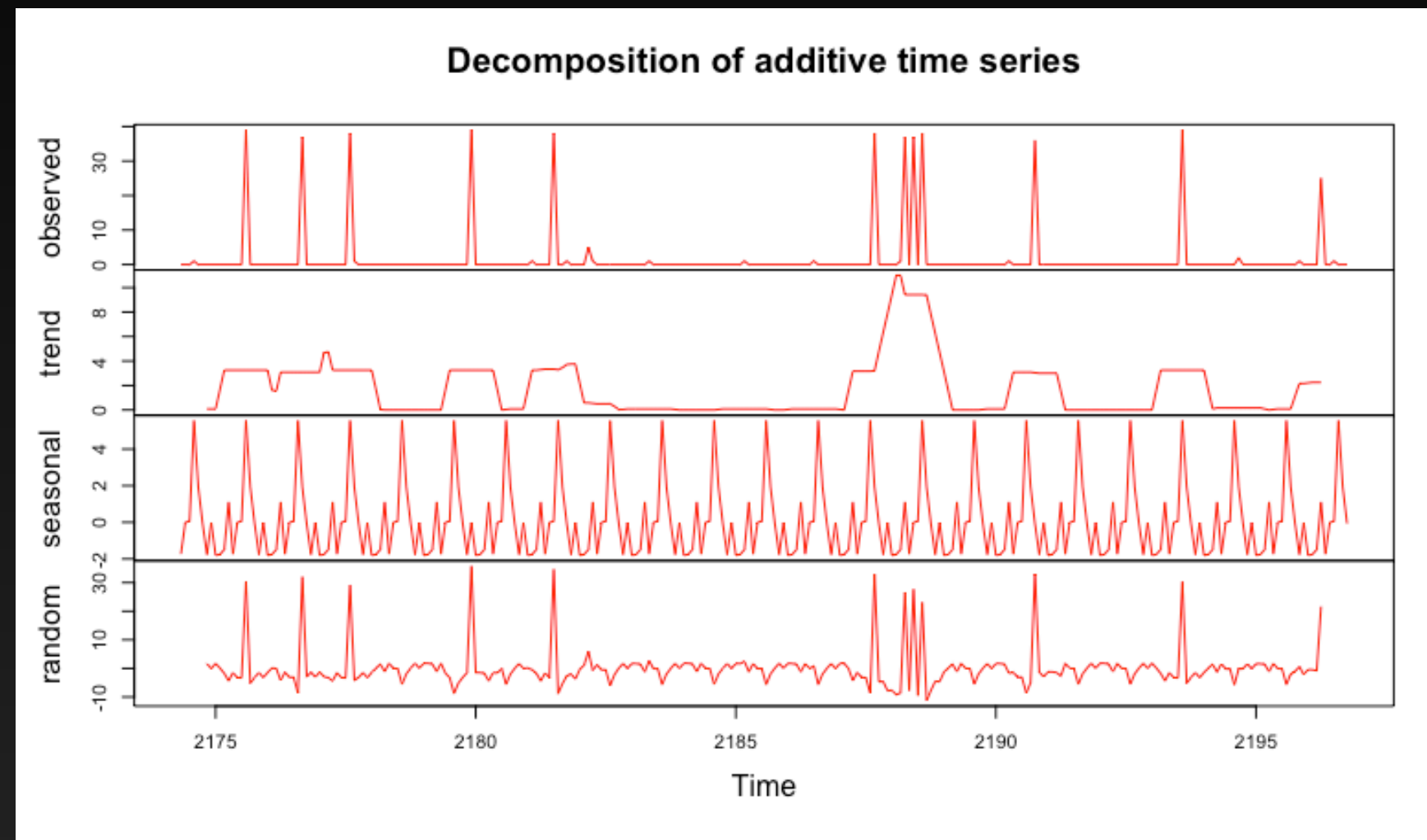
Sub 3 is weekly sampling of sub-meter 3

Power Consumption Forecasting by Sub-Meter



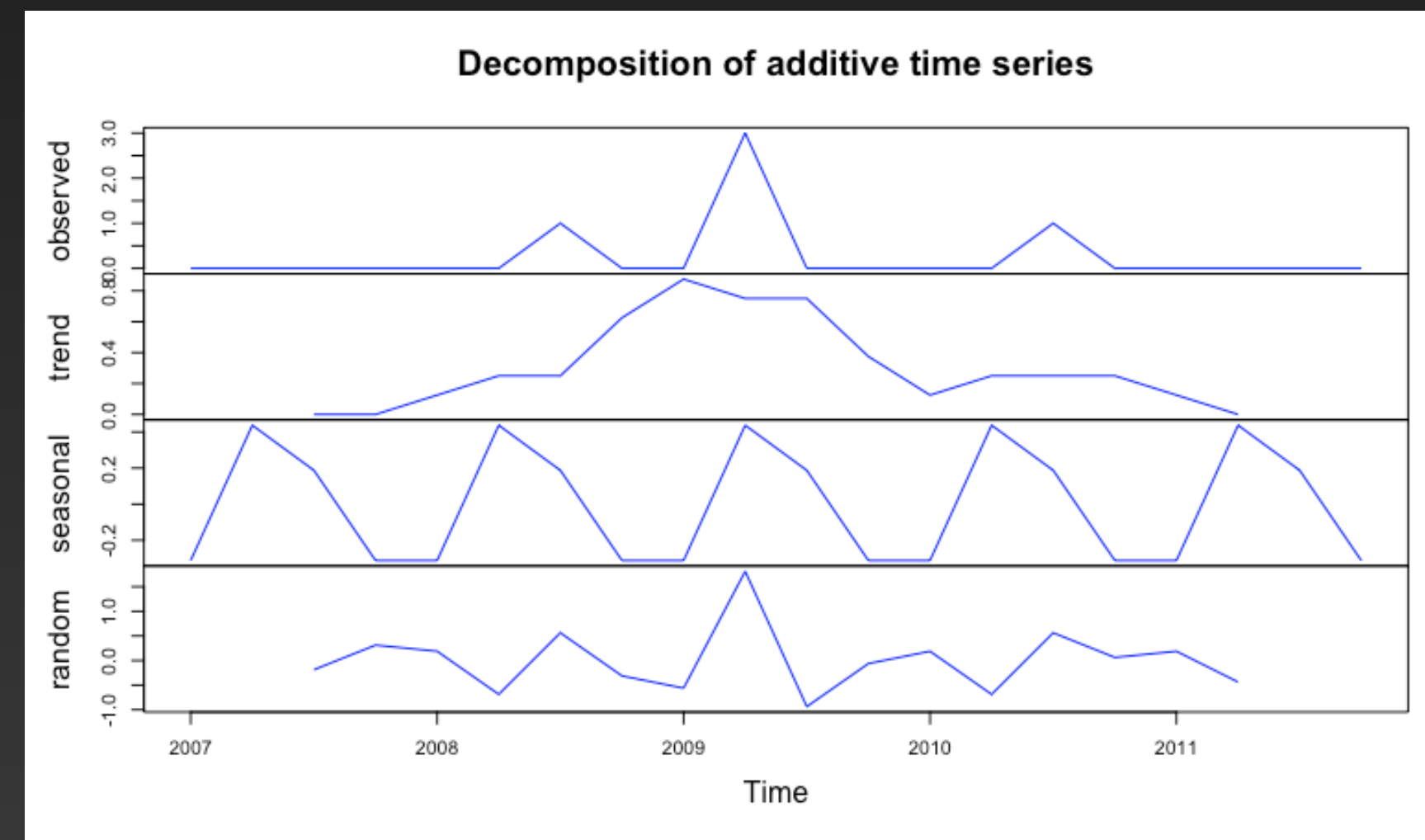
In these three plots, we see the see forecasted data plotted onto our data samples. The grey areas represent the zone within our confidence level, and the blue represents the forecasted data point. Sub-meter 1 was sampled monthly and appears to have a forecast exactly like the historical data. This indicates that the sample frequency here may be too small to provide an accurate forecast.

Seasonality by Sub-Meter

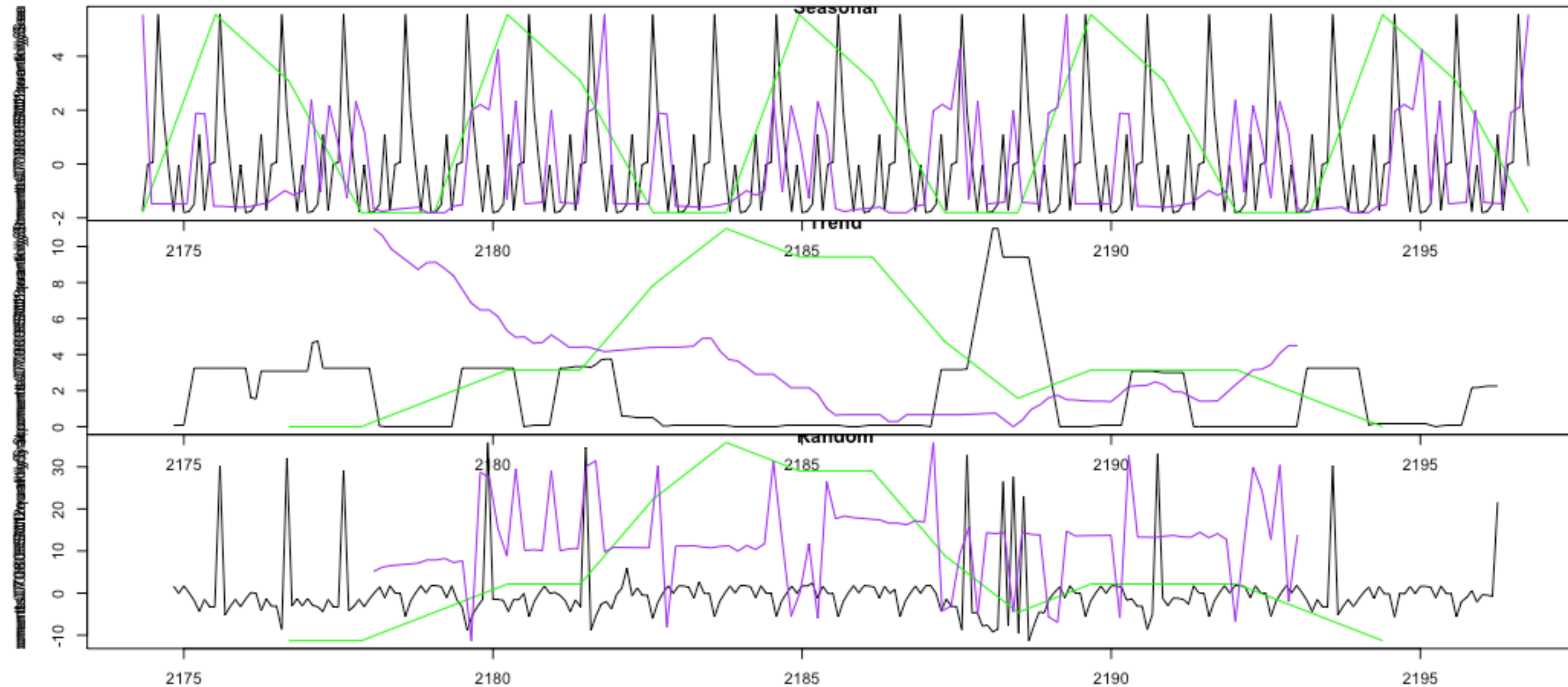


In these three plots, we see the seasonality for sub-meter 1 (red), sub-meter 2 (blue), and sub-meter 3 (purple).

It is clear that there are times of the year where much less power is being consumed in the kitchen (sub-meter 1). Additionally, we see peaks in the winter months for the water heater and AC (sub-meter 3).



Seasonality by Sub-Meter



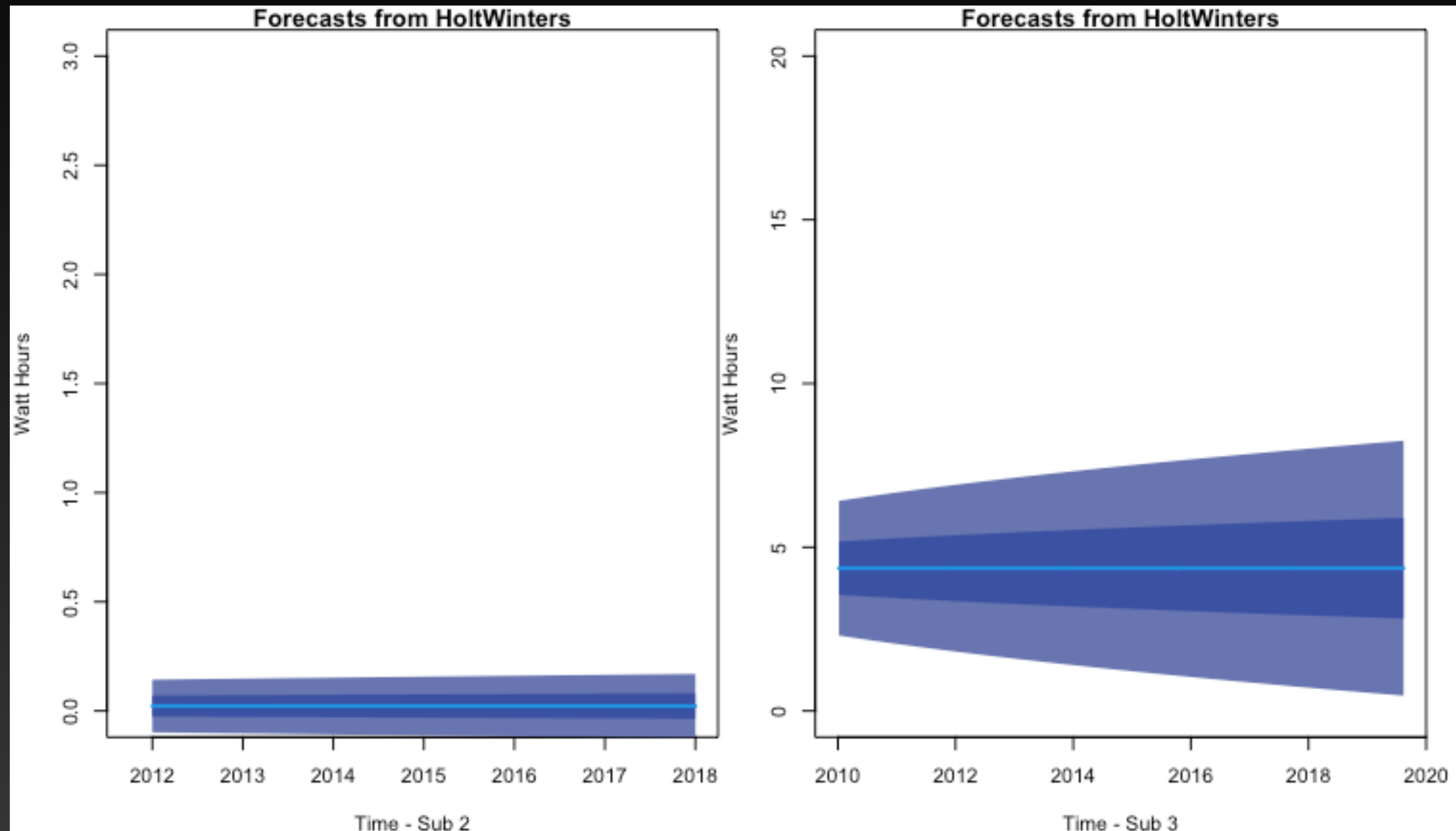
In these plots, the seasonality is compared between our three sub-meters at three different sampling frequencies.

Sub-meter 1: black

Sub-meter 2: green

Sub-meter 3: purple

HoltWinters Forecast



In these plots, we are forecasting the power consumption for sub-meters 2 and 3 over the next eight years beyond what the data provides.

Sub-meter 1 is not shown because there was not enough data points in the sampling to provide a forecast.

Relationships Observed

- In the day analysis, we can see that the water heater and AC are used nearly throughout the day. One would presume that for this day (January 1), the AC is running to heat the home while it is occupied.
- We can also observe a small spike in the power consumption in the laundry room every few hours throughout the day. This spike may be coming from a small appliance that is automated to kick on regularly, even though it is not in use.
- Additionally, the kitchen and laundry room appliances are often used at the same time. This brings the overall power consumption for a single home to high levels. When compounded across the entire building, this could mean the majority of the power is being used when energy costs are most expensive.
- It would be beneficial to know what major appliances the apartments are equipped with and the respective energy ratings of those appliances. This could help tie high usage in one area with outdated, inefficient appliances.

The background of the slide features a dark blue field with a network of glowing cyan lines and white circular nodes, resembling a digital or circuit board pattern.

Project Goals

With our analysis of the different sub-meters at three different frequencies, I believe that we have come to understand what is typical of power consumption.

We can see the pattern that the water heater and AC is used most during the end and beginning of the year (winter months).

Additionally, we can see that usage for the laundry room is often very low and goes unused much of the time.



Business Recommendations

1. Identify the cause of the small regular energy spikes in the laundry room. This appliance could be either turned off or replaced with another that doesn't regularly consume power.
2. During the year, the AC units are not used very much in the early autumn months. Consider using this window as an opportunity to replace outdated units and conduct routine maintenance to prepare for heavy usage during the winter months.
3. When in use, the laundry room consumes a large amount of power. This power consumption may be caused by only one machine. Consider identifying the machine and replacing it with an energy efficient solution.
4. In the sub-meter 2 sampling plot, we can see three distinct levels of power consumption that show up regularly. This indicates there may be three appliances being measured here and identifying one or more of the three would be beneficial. These appliances may be replaced with versions that only run when necessary or perform better and use less power.
5. Identify other appliances that use power even when not in use and ask residents to unplug those appliances when they are not home or when they are on vacation.

Lessons Learned

In the project, I learned how to load time series data and manipulate it into a usable format for analysis. This entailed using the “time series” function paired with other functions. Since the data was gathered over several years and we wanted to perform large analysis, I had to discard the data from incomplete years. I learned that not all the data is “good data” in that if it only shows a partial picture, it may skew our final results - providing harm rather than help.

Additionally, I discovered that working with time series data is difficult because there are so many seasonal variables. Many environmental changes occur that affect data from day to day, week to week, and so on. This makes it challenging to compare time periods without years of data.

Thank You

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