Modeling Hourly Historical BTM PV Generation

CED 2021

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California Energy Commission
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Introduction

- Methodology and results are exploratory
- Not used in CED 2021
- Attempt to more accurately model hourly historical PV generation
- One of several approaches staff is exploring

Modeling Hourly PV Generation

- General Approach
  - Simulate hourly PV generation for different locations, panel orientations (tilt and direction), weather years
  - Match simulated data (by location, panel orientation, year) with installed PV system data
  - When actual or measured data is available compare actual generation with simulation generation

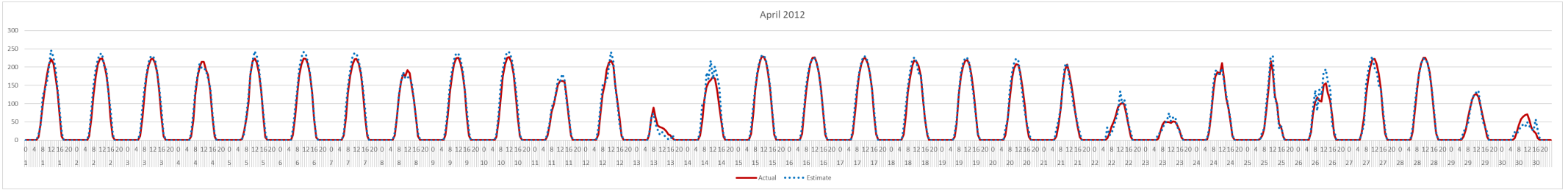
Modeling Hourly PV Generation using SAM

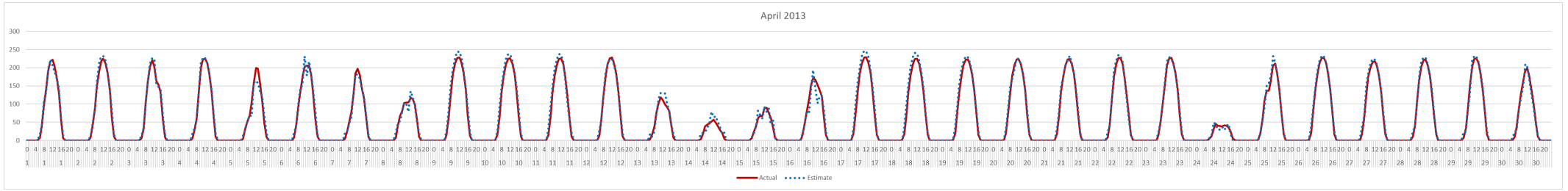
- Use NREL's System Advisor Model (SAM)
- SAM can estimate hourly PV generation:
  - Historical weather data
    - 1999-2019 and TMY; 2020 weather data not available
  - By location
    - For some locations, solar insolation is simulated using satellite data
  - By system tilt and orientation
  - Other PV system specifications
- Compare SAM results with known PV system output
  - California Solar Initiative (CSI) 15-Minute Interval Data
  - CSI Measured Production Data Set (for years 2011-2016)
    - CSI data sets have location and system orientation information
    - Publicly available at: www.californiadgstats.ca.gov/downloads/

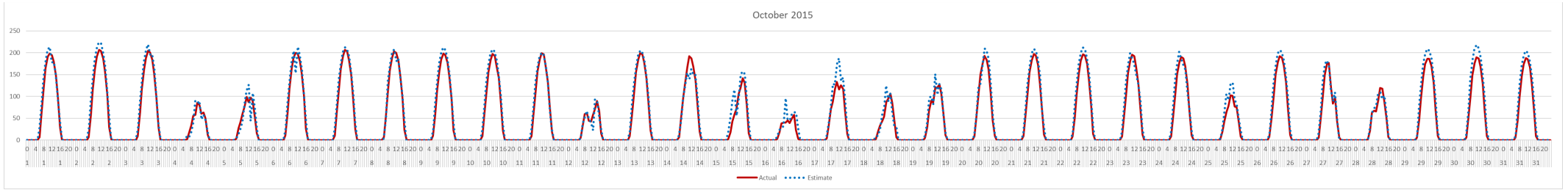
Modeling SDG&E CSI Systems

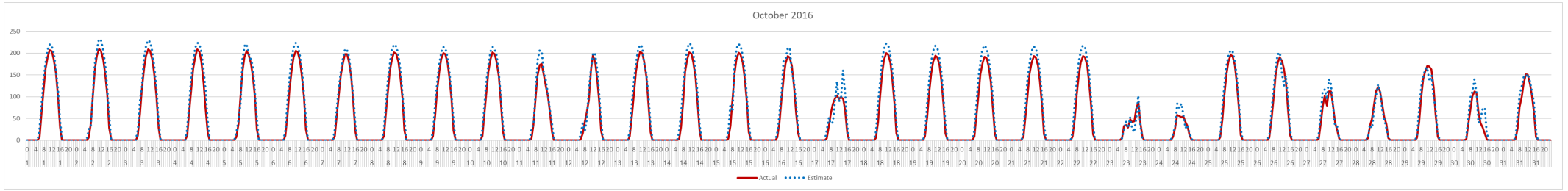
- A first attempt at modeling SDG&E
- 62 CSI Systems
  - Located across SDG&E territory
  - Years 2011-2016
  - Measured sub-hourly generation
- Modeled in SAM
  - Assumed 10 kW_{dc} system
  - Using only one location: Downtown San Diego
  - Used parametric simulation option
    - 9 representative system tilts
    - 8 representative system orientations
  - Adjust system size to match CSI systems: (kWh / 10 kW) * (CSI size in kW)

SDG&E: Actual vs Simulated CSI Gen.





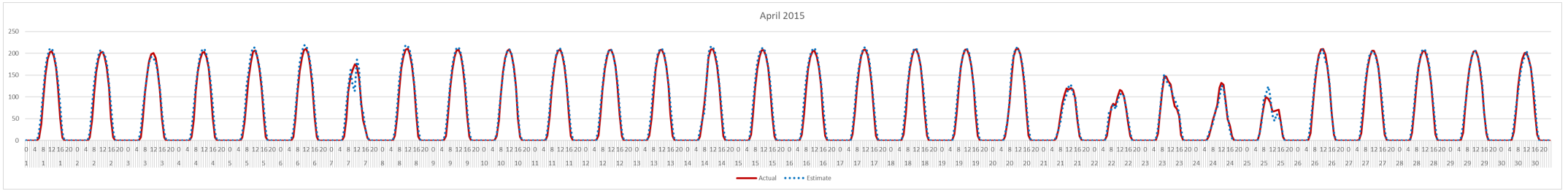


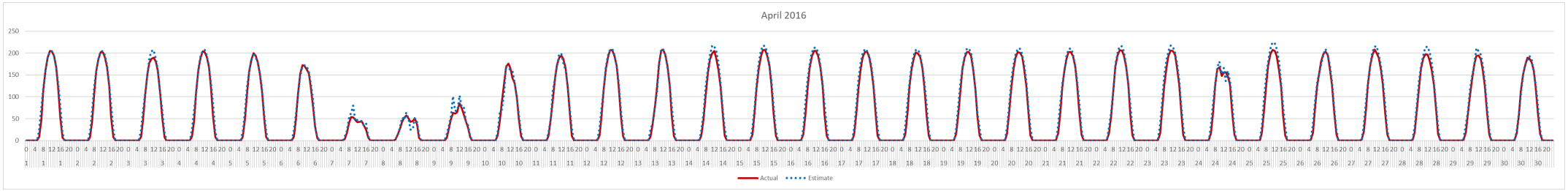


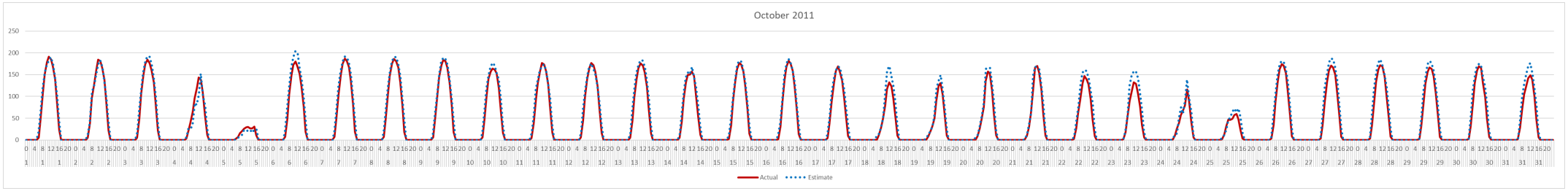
Modeling SCE CSI Systems

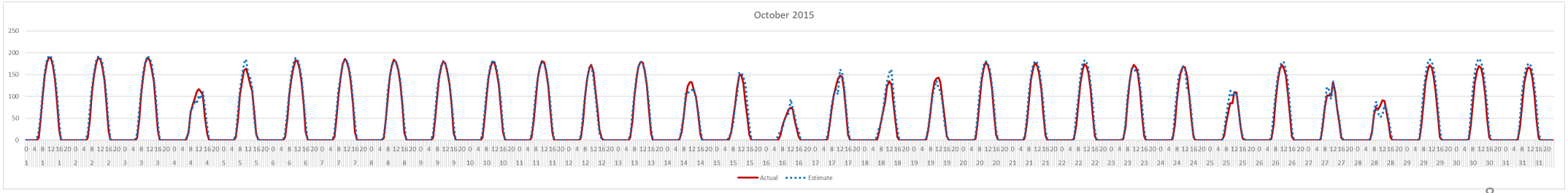
- SCE Forecast Zone 7 (LA Basin)
- 61 CSI Systems
  - Located across LA / Orange County
  - Years 2011-2016
  - Measured sub-hourly generation
- Modeled in SAM
  - Assumed 10 kW_{dc} system
  - Used 11 locations across forecast zone
  - Used parametric simulation option
    - 9 representative system tilts
    - 8 representative system orientations
  - Adjust system size to match CSI systems: (kWh / 10 kW) * (CSI size in kW)

SCE (FZ 7): Actual vs Simulated CSI Gen.









Modeling All of SDG&E Territory

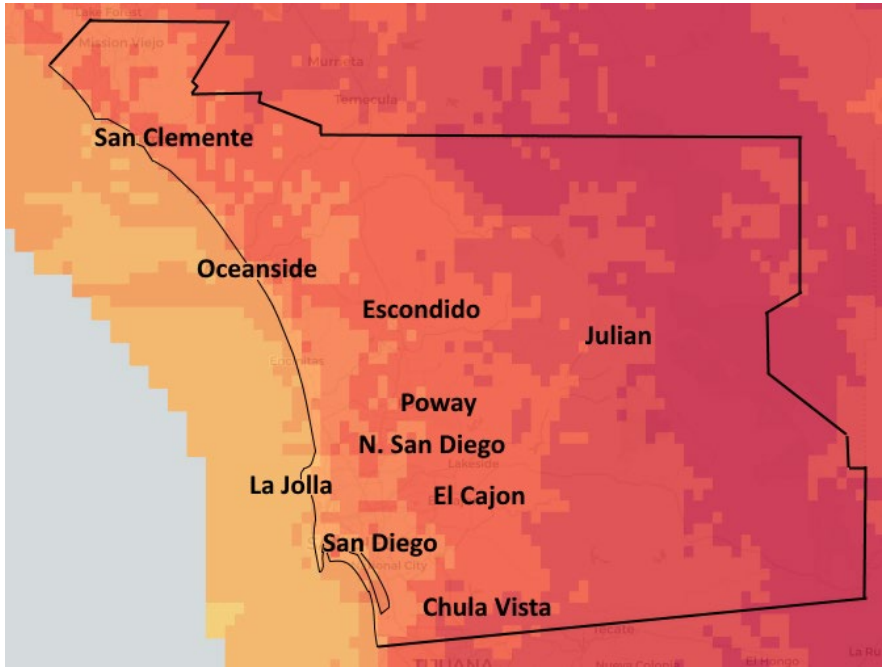
- Start with SDG&E Interconnection Data
  - www.californiadgstats.ca.gov/download/interconnection_rule21_applications/
- Classify PV systems by location, tilt, orientation, and sector
  - Grouped into 10 representative locations, 9 rep. tilts, 8 rep. orientations, 2 sectors
  - About 75% of systems have tilt and orientation information
    - Limited or no tilt/orientation information prior to 2016
- Calculate weighting or share of each distinct group
  - Distinct group = PV systems w. 1 rep. location, tilt, orientation, sector
  - Calculate "share" of each group by month

$$Share = \frac{PV\ Capacity\ of\ Group_{year,month}}{PV\ Capacity\ in\ SDG\&E_{year,month}}$$

  - Tilt and orientation shares hold constant prior to 2016

Modeling All of SDG&E Territory – SAM runs

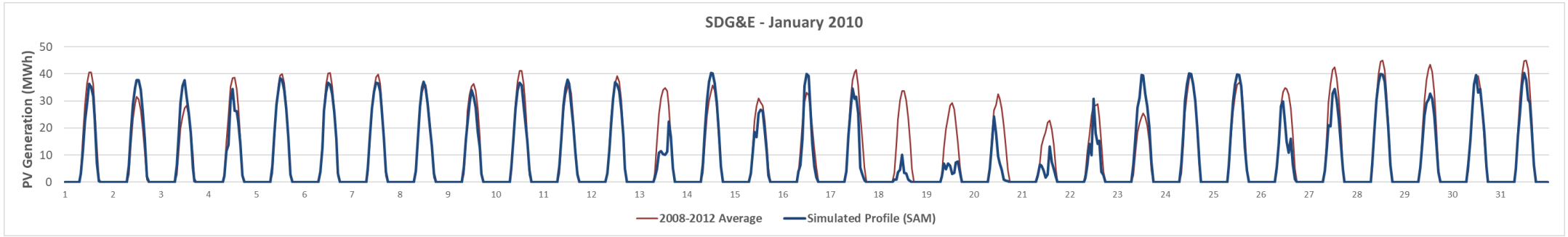
- SAM simulated runs:
  - Assumed 10 kW_{dc} system
  - 10 different locations
  - 10 historical weather years (2010-2019)
  - Used parametric simulation option
    - 9 representative system tilts
    - 8 representative system orientations
    - 2 system mounting methods
  - Over 1,000 simulated hourly profiles
    - 10 locations, 9 tilts, 8 orientations, 2 mounting types

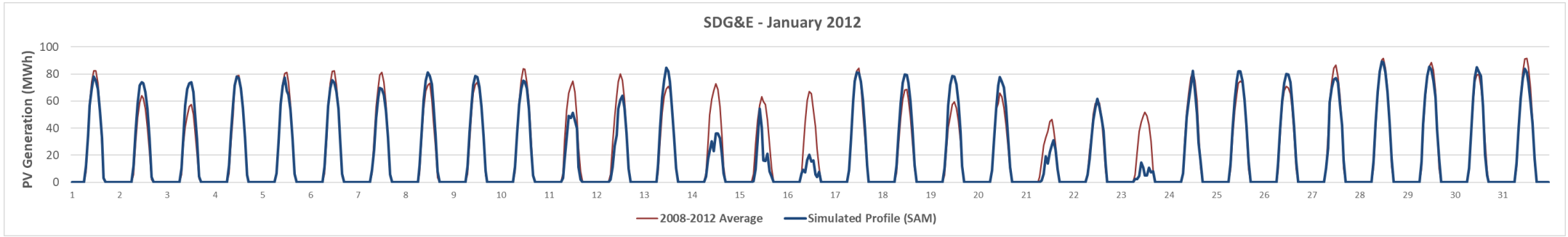


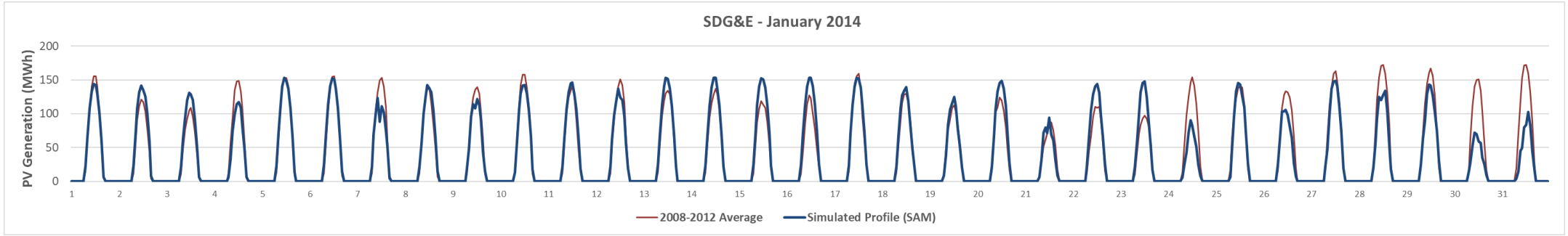
Formula

- Assign simulated profiles to each distinct group
  - Assign based on representative location, tilt, orientation, and sector
- Multiply capacity share calculated for each group with associated profile
  - “Weighting” each simulated profile based on capacity
- Add together weighted simulated profiles to create a single simulated hourly profile for SDG&E
  - The new profile accounts for weather, tilt and orientation (years 2016+), observed locational effects, and to an extent mounting method

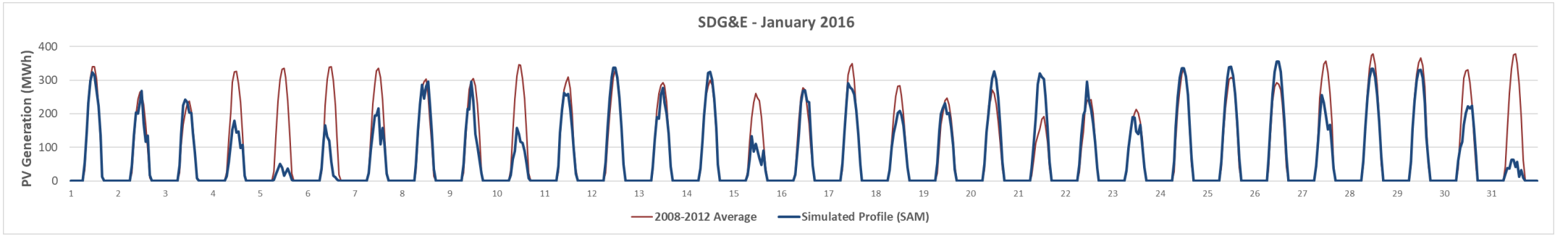
SDG&E Simulated Generation

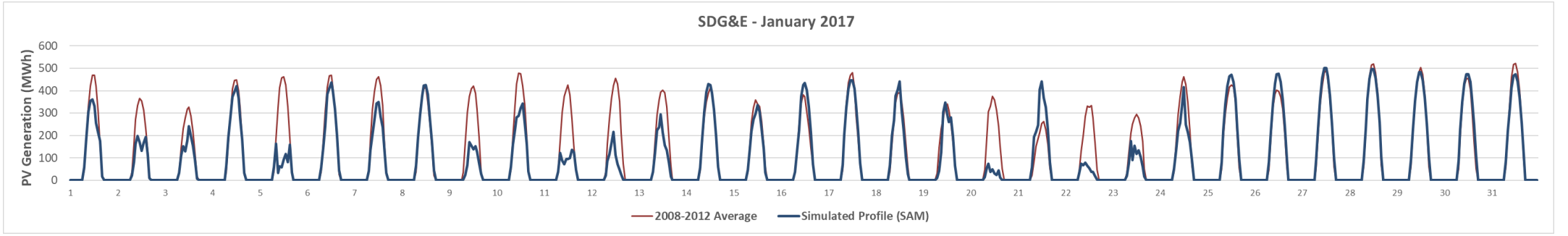


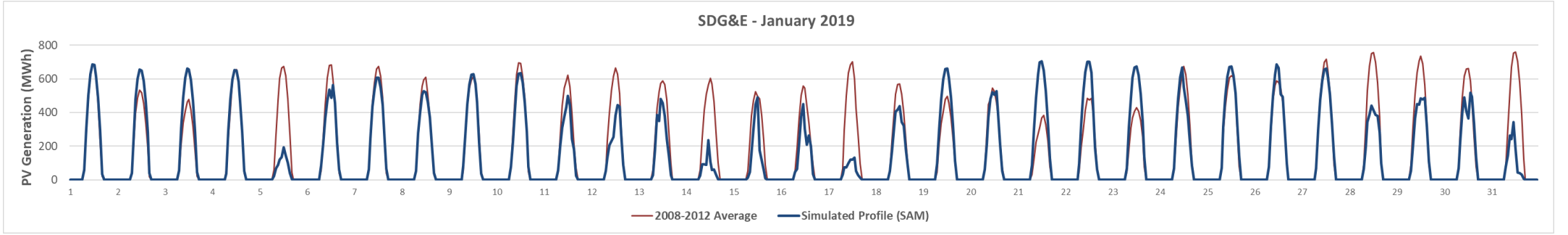




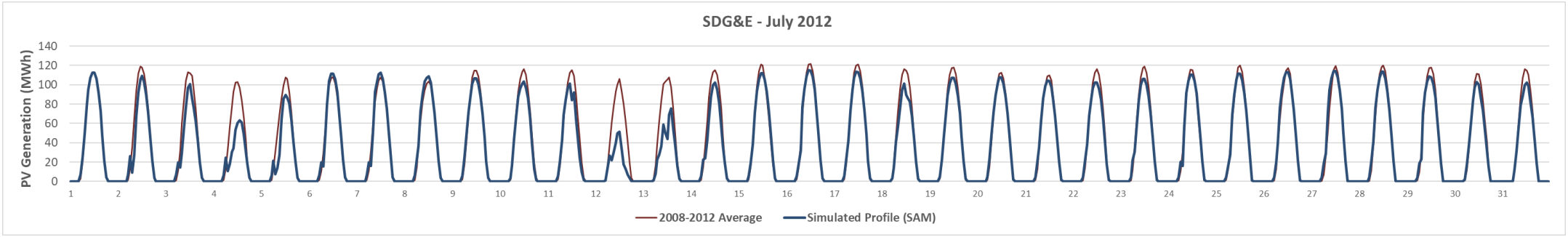
SDG&E Charts

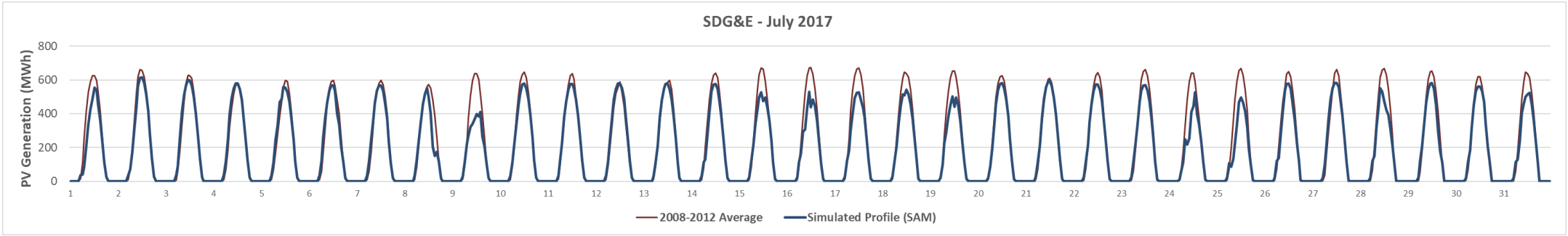

SDG&E - January 2016
PV Generation (MWh)
0
100
200
300
400
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
2008-2012 Average
Simulated Profile (SAM)

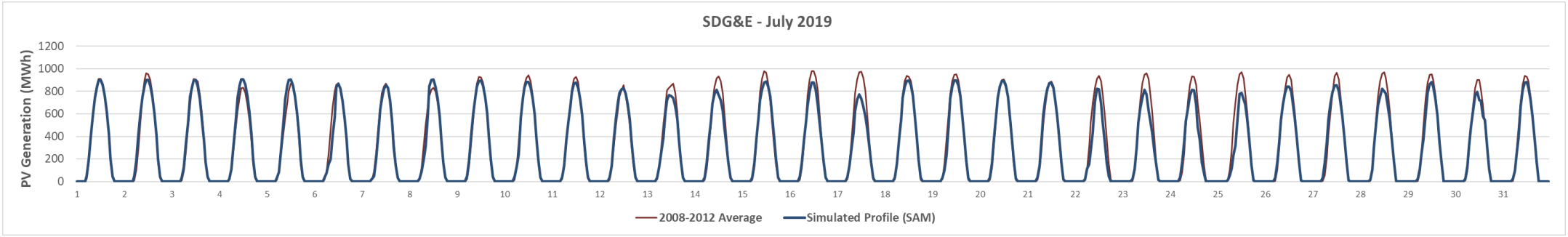

SDG&E - January 2017
PV Generation (MWh)
0
100
200
300
400
500
600
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
2008-2012 Average
Simulated Profile (SAM)


SDG&E - January 2019
PV Generation (MWh)
0
200
400
600
800
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
2008-2012 Average
Simulated Profile (SAM)

More SDG&E Charts





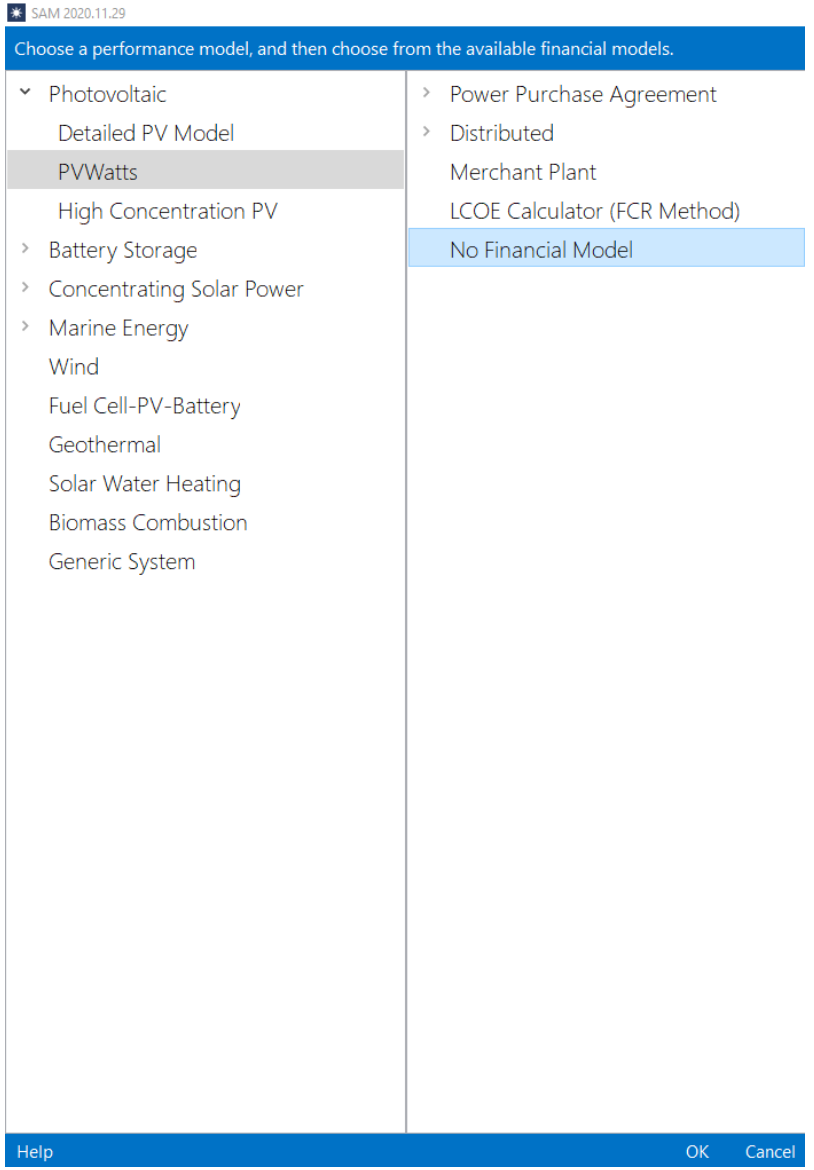


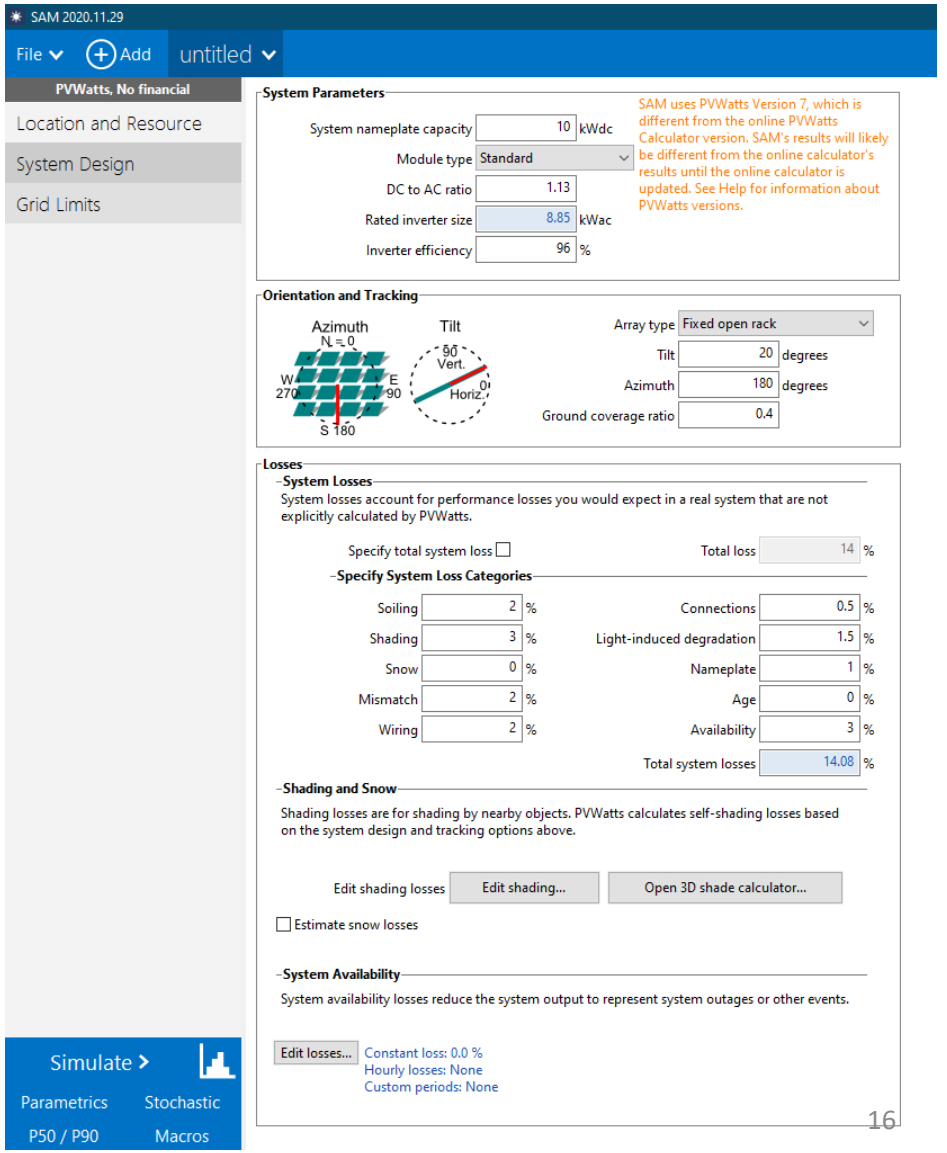
Takeaways

- Advantages
  - More accurately estimates historical PV generation
    - Seemed to reasonably estimate measured data set
  - Multiple profiles available if needed
  - Repeatable – nearly all data used is publicly available

- Drawbacks
  - Will not have the latest weather data
    - SAM historical weather data updated 10-11 months after end of year
    - So cannot update base year of forecast
  - Requires significant staff effort / time

SAM Screenshots





More SAM Screenshots