ENERGY INDEPENDENT@HOME

MONITORING TOOLS

SYSTEM CONFIGURATION

- 27kW Solar Panels
- 2 x 12kW SMA Tripower 12000TL inverters
- 1 x Tesla PowerPack 232kWh
- 1 x 480Vy208V transformer

SETUP

- Collection of Open Source tools
  - Grafana dashboards (https://www.grafana.com)
  - InfluxDB for time series database (https://www.influxdata.com/get-influxdb/)
  - Telegraf to collect metrics (https://www.influxdata.com/time-series-platform/telegraf/)
  - Linux (in my case Oracle Linux 8 – (https://yum.oracle.com/oracle-linux-isos.html))
- All of this runs at home on a Supermicro server (5018D-FN8T)

There are many similar projects out there that will do exactly the same. I just picked these because I am familiar with them already.

It's certainly possible to run all this on hosted/cloud servers. I just run it at home so I continue to collect data if my internet connection goes down and I don't have to open up ports to the outside world to collect data from. (Also, for folks that don't have a static IP or an ISP that drops incoming connections)

DATA SOURCES

- Tesla Site Controller (local)
- SMA site (https://ennexos.sunnyportal.com)
- AirVisual/IQAir (https://www.iqair.com)
- OpenWeatherMap (https://openweathermap.org)
- PurpleAir (https://www2.purpleair.com)

WHY?

- History of Performance of the system under various conditions
  - How do rainy/cloudy days impact the generation?
  - How does Air Quality affect generation? (quite relevant these days in California)
  - Transformation loss (power used by inverters, conversion from DC to AC to DC, transformer)
  - Use history data to automate turning on/off energy consuming entities (Tesla charger, bitcoin miner(s))
  - Ensure optimal use of all solar energy generated and not have the system shut down early (wasted/lost energy)
- Mostly for educational purposes and provide some (hopefully useful) data to others

SITUATION

- While I have a beefy system. I do not have the option of GRID backup. My closest utility pole is 770ft away and bringing power to my property is cost prohibitive (expect $500/ft). So I had to ensure I would be able to be self-sustaining.
- I opted for not having a backup generator (propane or gas) – town permits would have delayed construction and in general painful.
  - Could be used for 2 reasons
    - Charge the battery if not enough solar generation
    - Take over generation if the battery system were to fail (equipment failure)

SITUATION

- I don't live in a tiny house. In fact, while my lighting etc are all LED, I have a lot of network equipment and electronics (hobby) and my base-consumption even with no lights or appliances turned on is significant (1.5kW). That's a personal choice.
- I have a Tesla Model S, which I charge/wanted to charge at home and that is a big consumer (10kW/10kWh when plugged in).

So it's important to be able to predict generation/usage and remove the worry.

SOME OBSERVATIONS

- Collecting cloud coverage % doesn't help much, it's important to also collect humidity levels and basically determine cloud thickness.
- AQI is very important, with AQI > 100 there's a significant impact on the solar generation upward of 30-40% on any given day.
- There is loss on the system, just adding up Watt and assume Watt generated is Watt available is not quite right.
- Collecting data is important, I discovered an imbalance in the solar array strings connected to the 2 inverters early on, which, after correcting it, gave me an extra 1-2kW

SOME OBSERVATIONS

- Knowing what time of day generation starts, helps automate turning on/off appliances. This obviously changes throughout the year summer/winter.
- Understanding and learning how this all works really – how the powerpack turns off the solar inverters (hz freq shift) to push the inverter off the cliff.
- Incredibly STABLE power (Voltage + Frequency)

Most importantly – it's kinda cool and fun! ☺

SOURCES DETAIL - TESLA

- https://powerpack:1111/api/meters/aggregates

{"battery":{"last_communication_time":"2021-08-29T11:34:19.686620198-07:00","instant_power":-17107.061862945557,"instant_reactive_power":3160.7550121843815,"instant_apparent_power":17396.60707809701,"frequency":60.130001068115234,"energy_exported":10652700,"energy_imported":16017100,"instant_average_voltage":479.993682861328 1,"instant_total_current":38.56667006958138,"i_a_current":0,"i_b_current":0,"i_c_current":0,"timeout":60000000000},"solar":{"last_communication_time":"2021-08-29T11:34:19.686697959-07:00","instant_power":19933.49552154541,"instant_reactive_power":397.78593741357327,"instant_apparent_power":19937.464165722653,"frequency":60.130001068115234,"energy_exported":25692300,"energy_imported":0,"instant_average_voltage":479.80029296875,"instant_total_current":41.69035049931486,"i_a_current":0,"i_b_current":0,"i_c_current":0,"timeout":60000000000}}

SOURCES DETAIL - TESLA

- https://powerpack:1111/api/system_status/soe

{"percentage":72.87362432422005}

SOURCES DETAIL - TESLA

- https://powerpack:1111/api/meters/solar


```
[{"id":0,"location":"solar","type":"acuvim","cts":[false,false,false,false],"in
verted":[false,false,false,false],"connection":{"ip_address":"192.168.90.220","
modbus_id":1,"https_conf":{}},"Cached_readings":{"last_communication_time":"202
1-08-29T11:40:23.580825485-
07:00","instant_power":20210.01958847046,"instant_reactive_power":413.652041926
98,"instant_apparent_power":20214.25239226398,"frequency":60.099998474121094,"e
nergy_exported":0,"energy_imported":25694300,"instant_average_voltage":480.1305
847167969,"instant_total_current":42.2891808763402,"i_a_current":24.81986582279
2053,"i_b_current":23.595701903104782,"i_c_current":24.816304445266724,"real_po
wer_a":6868.890762329102,"real_power_b":6494.904041290283,"real_power_c":6846.2
24784851074,"reactive_power_a":236.8582934141159,"reactive_power_b":196.0597336
2922668,"reactive_power_c":-
19.26598511636257,"serial_number":"xxxxxxxx","version":"MeterFW:3.69,TCPmodule:
","timeout":60000000000}}]
```

SOURCES DETAIL - TESLA

- https://powerpack:1111/api/meters/battery


```
[{"id":0,"location":"battery","type":"acuvim","cts":[false,false,false,false],"
inverted":[false,false,false,false],"connection":{"ip_address":"192.168.90.201"
,"modbus_id":1,"https_conf":{}},"Cached_readings":{"last_communication_time":"2
021-08-29T11:42:01.585641708-07:00","instant_power":-
17784.77144241333,"instant_reactive_power":3261.61802560091,"instant_apparent_p
ower":18081.378470786058,"frequency":60.11000061035156,"energy_exported":160193
00,"energy_imported":10652700,"instant_average_voltage":480.01647949218 75,"inst
ant_total_current":39.999748499098956,"i_a_current":24.40587617456913,"i_b_curr
ent":21.252421662211418,"i_c_current":23.487083613872528,"real_power_a":-
6190.047740936279,"real_power_b":-5796.79536819458,"real_power_c":-
5797.928333282471,"reactive_power_a":1518.6129808425903,"reactive_power_b":22.6
6586571931839,"reactive_power_c":1720.3391790390015,"serial_number":"XXXXXXXX",
"version":"MeterFW:3.69,TCPmodule:","timeout":60000000000}}
```

SOURCES DETAIL - SMA

- Custom python script that pulls data from ennexos.sunnyportal.com – due to auth (log in / get token / collect data / output to json format for telegraf)
- https://uiapi.sunnyportal.com/api/v1/widgets/gauge/power


```
{ "sma_inverter_main" : {"value" : 19672.767},
"sma_inverter_1" : {"value" : 9037.767},
  "sma_inverter_2" : {"value" : 10635.0}}
```

SOURCES DETAIL - OPENWEATHERMAP

- http://api.openweathermap.org/data/2.5/weather?zip=94062,us&units=imperial&appid=xxxxxxxx


```
{"coord":{"lon":-
122.296,"lat":37.4245},"weather":[{"id":711,"main":"Smoke","descrip
tion":"smoke","icon":"50d"}],"base":"stations","main":{"temp":70.77
,"feels_like":70.61,"temp_min":55.85,"temp_max":87.48,"pressure":10
08,"humidity":65},"visibility":10000,"wind":{"speed":5.01,"deg":44,
"gust":10},"clouds":{"all":1},"dt":1630262610,"sys":{"type":2,"id":
2011157,"country":"US","sunrise":1630244255,"sunset":1630291371},"t
imezone":-25200,"id":0,"name":"Redwood City","cod":200}
```

SOURCES DETAIL – AIRVISUAL IQAIR

- http://api.airvisual.com/v2/city?city=Woodside&state=California&country=USA&key=XXXXXX


```
{"status":"success","data":{"city":"Woodside","state":"California",
"country":"USA","location":{"type":"Point","coordinates":[-
122.255102,37.439847]},"current":{"weather":{"ts":"2021-08-
29T15:00:00.000Z","tp":17,"pr":1007,"hu":81,"ws":0.45,"wd":149,"ic"
:"01d"},"pollution":{"ts":"2021-08-
29T18:00:00.000Z","aqius":69,"mainus":"p2","aqicn":30,"maincn":"p2"
}}}}
```

WHATS NEXT

- More statistics to collect
- github project to host the python scripts
  - SMA readouts
  - Automation based on system state (turn on/off tesla charger, bitcoin miners, …)
- Promote change. The current electrical grid model doesn't work. While my setup is not typical, it's a good learning example of what's possible and what not, $/kWh will keep dropping. Just complaining about the grid state won't solve a problem and it's too expensive a problem (and it's too often trivialized) to just 'fix' with existing distribution models. Local microgrids, IMHO are critical.

QUICK WALK THROUGH

- SMA Site
- Tesla Site
- Grafana dashboard