Earth, Wind, Fire

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Hypothesis

As Rhode Island residents, weather is a predominant factor that determines the comfort we experience within our homes and dorms. We sought to investigate the effect weather has on residential energy consumption. Specifically, we wanted to test the following hypothesis: months with the most cold/hots days are the ones with the highest residential natural gas consumption and residential electricity consumption in New England.

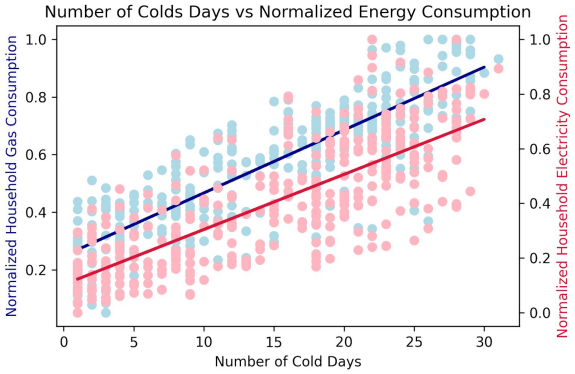
Data

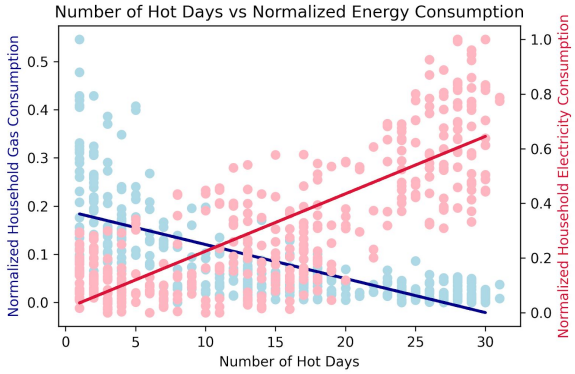
We downloaded daily min and max temperatures for the 6 states of New England from 2010-2019 from the United States National Centers for Environmental Information, and the monthly residential natural gas and electricity consumption from the United States Energy Information Administration. As our temperature data included min/max temp from multiple weather stations across each state, we decided to use the temperature readings from the station located in the largest city (population-wise) in every state. For each state, we aggregated the number of hot and cold days in a month. We defined a hot day as one with a maximum daily temperature above or at the 75th percentile and a cold day as one with a minimum daily temperature below or at the 25th percentile relative to its state in the 10 year period. Our data table had the following columns: year, month, state, season, hot_days, cold_days, gas_consumption, electricity_consumption.

Findings

Claim #1: There are strong correlations between the number of hot/cold days per month and monthly residential natural gas/electricity consumption.

Support for Claim #2: By observing the distribution of energy and electricity consumption, it became apparent that there were differences between states. This is most likely a result of different population sizes, which influences the number of households. In order to offset the discrepancies between states, we normalized each state's monthly natural gas/electricity consumption using Min-Max normalization. We then ran a simple regression on the normalized energy consumption data against the number of hot/cold days. We found that the 4 regressions were statistically significant and that there were strong correlations between all of them.





Independent	**Normalized Dependent**	**Pearson Coefficient**	**P-Value**
Cold Days	Gas Consumption	0.856	0.000
Cold Days	Electricity Consumption	0.776	0.000
Hot Days	Gas Consumption	-0.695	0.000
Hot Days	Electricity Consumption	0.790	0.000

Claim #2: The number of hot/cold days in a month influences the amount of residential natural gas and electricity consumed in a month in New England.

Support for Claim #2: We ran a multiple regression to see the effect cold/hot days have on electricity and natural gas consumption. Given the differences between consumption in different states and the fact that hot days and cold days cluster by season, we added dummy variables for each season and state. We also added interaction variables to consider the relationship between numbers of hot/cold days and seasons. All things being equal, an increase in the number of cold days in a month leads to an increase in gas and electricity consumption. An increase in hot days leads to an increase in electricity consumption but a decrease in gas consumption. Moreover, Electricity consumption is more responsive to a one unit increase in hot days than a one unit increase in cold days; whereas gas consumption is more responsive to a one unit increase in cold days than a one unit increase in hot days.

	Gas		**Electricity**	
	Coef	**P-Value**	**Coef**	**P-Value**
Cold Days	111.955	0.000	4.705	0.000
Hot Days	-45.646	0.013	6.282	0.000

Claim #3: The increase in one hot day or cold day in a month has a different impact on electricity consumption depending on what season it is in.

Support for Claim #3: With our interaction variables, we were able to see that electricity consumption is more responsive to a one unit increase in cold days during the winter than in the spring. Moreover, we saw that electricity consumption is more responsive to a one unit increase in hot days during the summer than in the spring. When analyzing gas consumption, however, our interaction variables weren't statistically significant, so we can't make such assertions.

	Gas		**Electricity**	
	Coef	**P-Value**	**Coef**	**P-Value**
Cold Days*Winter	30.406	0.348	2.991	0.018
Cold Days*Spring	42.155	0.140	2.719	0.015
Cold Days*Fall	39.394	0.368	-1.006	0.556
Hot Days*Summer	23.665	0.453	10.183	0.000
Hot Days*Spring	-26.207	0.527	-5.850	0.000
Hot Days*Fall	-43.104	0.180	1.950	0.120