SYNTHETIC SMART METER DATASET
A DELIVERABLE OF THE ENERGY DATA VAULT (EDV) PROJECT
LBNL, SFDOE, NREL

SEPTEMBER 2022

1. Introduction

LBNL, NREL, and San Francisco Department of Environment are partnering with the support of US DOE on the EDV (Energy Data Vault) project. The FY22 project purpose is to develop and test energy modelling methods that will improve San Francisco's understanding of the effect of many buildings nearby one another undergoing electrification and installing DERs. When many buildings are electrified, what are the implications for building energy use, greenhouse gas emissions, and grid infrastructure? San Francisco's 2021 Climate Action Plan proposes existing building electrification as a key strategy for reducing carbon emissions.

A case study is being conducted, applying the EDV workflow and generated synthetic smart meter dataset in lieu of measured data in order to analyze implications of local government policies to facilitate or require electrification of a district of buildings in San Francisco. Analysis of the district load profile will include implications for peak and seasonal demand at the district (or grid line-segment) level. This analysis will offer insight into fundamental questions, such as:

- Implications of commercial electrification for local grid reliability and potential DER deployment. *E.g. What is the relative impact of district-level commercial electrification?*
- Implications for peak demand, seasonal demand, and district-level load profile of electrification relying on equipment and measures corresponding to applicable local energy standards. *E.g. Can Energy Code combined with electrification yield a similar outcome to compliance with a Building Performance Standard?*

We utilize an advanced energy modeling framework to analyze implications of energy retrofits. Key questions for analysis include:

- What are practical options for high-efficiency electrification of individual commercial buildings?
- Can impact on the grid be minimized? Specifically, can groups of commercial buildings served by the same line or feeder be electrified within the capacity of existing equipment?
- Can energy efficient retrofits reduce the loads in buildings and neighborhoods so that electrification would not require infrastructure upgrades?

To address these questions, the project team will perform performance simulation for buildings in two districts of San Francisco. We will evaluate whether the PG&E grid serving the districts is capable of accepting the new load from electrification.

2. Content of the Deliverable

This deliverable of synthetic smart meter dataset includes three components:

1) This memo describing the dataset and how it is created

2) Tables (xls files) of characteristics of the buildings in the two districts, including monthly energy use data
3) Electricity and gas use profiles (10-minute interval), including the whole building and individual end uses, in csv files for the calibrated baseline building models. The csv files are named with Building IDs listed in the buildings table.

3. Technical Approach

3.1 Selection of the Two Districts of Buildings

Two districts of buildings were selected for the electrification case study and generation of the synthetic smart meter datasets based on the considerations of:

- A business district with mostly commercial buildings
- Data from PG&E's Integration Capacity Analysis Map of the Distribution Resource Planning Data Portal on available line or feeder capacity for determining the present-day load and rated capacity of lines or a feeder serving a business district
- Available monthly building energy use data

The building characteristics of the district buildings were saved in two GeoJSON files for modeling use.

The first district is located in the Fisherman's Wharf of San Francisco. It consists of 29 buildings, which are mostly hotels and retail stores. The second district is located in the Design District of San Francisco, which features quite a few furniture showrooms and stores. There are 25 buildings in total in the selected region. Figures below show the 3D buildings visualized in CityBES. Detailed information of each building can be found in the spreadsheet "Buildings and Measures.xlsx"

Figure 1. Buildings in the Fisherman's Wharf neighborhood

Figure 2. Buildings in the Design District neighborhood

3.2 Baseline Model Development

The EDV workflow was used to generate the baseline building models (OSM files) by reading the building characteristics in CSV format. The inputs for each building include the building type, building height, number of floors, building footprint area and year of construction. The OpenStudio models were generated based on the prototype models with OpenStudio-Standards library. The audit report for some of the buildings are available through San Francisco's Existing Buildings Ordinance, which contains some HVAC information of the building. The information of the actual HVAC system type is incorporated to modify the baseline model.

One current limitation of the model is that mixed-use buildings cannot be directly simulated. Therefore, for buildings described as mixed-use of multiple building types without a major type (e.g. half restaurant and half retail) in the audit report, baseline model of each type was generated. After simulation, whichever model has the closest energy consumption to the measured data will be considered as the best approximation of this building.

3.3 Baseline Model Calibration

For buildings with available monthly energy use data, their baseline models were automatically calibrated using the monthly energy use data in 2019 and the pattern-based calibration algorithm (Sun et al 2016, Sun et al. 2022). The building characteristics to be calibrated include occupancy ratio, window properties, cooling/heating setpoints, cooling COP, infiltration rate, etc. Two metrics, Coefficient of Variation of Root-Mean Squared Error (CVRMSE) and Normalized Mean Bias Error (NMBE) are used to evaluate the calibration results. Evaluated by the monthly source energy, 10 and 7 buildings in the two neighborhoods respectively can be calibrated successfully.

Table 1. Summary of calibration results for buildings in the two districts

	Design District	Fisherman's Wharf District
Total # of buildings	25	29
# of buildings with monthly energy data	17	20
# of buildings covered by the calibration algorithm	15	10
# of buildings calibrated successfully by loose criterion	10	7

It's worth noting that the monthly energy data for some of the buildings doesn't have a reasonable pattern, which made the calibration impossible. See Figure 3 for examples, where building 1 has an increasing energy use throughout the year and building 2 has no natural gas consumption during the second half of the year. This might be due to the occupancy change or the meter error.

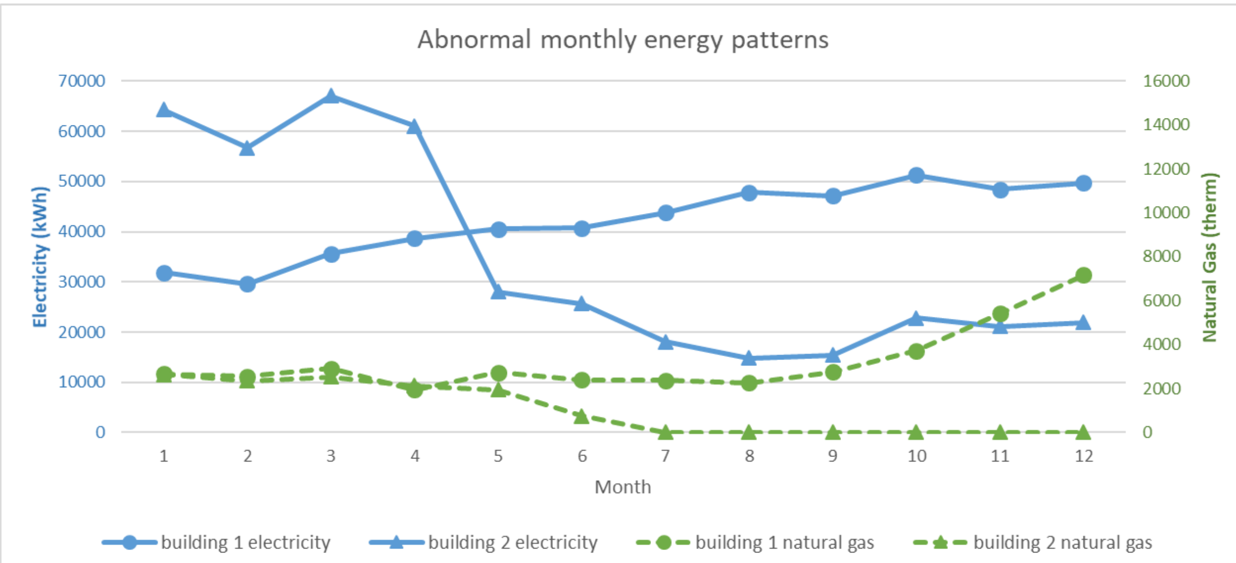

Figure 3. Example buildings with abnormal monthly energy use patterns

4. Results: Simulated Annual 10-minute Load Profiles

The calibrated baseline building models were run with EnergyPlus version 9.6 to produce the annual 10-minute electricity and natural gas load profiles for the whole-building and individual end uses. These load profiles are saved in CSV files with one CSV file for load profiles of each of the studied buildings.

In addition to the load profiles of the baseline building models, the dataset includes load profiles of the three scenarios, Electrification Package, Energy Efficiency Package, and the combined Electrification + Energy Efficiency Package, for each of the buildings in the two districts.

The dataset (total file size about 2GB before compression) is posted open-source at NETL's Energy Data eXchange (Hong et al. 2022) in October 2022.

5. Disclaimer

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