Understanding the Role of Electric Power Outages on the Adoption of Solar and Storage Technologies

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INTRODUCTION

Solar adoption plays a key role in questions of clean energy, carbon goals, and load/grid defection [1]. Home solar installations are increasing, in part due to declining technological costs, increasing climate awareness, and political support. One economic incentive is Net Energy Metering (NEM), which allows consumers producing electricity to mitigate costs by storing excess electricity on the grid [2]. As wildfires increase in frequency and effect, so do electric power outages, making power uncertainty an additional incentive for solar adoption.

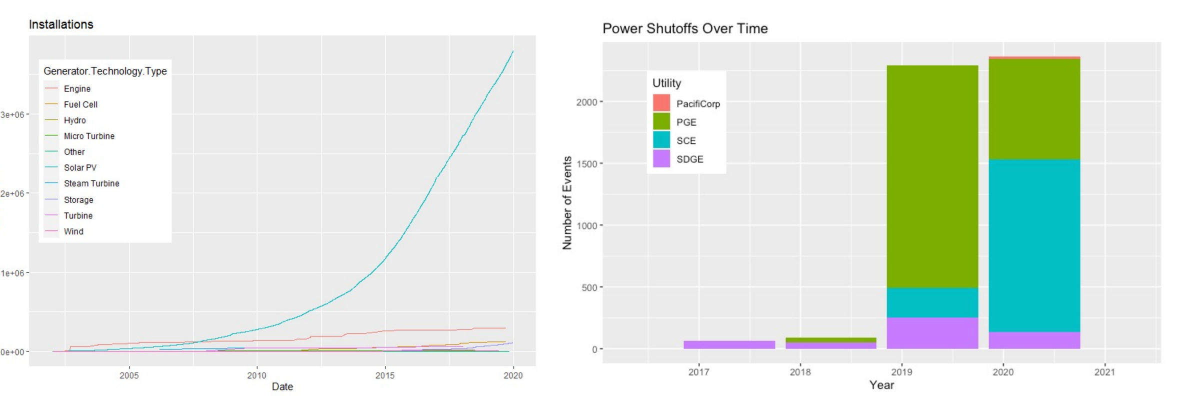

Figure 1: (a) Home solar installations in California are increasing. (b) Power shutoff frequency is increasing in California.

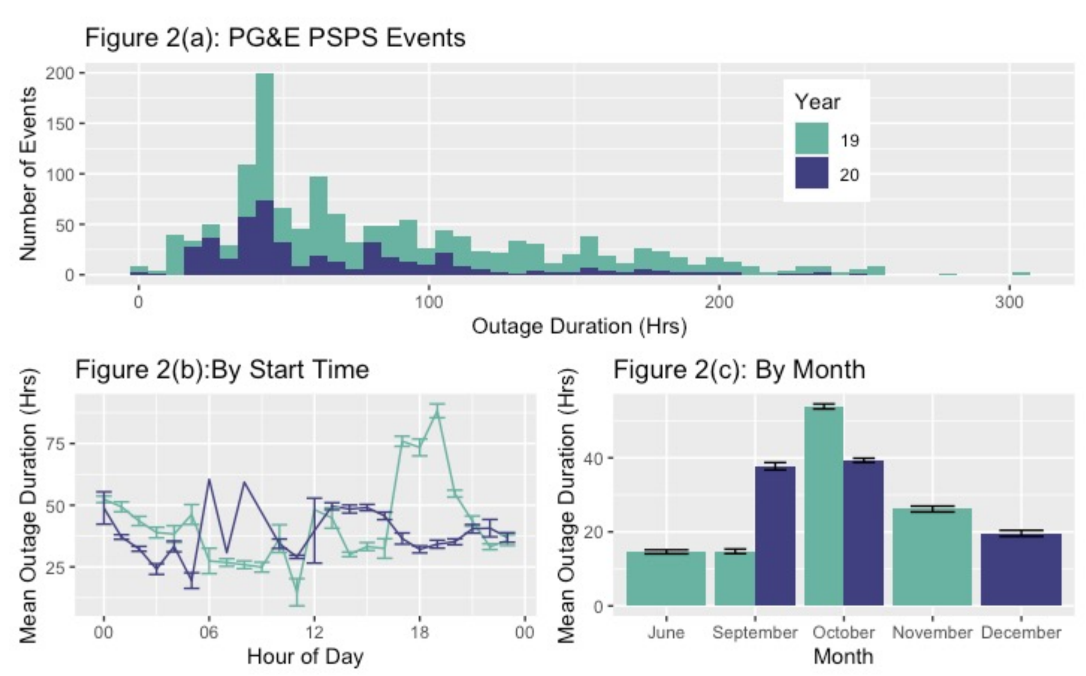

Figure 2: Comparison of PG&E power shutoff events in 2019 and 2020. Interestingly, PG&E PSPS event duration and frequency are decreasing.

Access to California data on NEM installations and 2019 PG&E Public Safety Power Shutoff (PSPS) events guided our investigation.

OBJECTIVE

Our goal is to visually and computationally identify trends in NEM installations that may have been influenced by 2019-2020 PG&E PSPS events while also developing and standardizing procedures for address parsing and geocoding.

CHALLENGES

Developing a coding framework for unwieldy datasets that is reliable, timely, and flexible with regards to geocoding APIs and human error in address recording.

THEORY

Ultimately, we employ a difference-in-differences approach to answer the question, "How did 2019 PSPS events affect home solar installation?" The 2019 PSPS events provide a natural experiment, with the exogenous event being the power shutoffs. Because the shutoffs occurred close together at the end of 2019, we treat them as one event separating solar installation in 2019 and 2020. The control group contains all installations in feeders unaffected by PSPS events. The treatment group contains all installations in feeders that experienced at least one PSPS event. The parallel trends assumption holds if solar installation would have grown similarly in all feeders in the absence of PSPS events. Then

$$y_{fm} = \beta_0 + \delta_0 d2020_f + \beta_1 dT_f + \delta_1 dT_f \cdot d2020_f \qquad [3]$$

with $\begin{cases} y_{fm} = monthly\ capacity\ installed\ in\ a\ feeder\ (kW) \\ d2020_f = \ 2020\ time\ period\ (dummy) \\ dT_f = feeder\ affected\ by\ outage\ (dummy) \end{cases}$ and $\begin{cases} \delta_0 = changes\ in\ all\ feeders\ from\ 2019\ to\ 2020 \\ \delta_1 = change\ in\ capacity\ installed\ due\ to\ PSPS\ events \\ \beta_0 = average\ capacity\ installed\ in\ control\ group\ in\ 2019 \\ \beta_1 = effects\ not\ due\ to\ PSPS\ events \end{cases}$

METHODS

Initially, we write "points-in-layer" code to identify which home solar installations occurred in feeders affected by PSPS events and which did not. For geospatial analysis, street addresses are geocoded. Standardizing the addresses reduces address documentation errors and improves geocoding. Along the way, code is formatted into functions with clear descriptions and steps.

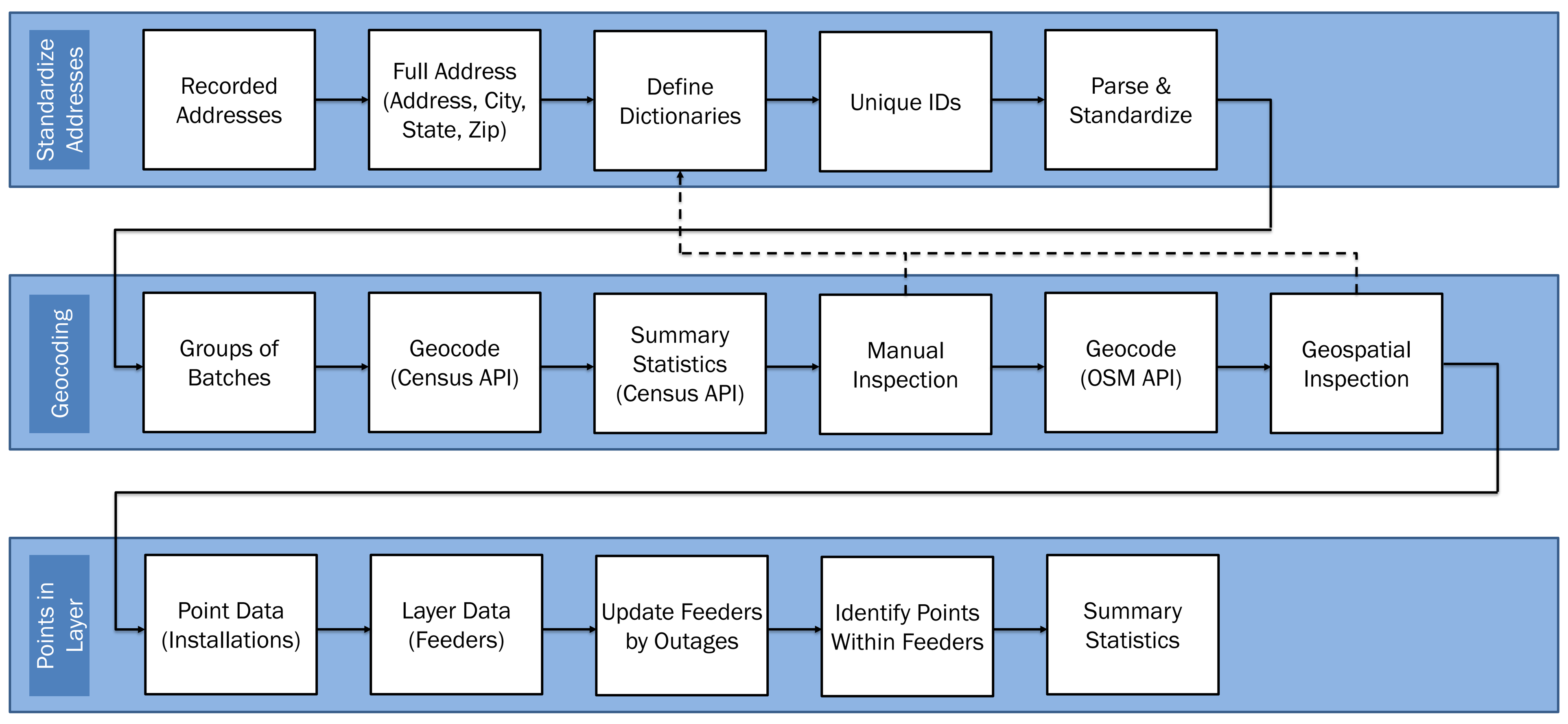

Figure 3: Flowchart of the procedure we established, displaying key steps and outputs. Code for this procedure can be found on GitHub at https://github.com/SRKadam1/SPUR_Sp21_PSPS.

FIRST RESULTS

Statistic	Success	Total
Parsing (Addresses)	473,030	491,768
Geocoded (Addresses)	454,292	473,030
In California (Addresses)	470,627	473,030
Point-in-Layer (Addresses)	458,954	473,030
Parallelization (hours)	~ 4	~ 17

Table 2: Key summary statistics for the established procedure. Generation types include Solar PV (98.1%), Storage (1.7%), and Fuel Cell (<0.1%). Year composition includes 2019 (14.2%), 2018 (13.0%), and 2017 (11.9%).

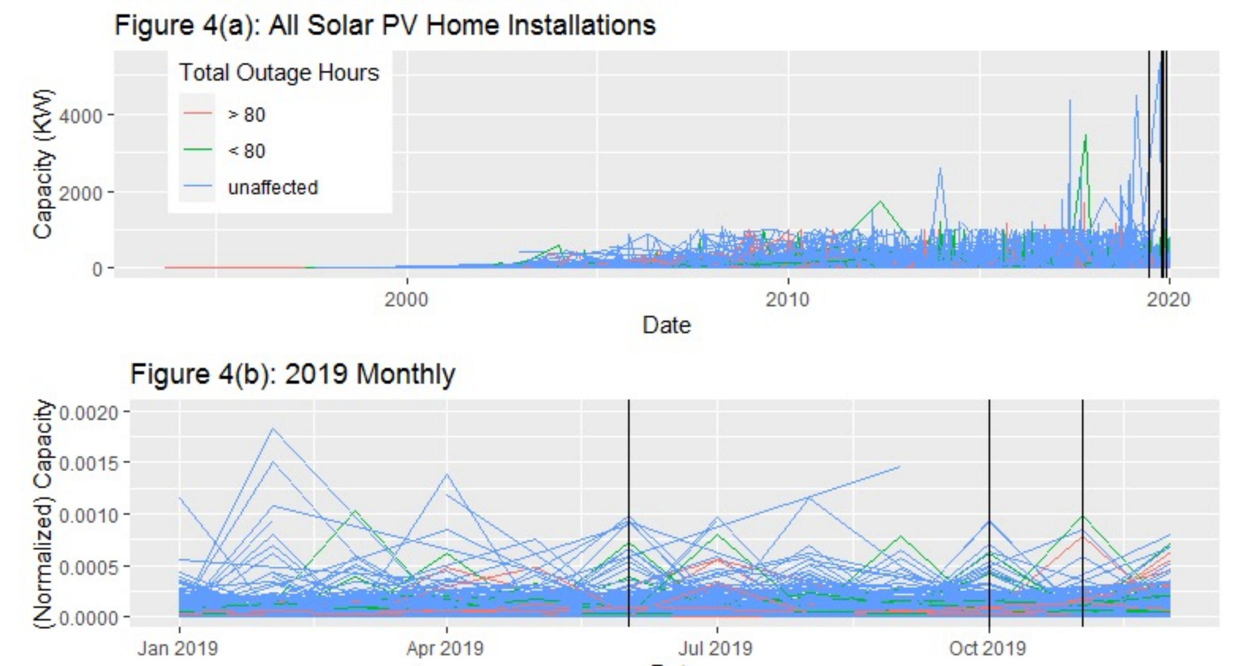

Figure 4: (a) Solar PV installations over time (not cumulative). (b) 2019 installations by month (normalized to 2017-2018 total installation). Black, vertical lines indicate outage events (1 in June, 8 in October, 1 in November).

IMPROVEMENTS

- PG&E provides geographic regions for feeders affected by PSPS events. For unaffected feeders, we assume a uniform 0.5 mile buffer. Improving buffer estimates for unaffected feeders will refine point-in-layer and difference-in-difference analysis.
- Point data (e.g. home solar installations) can be large and slow to computationally analyze. Parallelization can greatly improve this process, reducing wait time and stimulating the research process.
- The number of street addresses geocoded each time varies. The variation is small relative to the dataset size but is important to fix. Furthermore, some of the geocoded addresses are outside California, which is incorrect.
- Fine-tuning the address parsing code by providing dataset-specific dictionaries of street labels and house suffixes will increase the number of addresses geocoded.

CONCLUSIONS

- There is not a noticeable divergence in cumulative installed solar capacity between affected and unaffected feeders. This paves the way for a difference-in-difference analysis.

FUTURE WORK

Future work should aim to obtain 2020 PSPS geographies and home installations in order to implement a difference-in-difference regression analysis. The effect of experiencing multiple power outages on solar installation should be considered, as well as whether socioeconomic status and geography account for differences between feeders. This framework could then be applied to other generation types and power utilities in California.

REFERENCES

[1] Gorman, W., Jarvis, S., and Callaway, D. (2020). Should I Stay Or Should I Go? The importance of electricity rate design for household defection from the power grid. Applied Energy, 262.

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[3] Wooldridge, J. (2020). Introductory Econometrics, 432.

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