An Assessment of the Impact of Height Dependent Windspeed on Energy Yield Estimation

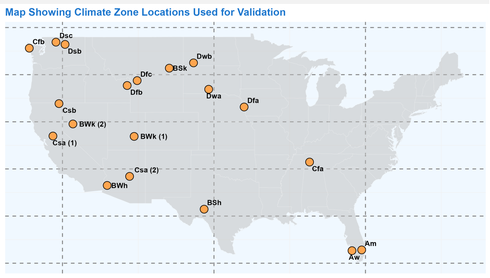
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Abstract

- Meteorological variables, such as solar irradiance, air temperature, humidity, wind speed, and dew point, have an impact on solar generation. This standard set of variables is widely used by the solar industry for many applications such as, establishing reference spectral irradiance distributions.
- Most of these variables are inputs to PV performance models. Performance models like the System Advisor Model (SAM) assume a 10-meter wind speed measurement height. This is a legacy practice, and the PV performance models do not generally have the flexibility to select the actual height of the input wind speed. Additionally, these models have a built-in scaling model to scale the 10 m wind speed to the actual height of PV panels (approximately 2 m).
- The National Solar Radiation Database (NSRDB), which is used as a weather file input to SAM/PVWatts, provides wind speed data at a 2-meter height.
- We demonstrate a systematic approach to evaluate the impact of the use of wind speed at differing heights on the energy yield calculation.
- Sensitivity of PV generation to windspeed height is found to be low and in the order of 0.2-0.3% when 10 m and 2 m windspeeds are considered.

Method

Climate zones based on Köppen-Geiger climate classes.



Main Climates	Precipitation	Temperature
A: equatorial/tropical	W: desert	h: hot arid
B: arid & semi-arid	S: steppe	k: cold arid
C: warm temperate	f: fully humid	a: hot summer
D: snow	s: summer dry	b: warm summer
E: polar	w: winter dry	c: cool summer
	m: monsoonal	d: extremely continental
		f: polar frost
		T: polar tundra

System specifications:

- *Single-axis tracking system:*
  - ❖ 101.589 MWDC
  - ❖ East-West tracking, 180° Azimuth
  - ❖ Ground coverage ratio (GCR) = 0.3
  - ❖ Tracker rotation limit 45° degrees
- *Fixed-tilt system:*
  - ❖ 101.589 MWDC
  - ❖ 20 deg tilt, 180° Azimuth
  - ❖ GCR =0.6

Performance Models

- *CEC Performance Model (CEC) [1] [2]:*
  - SunPower SPR-E19-315 module specs
  - Nominal Operating Cell Temperature (NOCT) model
- *Sandia Array Performance Model (SAPM) [3]:*
  - SunPower SPR-315E-WHT [2007 (E)] module specs
  - Sandia cell temperature model
- *Mermoud Lejeune Performance Model (MLM) [4]:*
  - Module specs copied from CEC model
  - Inverter specs copied from Sandia inverter model inputs to both models

Methodology

1. Setup system specs in SAM; generate PySAM JSON files for use in Python analysis of systems.
2. Run system specs for each of the three models for 19 weather files covering all climate zones. Run each simulation for (a)10 m wind speeds, (b) 10 m wind speed (5^{th} percentile), (c) 10 m wind speed (95^{th} percentile), (d) 2 m wind speed.
3. Export SAM results with annual energy (kWh), hourly power generation (kW), and hourly cell temperatures (deg C).
4. Perform statistical analysis of each system simulation (2 system specs x 3 module models x 19 weather files) assuming 10 m wind speed as ground truth.
5. Investigate trends in results

**Python code will be open-sourced in the future*

Results

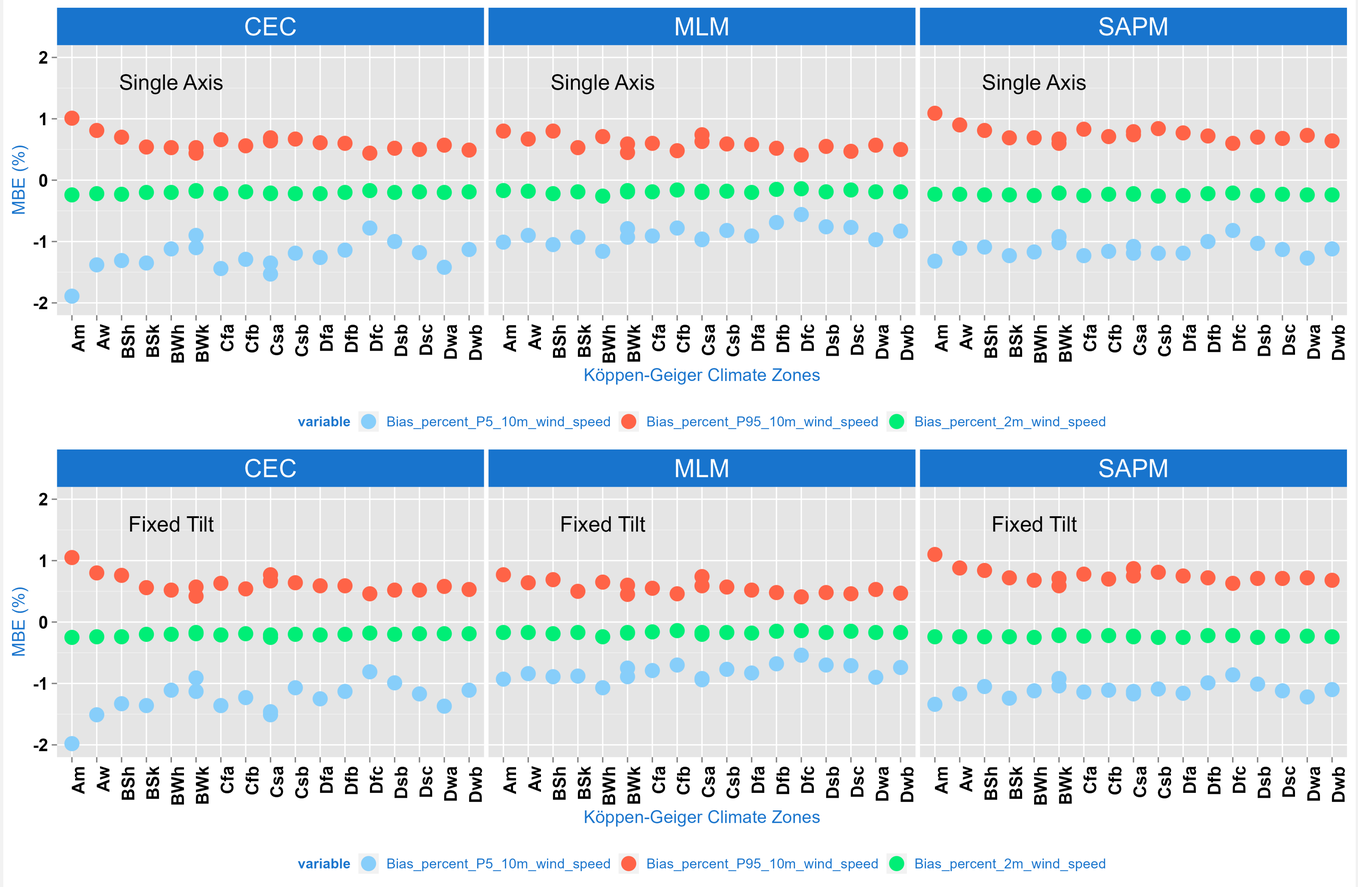


Figure 1: Annual energy yield bias when various wind speed data is used. 10 m wind speed is used as the ground truth.

- Given the small changes of around 0.2-0.3 percent when comparing generation for 10 m vs 2 m windspeed the sensitivity to windspeed height appears to be low.
- When using extreme sustained wind speeds (5 percentile or 95 percentile), we find that generation will differ between 1-2%. This again indicates that sensitivity to wind speed height is low and is not a major factor in generation when compared to other sources of uncertainty.

Reference

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