P3: Initial Data Exploration

Optimization of house appliances demand response to minimize electricity cost

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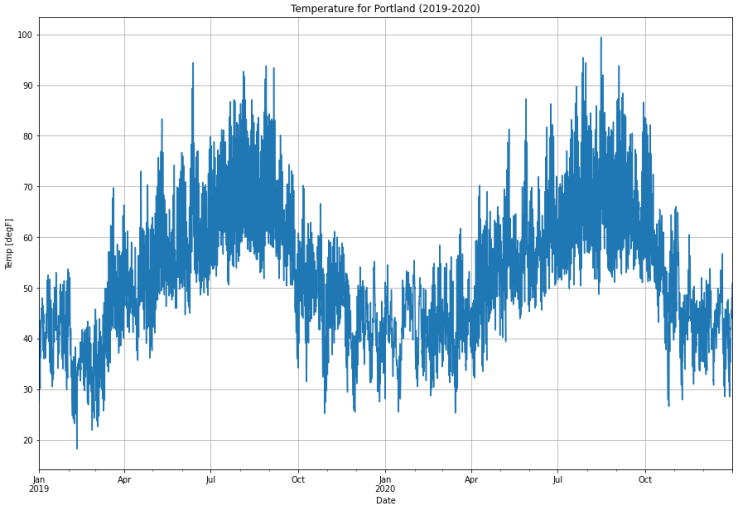
For the goal of optimizing demand control for a residential unit, specifically for heating/cooling, we need to understand the load profile for the different appliances used within the house. At first, we were able to get the average total load profile throughout the day for a residential address but we didn't know how to decompose the total load into a specific appliance load profile.

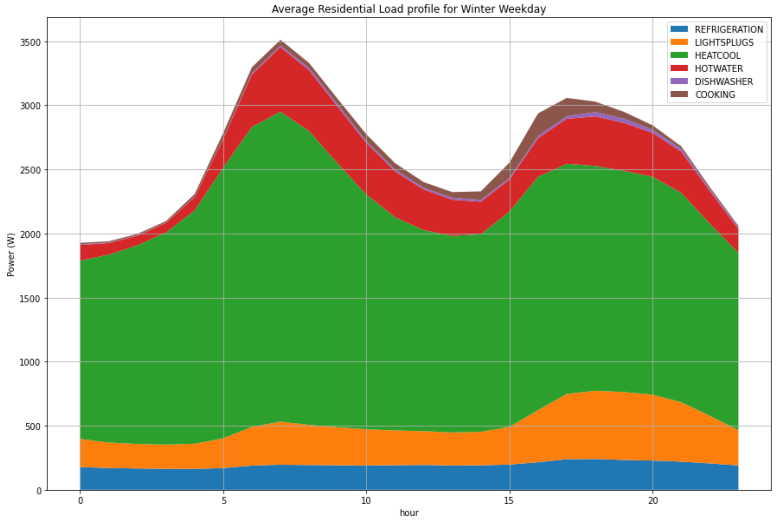
Our research advisor, David Chassin, who is working as a chief scientist for the Grid Integration Systems and Mobility Group at SLAC National Accelerator Laboratory (GISMo), was able to provide us with load profile data that was conducted at the Bonneville Power Administration (BPA) that represents the actual load profile for main appliances (Water heater, Refrigerator, Washer, Dishwasher, Cooking stove, Lightsplug, and Heat Pump) by different months of the year and the weekday/weekend day type. The data represents the aggregate demand for a collection of thousands of residential houses around the Portland area which was averaged per household. Attached next page is the initial analysis of the decomposed residential electrical loads and weather pattern data. We can see patterns corresponding to appliance use for different seasons because of the difference in comfortness requirements and energy consumption.

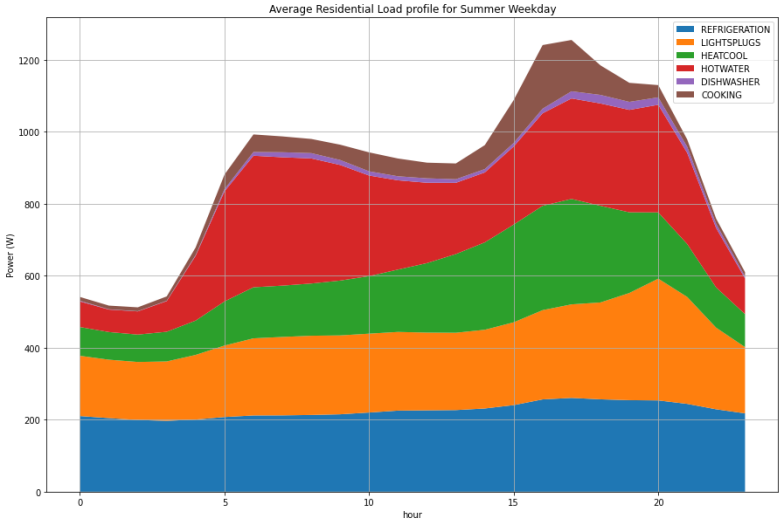
For our optimization problem, we are focusing to control the residential air heater/cooler system (which represents the majority of the total load profile). We can model the climate control demand at a given hour like thermal storage, the present hour's energy need is based on the previous hour's energy, current ambient weather temperature, and the house thermostat set point. We are still yet to figure out the mathematical relationship for this household thermal storage, but we do have some leads. Furthermore, we also needed to get the hourly ambient temperature from the weather data that could help us model the change in heating/cooling power requirement for the thermostat. After some digging, we were able to get hourly weather data taken from Portland International Airport that we assumed to be the temperature of the residential houses around the area.

The only remaining dataset still needed for our study is the time of use electricity prices around that area, which we believe we can get easily from the electricity supplier (Portland General Electric).

We assume that the houses have the same setpoint of 70 F, but different comfortness requirements. Such that, they could tolerate +/- (1-5 F) This could help relax the energy requirement constraint and induce more savings. Finally, one of the possible goals of our project is to shift the load to when the price of electricity is lower subject to the constraints. Because this optimization is for static load management, we still need to work on the online dynamic scenario with changing setpoints from customers.


Temperature for Portland (2019-2020)
Temp [degF]
Jan 2019
Apr
Jul
Oct
Jan 2020
Apr
Jul
Oct
Date


Average Residential Load profile for Winter Weekday
REFRIGERATION
LIGHTSPLUGS
HEATCOOL
HOTWATER
DISHWASHER
COOKING
Power (W)
hour


Average Residential Load profile for Summer Weekday
REFRIGERATION
LIGHTSPLUGS
HEATCOOL
HOTWATER
DISHWASHER
COOKING
Power (W)
hour