

Community Solar Project

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What is Project Sunroof?

- ▶ Google mapped the roofs of building on Maps
- ▶ Assesses potential solar power generation
 - ▶ Accounts for weather
 - ▶ 3D modeling of Building to place solar panels
- ▶ Organized by Census Tract

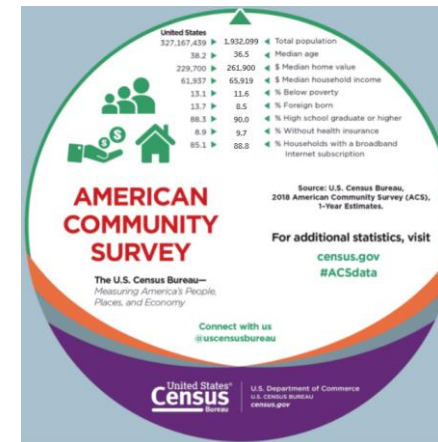


Original Data Questions

- ▶ What cities or metro areas would large scale adoption of solar roofs make the most impact?
 - ▶ High Solar Potential and High Savings
- ▶ Where has there been success (high volume of installs) and what best describes each location?
 - ▶ Income, Solar Potential, Cost Savings

What data is required?

- ▶ Energy Cost
 - ▶ US Energy Information Administration Annual Report 2019
 - ▶ Energy Sales, Megawatts and customer counts by provider
 - ▶ Used API from OpenEI.org to locate power providers by location
 - ▶ Census Metro/Micropolitan areas for Lat/Long points
- ▶ American Community Survey 2018 by US Census
 - ▶ Various Census data organized by Census Tract
 - ▶ Concentrated on Housing and Population

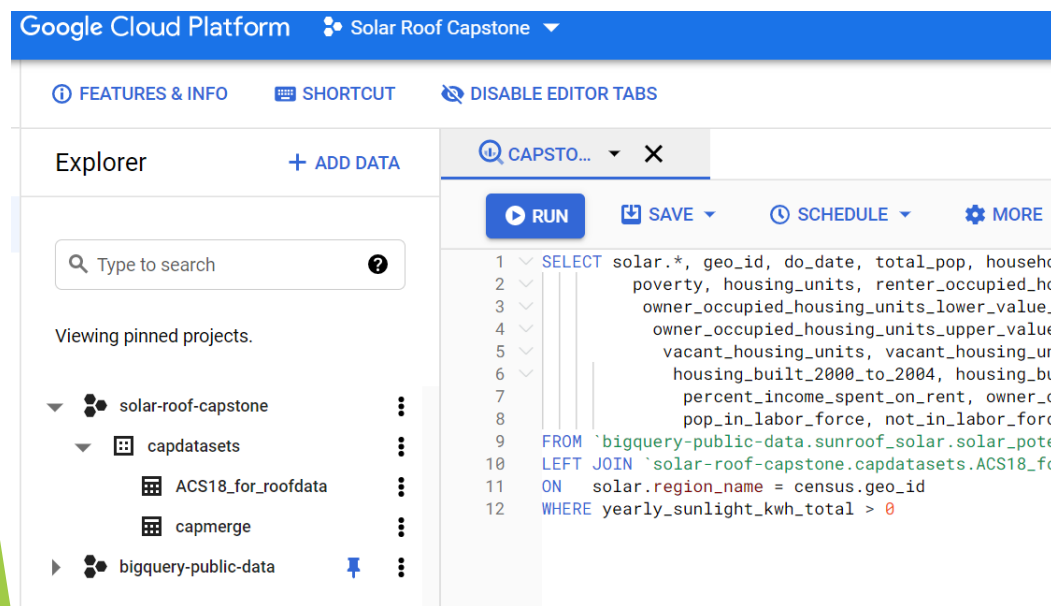


Google BigQuery Public Data



Google
BigQuery

- ▶ Both Project Sunroof and ACS 2018 available
- ▶ Used SQL to join data in the cloud
- ▶ Python to geo join Energy Cost and package for Tableau
 - ▶ Buckets of install sizes saved as JSON in dataframe



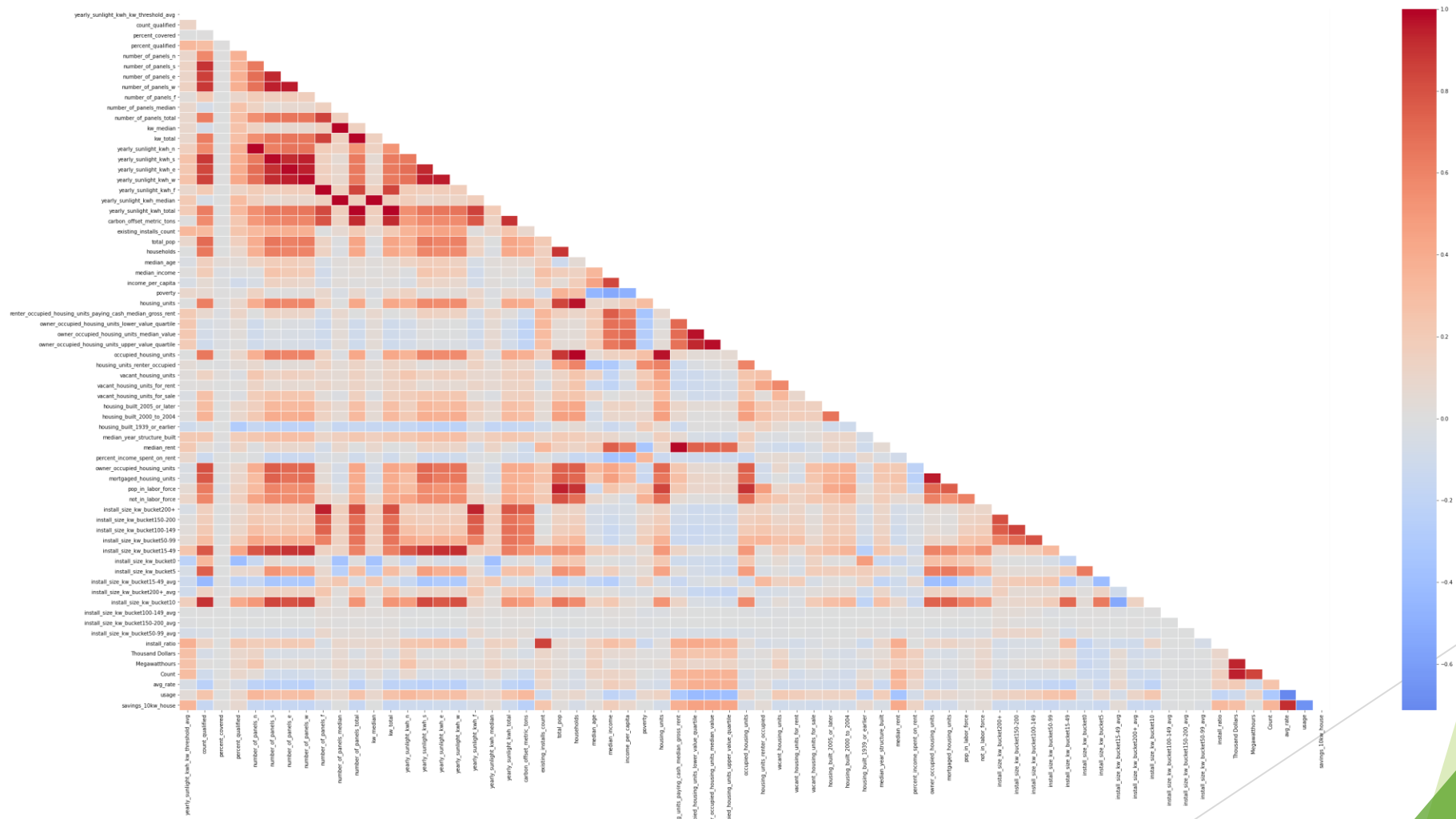
```
In [1]: 1 from google.cloud import bigquery
        2 from google.oauth2 import service_account
        3 import pandas as pd
        4 import ast

In [2]: 1 credentials = service_account.Credentials.from_service_account_file(
        2         'C:/Users/pfbab/NSS/googlekey/solar-roof-capstone-787ff1e58b5f.json',
        3         )
        4 client = bigquery.Client(credentials=credentials)

In [3]: 1 query = """SELECT solar.*, geo_id, do_date, total_pop, households, median_age, median_income, income_per_capita,
        2         poverty, housing_units, renter_occupied_housing_units_paying_cash_median_gross_rent,
        3         owner_occupied_housing_units_lower_value_quartile, owner_occupied_housing_units_median_value,
        4         owner_occupied_housing_units_upper_value_quartile, occupied_housing_units, housing_units_renter_occupied,
        5         vacant_housing_units, vacant_housing_units_for_rent, vacant_housing_units_for_sale, housing_built_2005_or_later,
        6         housing_built_2000_to_2004, housing_built_1939_or_earlier, median_year_structure_built, median_rent,
        7         percent_income_spent_on_rent, owner_occupied_housing_units, mortgaged_housing_units,
        8         pop_in_labor_force, not_in_labor_force
        9 FROM `bigquery-public-data.sunroof_solar.solar_potential_by_censustract` AS solar
       10 LEFT JOIN `solar-roof-capstone.capdatasets.ACS18_for_roofdata` AS census
       11 ON solar.region_name = census.geo_id
       12 WHERE yearly_sunlight_kwh_total > 0"""

In [4]: 1 query_job = client.query(query)
```

How does it correlate?

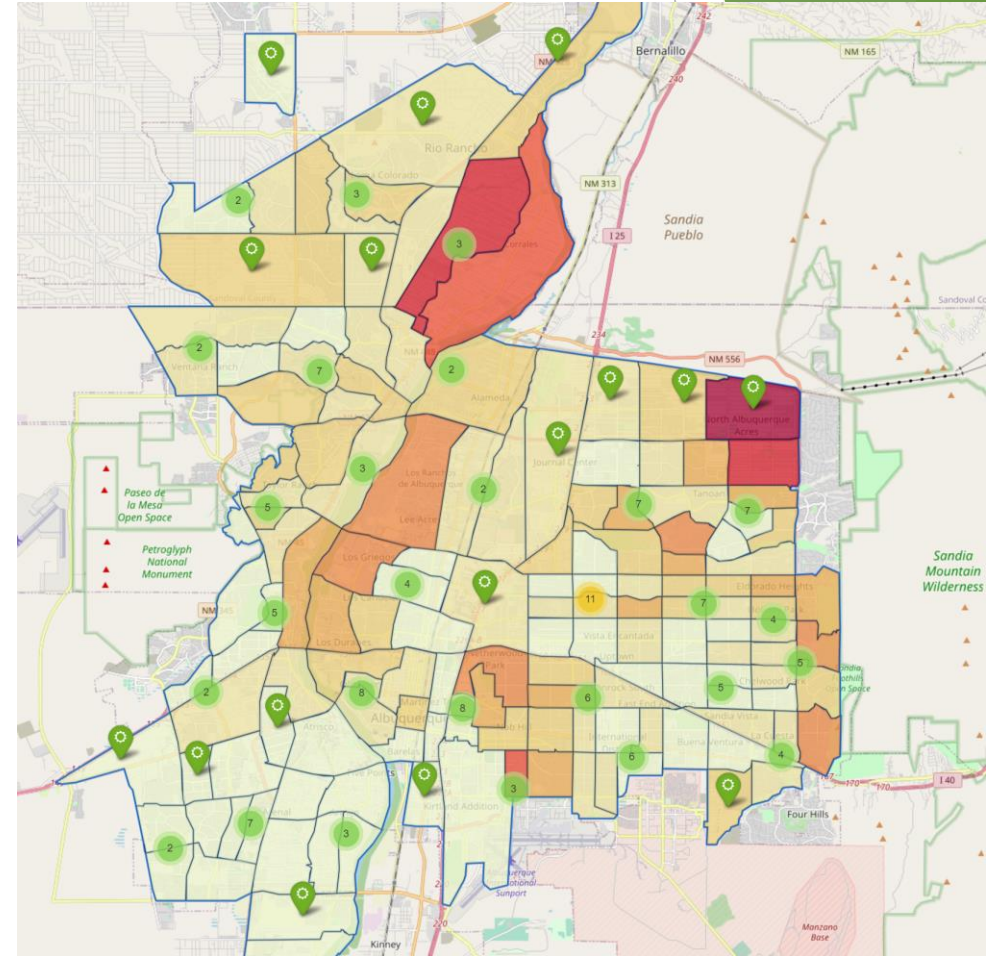


Measures

- ▶ Potential AC Generation
 - ▶ $\text{Size of Solar Panels} \times \text{Sunlight kWh/kW Threshold} \times \text{Derate Factor DC to AC of 85\%}$
- ▶ Saving for a Homeowner
 - ▶ $\text{Potential AC Generation} \times \text{Utility Cost}$
- Average Bill for Residential Customer
- ▶ Coverage
 - ▶ $\text{Potential AC Generation} / \text{Households} * \text{Usage}$

Initial Question

- ▶ Top 3 States for homeowner savings
 - ▶ \$3,026 - Hawaii
 - ▶ Top Install Ratio 12%+
 - ▶ \$1,471 - California
 - ▶ 2nd Top Install Ratio 3.8%
 - ▶ \$1,277 - Albuquerque, New Mexico
 - ▶ 9th Install Ratio 1%
 - ▶ Top Electricity Generation
 - ▶ Low Adoption of Solar 1%
 - ▶ High Savings \$1,277 annual for Large Install 10kw



Key Finding

- ▶ Installs are more common with best solar yields
- ▶ Owner Occupied Housing increases Install Rates in high yield areas
- ▶ Median Income has consistent correlation in areas with high installs
 - ▶ Less pronounced in more Rural States - Homesteading?

Further Insights

- ▶ Air Conditioning in the South
 - ▶ High Electricity Usage sees more install despite average savings
 - ▶ Florida and Arizona high install rates but low savings
 - ▶ More exploration needed on how high usage households use Solar
- ▶ Flat Roof Space Potential is Huge
 - ▶ Potential Energy from flat roof multiple time that of residential
 - ▶ More space = more power
 - ▶ 10 state have potential for 100% Residential Coverage

Conclusions

- ▶ Solar Energy is a complicated topic, homeowners mostly making money saving decisions
- ▶ Large potential for Commercial Installation on Flat Roofs
- ▶ More Exploration Needed to fully describe how people adopt solar