Modeling Hourly Historical BTM PV Generation

CED 2021



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Introduction

Methodology and results are <u>exploratory</u>

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 <u>known</u> 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 kWdc 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 kWdc 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 kWdc 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









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

* SAM 200 File V Location System Grid Lin

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244	SAIVI 2020, 11,29	

Choose a performance model, and then choose from the available financial models.					
 Photovoltaic 	Power Purchase Agreement				
Detailed PV Model	 Distributed 				
PVWatts	Merchant Plant				
High Concentration PV	LCOE Calculator (FCR Method)				
> Battery Storage	No Financial Model				
 Concentrating Solar Power 					
Marine Energy					
Wind					
Fuel Cell-PV-Battery					
Geothermal					
Solar Water Heating					
Biomass Combustion					
Generic System					

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		Snow	0	%			Nameplate	1	%
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		Wiring	2	%			Availability	3	%
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More SAM Screenshots

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Number of simulations: 320	OK Cancel	Help

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	Γ	Module temperature {'tcell'} (C) [array]					
	Γ	Plane of array irradiance {'poa'} (W/m2) [array]					
	Shading factor for beam radiation {'shad_beam_factor'} [array]						
	Γ	Sun up over horizon {'sunup'} (0/1) [array]					
	System power generated {'gen'} (kW) [array]						
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Ш	Weather file ambient temperature {'tamb'} (C) [array]						
Ш	Weather file beam irradiance {'dn'} (W/m2) [array]						
Ш	Weather file diffuse irradiance {'df'} (W/m2) [array]						
Ш	Weather file global horizontal irradiance {'gh'} (W/m2) [array]						
Ш	Weather file snow depth {'snow'} (cm) [array]						
	Weather file wind speed {'wspd'} (m/s) [array]						
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