Analysis of Solar External Timelines and Requirements

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2/15/2023

Purpose

Gain a better qualitative understanding of external factors affecting residential PV installers such as external timelines, requirements, and limitations by Authorities having jurisdiction (AHJ; permitting authorities) and utility companies

Summary

With a focus in the market research scope of residential PV installation, my previous data compilation [Solar Data Sources] focused heavily on consumer census data such as average household income, population, and geography. In addition, I was able to use utility energy consumption, rates, and customers to approximate an average utility bill in an area. However, more information is needed to determine market viability in the residential PV space.

One of the largest time sinks in residential PV installation is out of the control of the installer. Typically, the permitting & inspection process makes up most of this time sink with interconnection & permission to operate (PTO) making up the remainder. A large portion of customer criticism relates to the timeline of installation. An above average installer (shorter install timeline than most) can install in an area where the external factors outweigh the controllable.

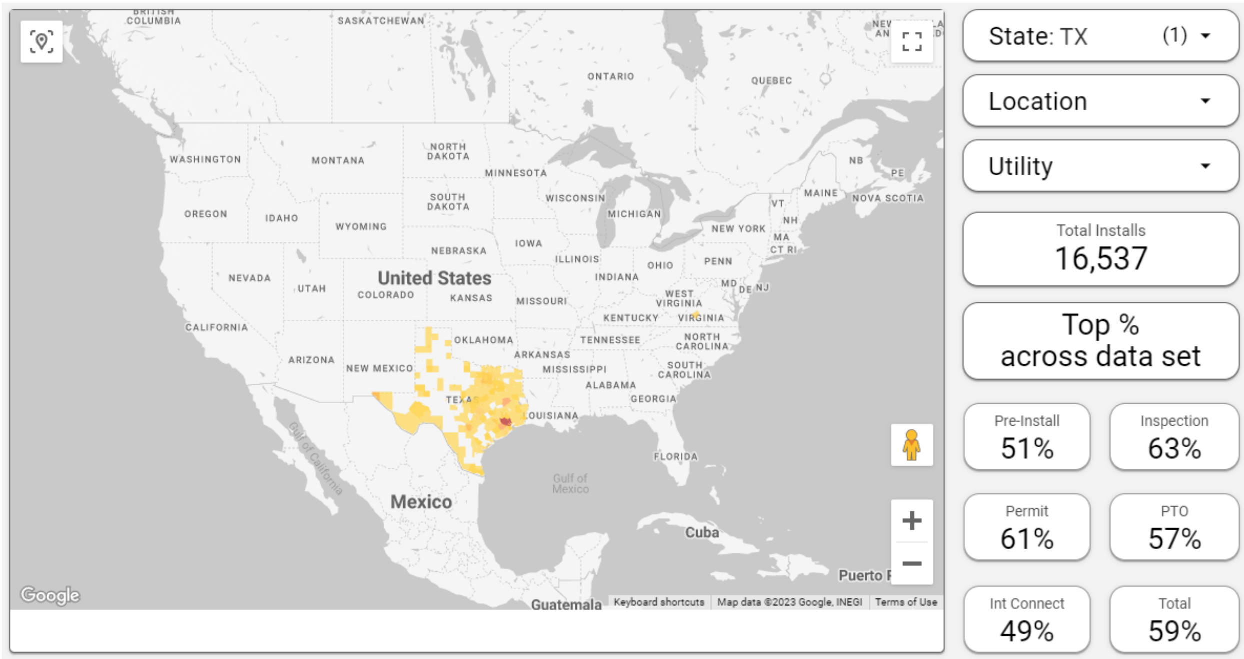
External timelines can heavily impact an installation. Understanding policies, requirements, and responsiveness respective to both Authorities having jurisdiction (AHJ; Permitting authorities) and Utility companies can determine ease of installation & market viability. These factors include net-metering policies (offset), structural analysis, building permits, inspections, and system size.

The National Renewable Energy Laboratory (NREL) researches and publishes data in the renewable energy space. The focus of this project focuses on the "Solar permitting, inspection, and interconnection cycletimes and requirements[1]" dataset published on September 26th, 2022.

"Thirteen small-to-large residential PV installers submitted project-level data for analysis, which included timestamps for major components of the permitting, inspection, and interconnection process as well as contract and installation dates. NREL calculated median timelines for these processes across the authorities having jurisdiction (AHJs) and utilities represented in the data. Also included are relevant permitting requirements for AHJs and interconnection process requirements for utilities. This dataset represents the underlying results shown in the Solar Time-based Residential Analytics and Cycle time Estimator (Solar TRACE) viewer. This dataset has been reviewed but errors may exist and it may not be comprehensive. Errors in the sources (e.g., AHJ permitting requirements lists from data partners) may be duplicated in the dataset."

[1] Cook, Jeffrey; Cruce, Jesse; Fekete, Emily; Dong, Shiyuan (Sara) (2021): Solar permitting, inspection, and interconnection cycletimes and requirements. National Renewable Energy Laboratory. 10.7799/1774106

Result



Authority	Utility	Utility Approval	Online Permitting	Offset Policy	Size Limit	Req # of Inspections	Structural	External AVG Time	Offset Percentage	Total Installs	Median Permit Cost
Lakeway city	Austin Energy	No	Yes	Yes	10	-	No	17	110.00%	3	150
Bee Cave city	Austin Energy	No	Yes	Yes	10	-	No	18	110.00%	9	75
Austin city	Austin Energy	No	Yes	Yes	10	-	No	12	110.00%	319	208
Williamson Co...	Austin Energy	No	No	Yes	10	-	-	9	110.00%	0	0
Travis County	Austin Energy	No	Yes	Yes	10	-	No	11	110.00%	38	0
The Hills village	Austin Energy	No	No	Yes	10	-	No	18	110.00%	1	0

1 - 100 / 853

Source: NREL
Citation: Cook, Jeffrey; Cruce, Jesse; Fekete, Emily; Dong, Shiyuan (Sara) (2021): Solar permitting, inspection, and interconnection cycletimes and requirements. National Renewable Energy Laboratory. 10.7799/1774106

Looker

By utilizing the Solar permitting, inspection, and interconnection cycletimes and requirements dataset, google sheets, SQL, and Looker, I was able to effectively visualize data and build a tool usable by solar installers and solar market researchers. The intent behind this project was to utilize data and information to better understand solar markets, viability of expansion, and targeting marketing efforts within a territory.

The results of my query can be found in my Solar Query Data[2] google sheet should you be interested in processed data.

While this data set is limited, it proves to be a valuable proof of concept. This data set does get updated though it relies heavily on users of this database and solar professionals.

[2] *Full SQL Query*

Building The Data

This project begins by cleaning the data. One of the issues with this dataset is mixed data types within columns. Often variations of null (Null, NULL, -) and NA (na, N/A, #N/A) in columns primarily populated with integers. Once cleaned, additional preparation was needed before importing into SQL Server Management Studio (SSMS) as Comma Separated Values. Mainly, replacing the commas in strings and mapping the correct data type in the data import.

I started by loading the three datasets as tables into SSMS beginning with the SolarTRACE AHJ-Utility data (SolarData2). This dataset contains geography, utility, AHJ, total installs by year (2017-2021), and median timelines by external process by year (pre-install, permitting, inspection & PTO). My first major aggregation was averaging the timelines by process.

```sql
WITH avg_permit_time AS (
  SELECT
    [ahj],[state],
    AVG(COALESCE(
      [Median AHJ Permit Time 2017 0-10kW],
      [Median AHJ Permit Time 2018 0-10kW],
      [Median AHJ Permit Time 2019 0-10kW],
      [Median AHJ Permit Time 2020 0-10kW],
      [Median AHJ Permit Time 2021 0-10kW],
      [Median AHJ Permit Time 2017 11-50kW],
      [Median AHJ Permit Time 2018 11-50kW],
      [Median AHJ Permit Time 2019 11-50kW],
      [Median AHJ Permit Time 2020 11-50kW],
      [Median AHJ Permit Time 2021 11-50kW],
      0
    )
  ) AS avg_permit_time
  FROM [SolarData2]
  GROUP BY [ahj],[state]),
```

I decided to aggregate all timelines by process instead of year or system size mainly to keep focus on the summary scope of this project. This data set could be more comprehensive if aggregated by year instead of process. I chose not to pursue this method as the extensive historical data lacks relevance to the scope of this project.

I aggregate the AHJ processes first and then later add utility response time for interconnection which does not require an avg(). Then I added all of the average process timelines to get an average total external timeline.

Then I proceeded to run statistical analysis on these timelines by utilizing the NTILE() window function. For this project I was much more interested in the "top X% of all AHJ & Utility combinations". As such, to help narrate this I opted to use 100-NTILE(100) though one could just as easily use NTILE(4) for quartiles.

```sql
Select distinct
[SolarData2].[state],
SolarData2.ahj,
[SolarData2].geo_id,
[SolarData2].utility,
[SolarData2].[Total Installs],

round(avg_preinstall_time,2) as [AVG Preinstall Time],
100-ntile(100) over (order by avg_preinstall_time) PreinstallPCT,
round(avg_permit_time,2) as [AVG Permit Time],
100-ntile(100) over (order by avg_permit_time) PermitPCT,
round(avg_inspection_time,2) as [AVG Inspection Time],
100-ntile(100) over (order by avg_inspection_time) InspectionPCT,
round(avg_pto_time,2) as [AVG PTO Time],
100-ntile(100) over (order by avg_pto_time) PTOPCT,
```

Once the quantitative analysis was completed, I proceeded to work within the Utility PPI Requirements table (UTILITYData) to compile the qualitative information by Utility. The main columns I was interested in were; Offset Policy in Place from Utility, Offset Percentage, Level 1 Process Cutoff (kW), and Approval to build required from utility before install.

Offset Policy is the net-metering rates available through the Utility company. These policies typically are considered 1:1 or 100% offset. In some cases Utilities offer an above 100% offset, such as Baltimore Gas & Electric Co, (BGE) which offer a 200% offset. Many utilities in the US have a policy similar to this though some (TN, GA) do not. Those without net-metering are at an immediate disadvantage as many of the alternatives to net-metering are prohibitive policies that either have too many disadvantages to installing solar or require a battery, and thus more cost and longer return, to fully utilize a solar array.

Level 1 Process Cutoff (kW) indicates a simplified, fast tracked, or expedited interconnection application. This number indicates the system size limit for these policies. Interconnection describes connecting to the grid via a utility company and the requirements therein. These requirements include technical specifications such as automatic transfer switches, battery management unit, and configuration guidelines.

Additionally, some utilities require their approval before an installer can begin construction. In the scope of this project, this information is relevant as it can indicate the bureaucratic workload, time, and processes that can extend the timeline of the project as a separate factor to the quantitative external timelines.

```sql
UTILITYData.[Offset Policy in Place from Utiltiy] Offset_Policy,
UTILITYData.[Offset Percentage],
UTILITYData.[Level 1 Process Cutoff (KW)] KW_Limit,
UTILITYData.[Approval to Build required from utility before install] Utility_Approval,

case
    when AHJData.[Online Permitting]=1 THEN 'True'
    when AHJData.[Online Permitting]=0 THEN 'False'
    else 'N/A'
End as Online_Permitting,

AHJData.[Structural Review Required],
AHJData.[Median Permit Cost],
AHJData.[Number of Inspections Reqd]
```

After selecting the qualitative data from the UTILITYData table, I went on to identify key columns within the AHJ PII Requirements table (AHJData) to include with this data set. These columns are online permitting (boolean), structural review required, median permit cost, and number of inspections required. Like the utilities, AHJs can add additional, time consuming barriers, to a solar installation.

Permitting accessibility is a surprising factor as the method of submission greatly dictates expediency of processing. For instance, an online portal can be automated through the AHJ whereas faxing, mailing, emailing, or in-person submission can add several days to the process. While permitting costs might not add to the timeline for a project, I still found it relevant to include as an indication of an AHJ's willingness to cooperate.

Similarly to permitting accessibility, if a structural review is required, oftentimes an installer will have to hire a 3rd party to handle the structural analysis of the solar installation, thereby adding additional time to the project.

Lastly, the number of inspections required is likely the best indication of additional time to install. You will note that a similar metric is already calculated in the AVG Inspection Time aggregate from the [SolarData2] data set. Knowing the number of inspections required often correlates to the average inspection time, though from a summary perspective, it remains relevant as a standalone metric.

After identifying and selecting all the aggregate and qualitative metrics from the datasets, the next thing to do was to join the tables. As a note, the UTILITYData table contained additional information beyond the scope of the other tables. As such, I chose a full outer join to incorporate this information.

```
from SolarData2
    join avg_permit_time
        on SolarData2.[ahj]+SolarData2.[state] = avg_permit_time.[ahj]+avg_permit_time.[state]
    join avg_inspection_time
        on SolarData2.[ahj]+SolarData2.[state] = avg_inspection_time.[ahj]+avg_inspection_time.[state]
    join avg_pto_time
        on SolarData2.[ahj]+SolarData2.[state] = avg_pto_time.[ahj]+avg_pto_time.[state]
    join avg_preinstall_time
        on SolarData2.[ahj]+SolarData2.[state] = avg_preinstall_time.[ahj]+avg_preinstall_time.[state]
    Full Outer join UTILITYData
        on SolarData2.eia_id = UTILITYData.[EIA ID]
    join AHJData
        on SolarData2.ahj+SolarData2.[state] = AHJData.ahj+AHJData.[state]

order by [SolarData2].[state], Total DESC
```

As a separate note relating to the complex join keys above. Many states shared the same name of an AHJ. By joining only on the AHJ name, duplication ensued as a factor of how many different states shared the same AHJ. For example the AHJ Clark County is present for both Nevada and Wisconsin, thus generating 2 instances of Clark County. The solution to this was to include the state in the join key to eliminate the duplication. Additionally, the Utility data join is based on the EIA ID, which is defined by the U.S. Energy Information Administration (EIA) as a unique identifier for electric service providers.

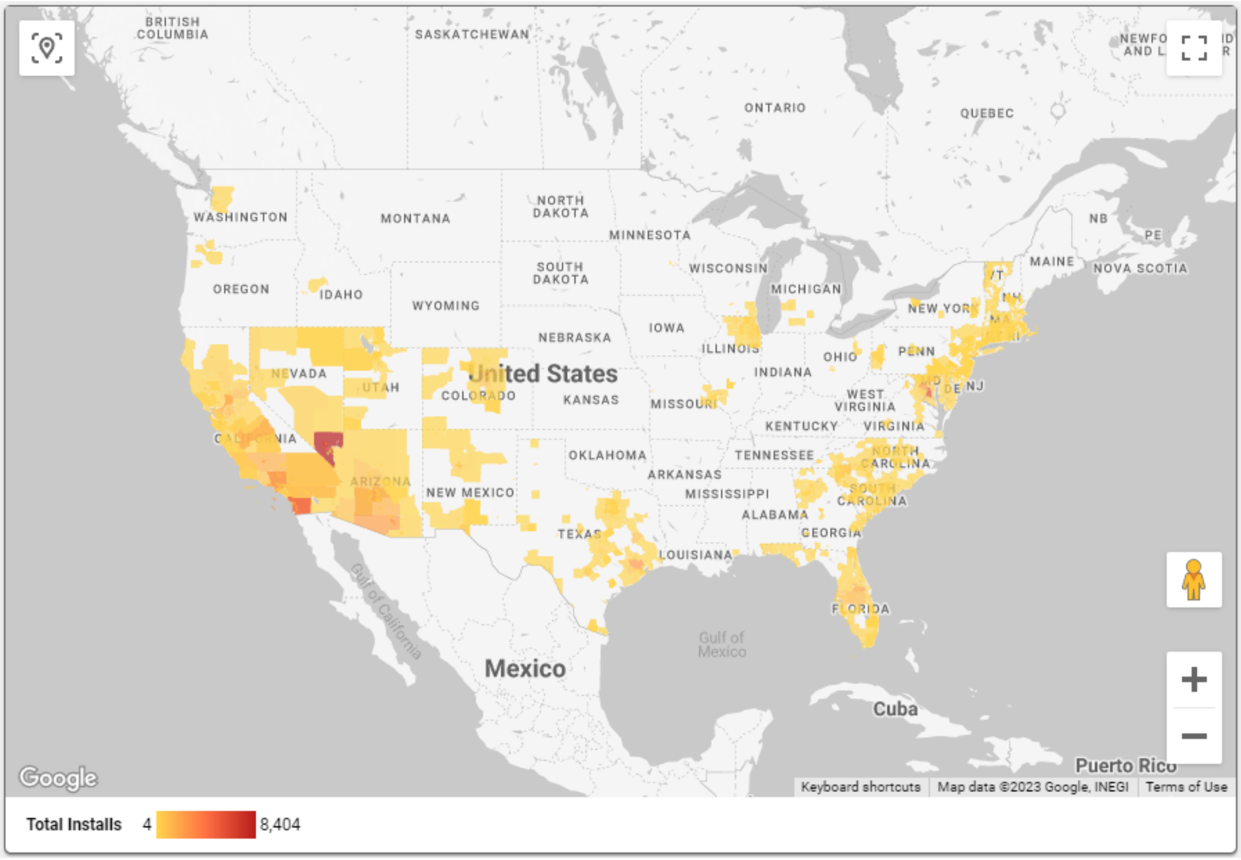
Looker Visualization

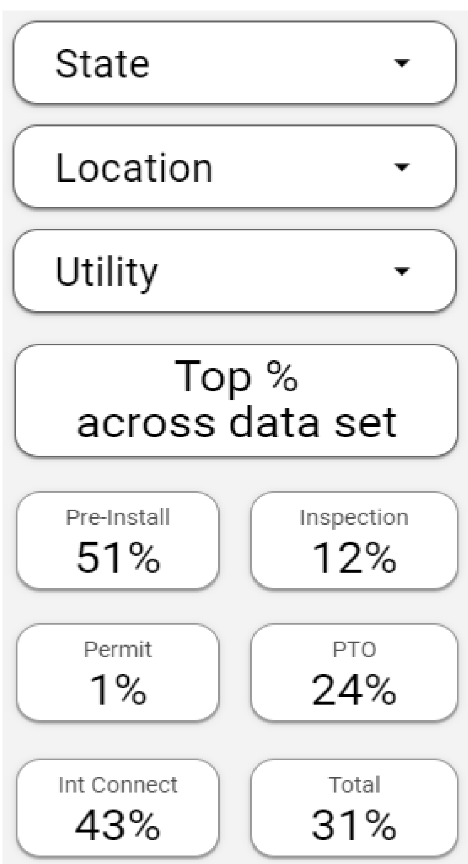
Now that the primary dataset is complete, I exported the SQL data into a google sheet to then connect with a new looker project. As part of adding the data source to Looker, I had to create fields to help Looker interpret the data easier.

Field	Type
Interconnection	123 Number
InterconnectionQuartile	123 Number
KW_Limit	123 Number
Location fx	Country subdivision (2nd level)
Median Permit Cost	123 Number
Number of Inspections R...	123 Number
Offset Percent Fix fx	123 Number
Offset Percentage	123 Number

As part of this process, I needed to fix the geographic information. This is explained further in the next section though essentially I needed to concat AHJ, State, and Country to get a more accurate mapping.

The first metric I decided to focus on was the number of installs. Generally speaking, the more installs in an area correlates to ease of installation, demand, and cooperative Utilities and AHJs. This is the fundamental metric driving this visualization.





In addition to the Total Installs map, I selected three key control fields that would focus the data set further. State, location, and utility are the key geographical indicators in this dataset. As a note, AHJs are included in the location field. By utilizing these key fields, users can view data in a variety of scopes, from state specific all the way down to individual cities.

After adding the control fields, I elected to include the quantitative metrics. This includes the timeline percentiles from pre-install, interconnection, permitting, inspection, PTO, and Total.

**Note data is from Clark County, NV*

Now that the quantitative data is implemented, the final step was to include the qualitative data. The best method for this was to utilize the table chart type. As a note, the chart type, control fields, and even map act as a way to filter down data. For instance, selecting a specific county or city on the map will filter the quantitative timeline data and qualitative data for that selection. The same can be done when utilizing the table by selecting an AHJ or Utility. This also limits the options available to select in the controlling fields.

Authority	Utility	Utility Approval	Online Permitting	Offset Policy	Size Limit	Req # of Inspections	Structural	External AVG Time	Offset Percentage	Total Installs	Median Permit Cost
Clark County	Nevada Power Co (NV Energy S...	No	Yes	Yes	25	1	Conditiona...	39	100.00%	8,387	254.1
Clark County	Valley Electric Assn. Inc (VEA)	Yes	Yes	Yes	25	1	Conditiona...	34	100.00%	2	254.1
Clark County	Overton Power District No 5	-	Yes	-	-	1	Conditiona...	-	-	15	254.1

1 - 3 / 3

Challenges

One of the first things I noticed is that I had missed a key column data type when cleaning the table in excel. Essentially, the data set was using 1(true) and 0(false) to determine eligibility of online permitting. Simple CASE function solved that pretty quickly.

Once my query was complete, I identified an issue with the geo_id field. While intended to identify a geographical area for GIS, it contains a mix of different ID types. Looker (previously Google Data Studio), follows a top down approach to geo-location, starting at continent and ending at Lat & Long. Mapping the geo_id field proved to be difficult and inaccurate which prompted a revision to the methodology. Instead of using the geo_id field, I opted to concat AHJ, State, and Country for a more readable location for Looker to map. This method is not perfect and I welcome other solutions.

Citations & Sources

1. Cook, Jeffrey, et al. "Solar Permitting, Inspection, and Interconnection Cycletimes and Requirements." *Solar Permitting, Inspection, and Interconnection Cycletimes and Requirements | NREL Data Catalog*, National Renewable Energy Laboratory, 25 Sept. 2022, https://data.nrel.gov/submissions/160.
    a. Cook, Jeffrey; Cruce, Jesse; Fekete, Emily; Dong, Shiyuan (Sara) (2021): Solar permitting, inspection, and interconnection cycletimes and requirements. National Renewable Energy Laboratory. 10.7799/1774106
2. Post-Query data,"Solar Query Data"
3. Final SQL Query, "SQLQuery1.sql"
4. Additional Solar Data Source, referenced. "Solar Data Source" - Compiled by Neil Maddox
5. Final Looker Visualization,"SolarTRACE 2017-2021"