Electricity Markets, Electric Vehicle Charging, and Demand-Side Management.

By:

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1) Plots to Summarize the Relevant Data

(a)

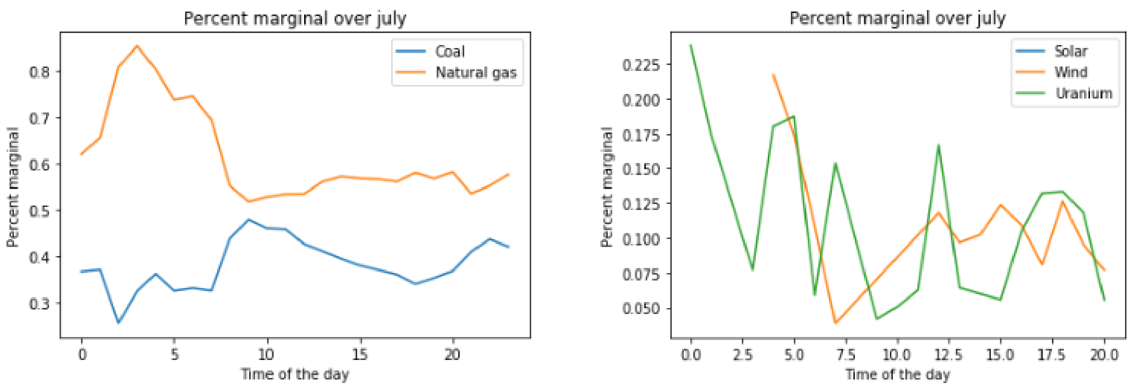

Figure 1: Percent Marginal over July, (a): Coal, Natural Gas, (b) Solar, Wind, Uranium

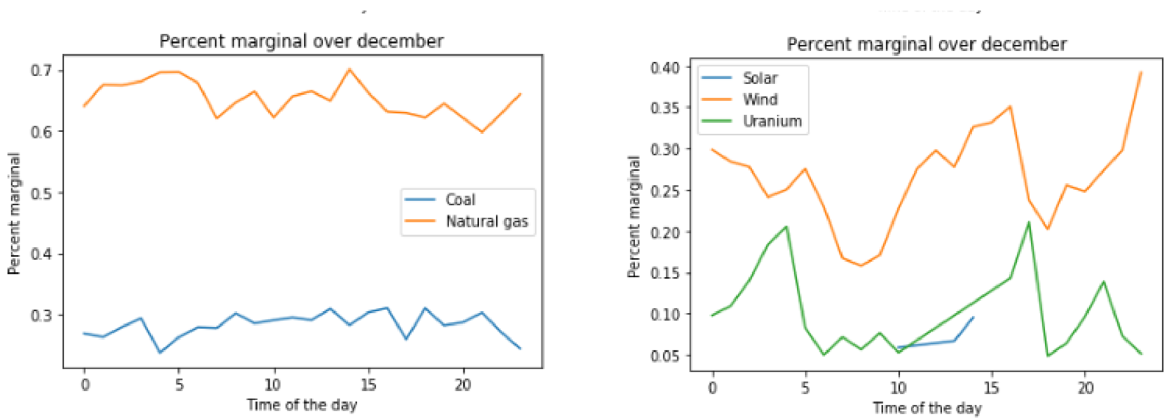

Figure 2: Percent Marginal over December, (a): Coal, Natural Gas, (b) Solar, Wind, Uranium

(b)

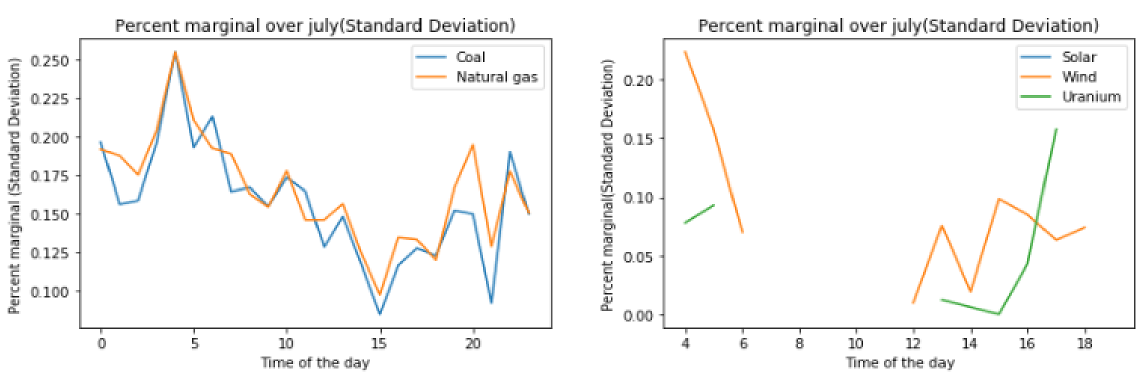

Figure 3: Standard Deviation of Percent Marginal over July, (a): Coal, Natural Gas, (b) Solar, Wind, Uranium

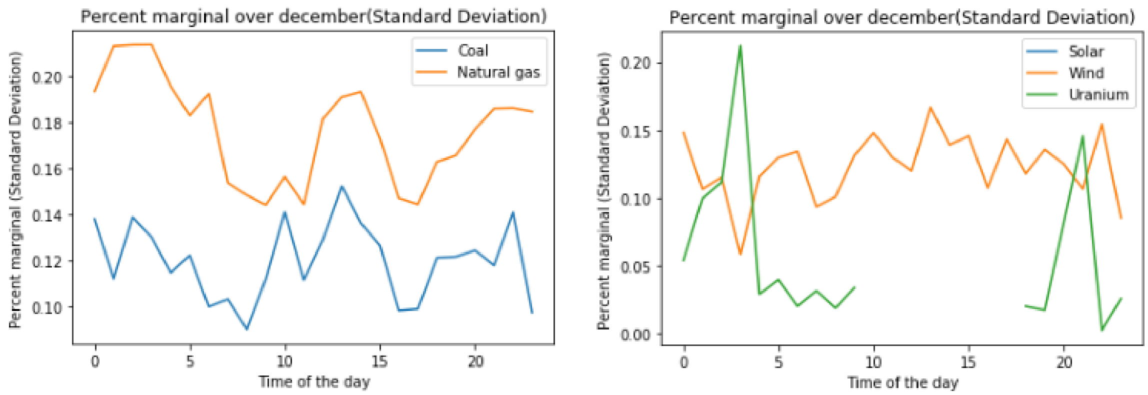

Figure 4: Standard Deviation of Percent Marginal over December, (a): Coal, Natural Gas, (b) Solar, Wind, Uranium

2)

On an average, Natural Gas releases 0.6-2 pounds CO2E/kWh (Carbon-di-oxide equivalent per kilowatt-hour), Coal releases 1.4-3.6 pounds CO2E/kWh, whereas renewable sources of energy such as Wind releases only 0.02-0.04 pounds of CO2E/kWh (Union of Concerned Scientists, 2008). Similarly, Uranium is also a low carbon emission fuel (Lenzen, 2015). Based on this, in order to lower the CO_2 emissions, the marginal fuel to be used is ideally a renewable source of energy, and thus, the DEP should incentivize charging when the Percent marginal for Renewable fuels is high.

Assuming incentivizing is a continuous process (year-round and not specific to a particular period),

a. **July:**
For the renewable energy sources, Figure 1(b) does not indicate a specific trend or period wherein the percent marginal for either of the renewable source is higher. Moving to the renewable sources of energy in Figure 1(a), from roughly 02:00-05:00, the percent marginal for Natural gas is higher and that of coal is much lower. As Natural gas has a lower carbon emission than Coal, it is better to incentivize EV charging during this period as it would ensure using the less-carbon emitting fuel as the marginal fuel.
From graphs 3(a)(b), the standard deviation for natural gas and coal has a fluctuating behavior whereas it shows significant decrease for wind during the period of 00:00-05:00, whereas that of uranium remains to be almost constant.
Thus, a good time to incentivize during July is **02:00-05:00**.

b. **December:**
Considering Figure 2(b), for the period of 22:00-00:00, the percent marginal is on a rise and reaches the peak around 00:00. It would ensure that the wind can be used as a marginal fuel during this period to allocate the additional load due to EV charging. Also, by Figure 2(a), we can see that the percent marginal remains almost constant for Natural Gas and Coal over the entire day, and thus, they would not work as a major decision factor in choosing the time to incentivize the EV charging. Also, from Figure 4(b), the standard deviation in the renewable percent margin drops during the period of 22:00-00:00.
Based on these factors, a good time to incentivize during December is **22:00-00:00.**

If it is further to be chosen between either December or July, then December would serve as a better time frame. However, as charging of EV is an all year round process, the incentives should be kept on an all year round basis.

3)

In order to incentivize charging, DEP should implements certain steps which would encourage the consumers to use EVs over conventional vehicles. Few possible steps can be:

i) The per-unit cost for charging EVs can be subsidized in comparison to using other appliances. The consumers can apply for the subsidy, wherein, for the particular time of the day, rates for using electricity is lower than on all other times.
ii) DEP can provide subsidies on installing EV Charging stations, either per household or for a community as a whole, encouraging the consumers to use this mode of transport, which proves to be cheaper in the long run, and also environmentally beneficial.
iii) Financial incentives such as rebates or tax credits can be implemented for the use of Electric Vehicles and Charging Stations, which could promote the further use of Electric vehicles.
iv) DEP can implement a program similar to the Workplace Charging Challenge (US Department of Energy, 2016), which would be to partner with Major Corporations to encourage and educate their employees on using EVs and giving them monetary incentives for using EVs and charging stations.

4)

The two policy options for PJM to reduce the load through demand-side management (DSM) are discussed as follows:

a. Dynamic/Real Time Pricing

This tool involves changing the price of using electricity from time to time (per hour basis) based on the supply and demand demographics. This implies that when the demand for electricity is higher, the price will be higher and when the demand is relatively lower, the price will be relatively lower

b. Time-of-Use Rates

Using this tool, the consumers are offered different rates for different times of the day, the price which is fixed on analyzing the past trends, wherein the usage of electricity would correlate to the price of electricity.

Comparing the two DSM tools:

Policy	Benefits	Uncertainty & Costs
Dynamic/Real Time Pricing	1. Consumers are not charged uniformly, but rather benefit by using appliances at unconventional times 2. Based on the past trends, consumers can decide	1. As the price fluctuates, the amount consumer pays for using electricity is not constant and varies based on real-time data 2. Consumers cannot be sure of paying a fixed amount for electricity and thus,

	the optimal time of operation	are at a risk of overspending
Time of Use-Rates	1. Consumers are aware of the price they pay for using certain units of electricity 2. Consumers can schedule the use of certain types of appliances at unconventional time based on lower price	1. As the pricing is fixed and based on past trends, it is immune to changing consumer behavior 2. As all the budget would be done using the fixed rate, any untimely changes in usage might lead to losses for the PJM

Based on the two DSM tools, the two corresponding policies can be put forth. However, I would advocate using the Dynamic/Real Time Pricing Strategy for reducing the load. As the Dynamic Pricing strategy is used, the DEP and PJM can fix their prices as per the demand and supply, enabling them to have a flexible framework. Based on the Figures 1 and 2, it can be inferred that the percent marginal is not constant over the day and has fluctuations based on the fuel type as well. For instance, when the percent marginal of renewable energy is high (i.e. Uranium, wind, solar), the price can be lowered, whereas, where the percent marginal of coal is high and those of other energy sources is low, then the price can be made a bit higher.

The flexibility in this approach overpowers its uncertainties, as the prices for this model can be fixed on the extensive amount of user data which is available. Moreover, if there is a sudden shift in consumer behavior, the price model can thus be tweaked to make it more inclusive.

Bibliography

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