A Smarter Typical Meteorological Dataset: Advancing Accuracy in Solar Energy Yield Estimation

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Abstract

- As solar energy deployment accelerates, accurate resource data is essential for effective project development and minimizing financing risks.
- Traditional models use typical meteorological year (TMY) datasets, which are based on horizontal irradiance and may not accurately represent generation from PV systems at various orientations.
- This poster introduces an enhanced method using typical plane of array year (TPY) datasets, which account for the specific geometry of solar panels (fixed-tilt and single-axis tracking).
- Analyzing 21 years of National Solar Radiation Database (NSRDB) data, TPYs demonstrate significantly reduced energy yield prediction errors—within ±1%–2% annually versus ±5% or higher with TMYs, and up to ±50% in extreme cases.
- This indicates TMY modeling can introduce considerable yield bias, affecting financial outcomes. TPY-based modeling presents a more accurate, geometry-specific approach for solar energy predictions. This poster presents these findings.

Approach

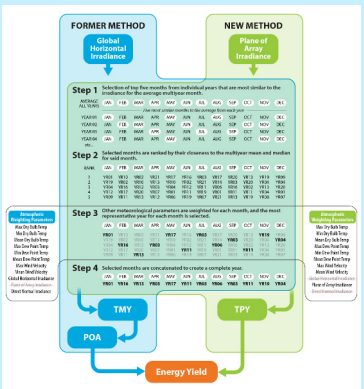

Fig. 1. Schematics of data, workflow, and analysis development process for both TMY and TPY when used to evaluate the energy yield of a solar system.

- Typical meteorological datasets such as TPY or TMY use multiyear hourly time series of GHI, DNI, temperature, dew point, and wind speed data.
- A typical year is formed by selecting months (January to December) based on comparing the cumulative distribution frequency (CDF) of a specific year's month to the long-term monthly average CDF of the same month.
- POA irradiance data for fixed-tilt and single-axis tracking solar arrays are also produced for TPY.
- This new method modifies the original TMY2/TMY3 approach by allocating half of the weights to POA irradiance. Fig. 1 illustrates the architectures and workflows of TPY and TMY, along with energy yield calculations performed using either data source.

Table 1
PV system model inputs examples for energy yield simulations with PVWatts. NH and SH refer to the northern and southern hemispheres, respectively.

Input Description	Fixed Tilt	Single Axis
Azimuth angle (°)	NH: 180° /SH: 0°	NH: 180° /SH: 0°
DC/AC ratio	1.1	1.1
Ground coverage ratio (GCR)(fraction)	0.4	0.4
Inverter efficiency (%)	96	96
System losses (%)	14.08	14.08
System size (MW)	5	5
Tilt (°)	latitude	0 (for the axis)
Software Module	PVWatts7	PVWatts7

- The PVWatts®-derived energy yield predictions for two example PV systems are compared, alternatively using TPY and TMY as the input files.
- Table 1 shows additional inputs used to predict the PV energy yield. These simulations were conducted for the Geostationary Operational Environmental Satellites (GOES) domain of the NSRDB.

Capacity Factor Using TPY Method

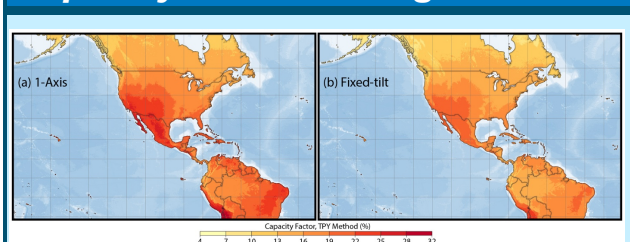

Fig. 2. Average capacity factor (as a percentage) using TPY for (a) single-axis tracking and (b) fixed-tilt PV systems over the Americas. Note: The capacity factor is the ratio of the annual average energy yield of a PV plant divided by the theoretical maximum annual energy production of an ideal plant operating at its peak-rated capacity throughout the year.

Analysis

Analysis Using Köppen-Geiger (KG) Climate Zones

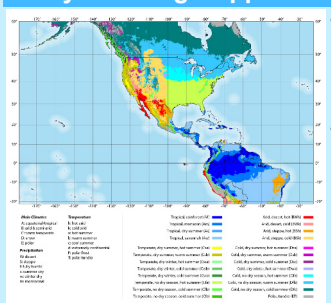

Fig. 3. Köppen-Geiger climate classification map for the GOES domain.

- Classification in Fig. 3 is used for the analysis to gain additional insight by partitioning the yield results by KG climate zones.
- To compare the TMY and TPY energy yield output of the two example PV systems described here, two key statistical metrics are used: mean bias error (MBE) and the Kolmogorov–Smirnov integral (KSI) statistic.

Annual Comparison Result

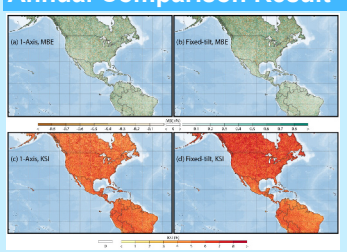

Fig. 4. Annual percent MBE and KSI metrics summarizing the energy yield deviation of the TMY-based method relative to the TPY-based method over the GOES domain for ideal single-axis tracking (left) and fixed latitude-tilt (right) solar PV systems.

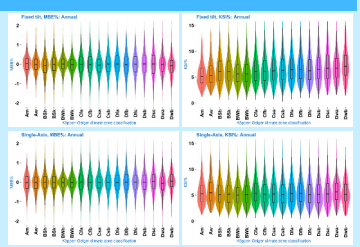

Fig. 5. Annual comparison results using the TMY- and TPY-based methods for both geometries (fixed latitude-tilt and single-axis tracking systems) over CONUS. First column: MBE%, second column: KSI%, classified by climate zones.

Example of Seasonal and Monthly Comparison Result

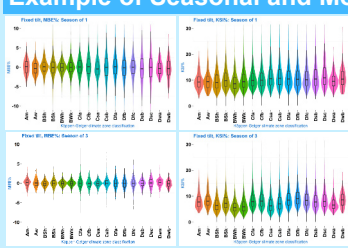

Fig. 6. Seasonal comparison results using the TMY and TPY methods for fixed latitude-tilt system over CONUS. First column: MBE%, second column: KSI%, classified by climate zones. Season 1: winter (December to February), Season 3: summer (June to August).

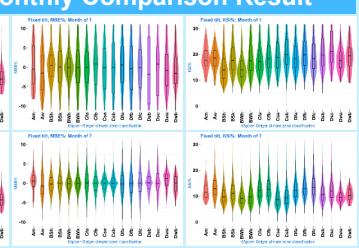

Fig. 7. Monthly comparison results using the TMY and TPY methods for fixed latitude-tilt system for CONUS. First column: MBE%, second column: KSI%, classified by climate zones.

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