Impact of Satellite-Based Solar Resource Models (SRM) on Utility Scale PV System Design and Project Economics

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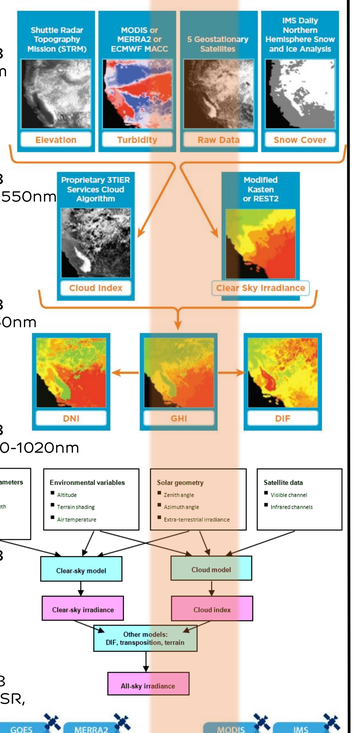
Introduction to Satellite-Based Solar Resource Models (SRMs)

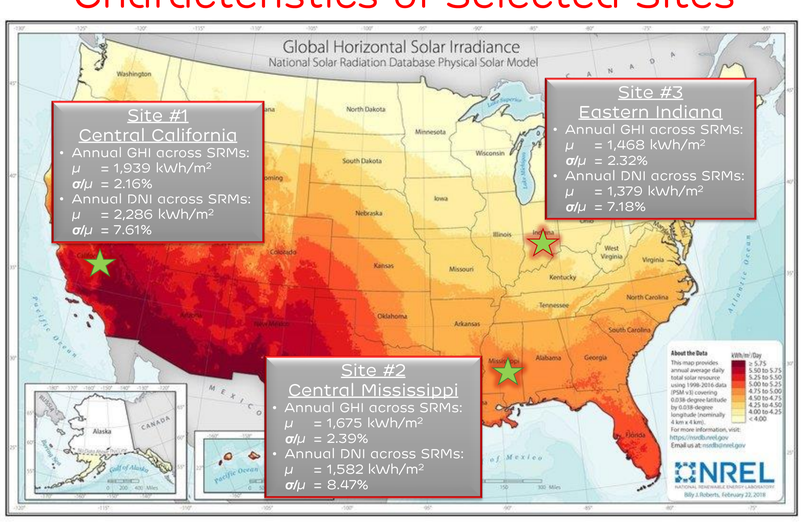
NREL NATIONAL RENEWABLE ENERGY LABORATORY · SOLARGIS · VAISALA · Clean Power Research® Powering Intelligent Energy Decisions® · Meteonorm

- **TMY2**
  by NREL, National Solar Radiation Database (NSRDB)
  - Hourly data from 239 stations (56 primary measured & 183 secondary modeled), **1961-1990**
  - Based on Sandia National Laboratories (Hall *et al.* 1978) method that created the 1952-1975 **SOLMET/ERSATZ** database (TMY1), with modifications
  - Sandia empirical TMY method
- **TMY3**
  by NREL, National Solar Radiation Database (NSRDB)
  - Hourly data from 1020 stations (Class I, II and III), **1991-2005**
  - Based on Sandia National Laboratories (Hall et al. 1978) method that created the 1952-1975 **SOLMET/ERSATZ** database (TMY1), with modifications
  - NREL TMY weighting method

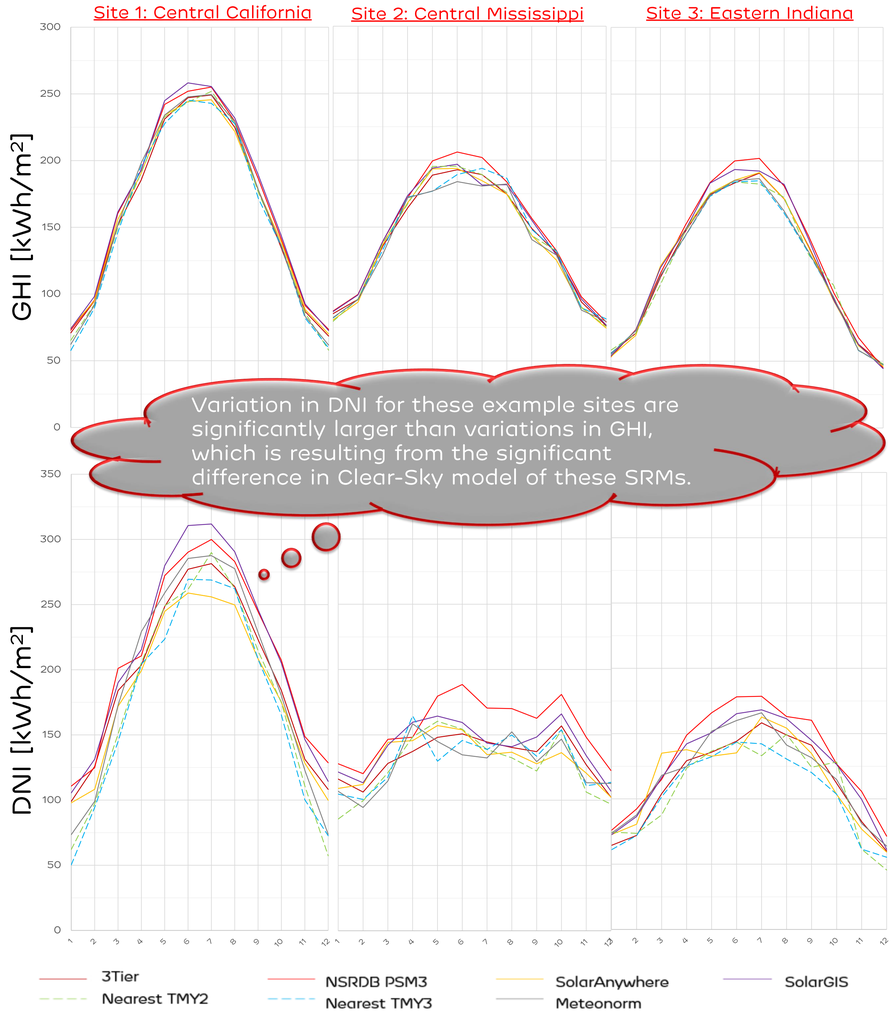
- **Meteonorm**
  Version 7.3.1, by Meteotest
  - Various spatial and temporal resolutions, **1981-1990** and **1991-2010**
  - Data Source: GEBA (WMO), AOD from Solar Consulting Services®
  - **Shepard's Gravity 3-D Inverse Distance Interpolation** amongst nearest stations, coupled with MSG satellite data or ERA5 reanalysis data that uses HelioSAT method
- **3TIER 1.0 Dataset**
  Version 1.0.2, by Vaisala
  - 3x3 km spatial, hourly temporal resolution, **1997-2018**
  - Data Source: GOES, MODIS Terra, Monthly AOD550nm
  - **Modified Kasten** Clear-Sky Radiation Model
  - Proprietary Cloud Model
- **3TIER 1.1 Dataset**
  Version 1.1.2, by Vaisala
  - 3x3 km spatial, hourly temporal resolution, **1997-2018**
  - Data Source: GOES, MODIS Terra/Aqua, Monthly AOD550nm
  - **Modified Kasten** Clear-Sky Radiation Model with Proprietary Cloud Model
- **3TIER 1.2 Dataset**
  Version 1.2.2, by Vaisala
  - 3x3 km spatial, hourly temporal resolution, **1997-2018**
  - Data Source: GOES, MODIS Terra/Aqua, Daily AOD 550nm
  - **Modified Kasten** Clear-Sky Radiation Model
  - Proprietary Cloud Model
- **3TIER 2.0 Dataset**
  Version 2.0.2, by Vaisala
  - 3x3 km spatial, hourly temporal resolution, **1997-2018**
  - Data Source: GOES, ECMWF-MACC, 3-Hourly AOD 380-1020nm
  - **REST2** Clear-Sky Radiation Model
  - Proprietary Cloud Model
- **3TIER 2.1 Dataset**
  Version 2.1.2, by Vaisala
  - 3x3 km spatial, hourly temporal resolution, **1997-2018**
  - Data Source: GOES, MERRA2, Hourly AOD 550nm
  - **REST2** Clear-Sky Radiation Model
  - Proprietary Cloud Model
- **SolarGIS**
  Version 2.1.26
  - 4x4 km spatial, 30min temporal resolution, 1998-2018
  - Data Source: GOES, MERRA2, MACC-II, MeteoSAT, CFSR, CFSv2, GFSprod, *etc.*
  - **SOLIS** Clear-Sky Radiation Model
  - Proprietary Cloud Model
- **SolarAnywhere**
  Version 2.3, by Clean Power Research
  - 10x10 km spatial, hourly temporal resolution, 1999-2018
  - Data Source: GOES in conjunction with various meteorological sources
  - Enhanced **Perez SUNY v1.0** Clear-Sky Radiation Model
  - Proprietary Cloud Model
- **Physical Solar Model (PSM)**
  Version 3.0.2, by NREL National Solar Radiation Database (NSRDB)
  - 4x4 km spatial, 30min temporal resolution, 1998-2017
  - Data Source: GOES, MERRA2, MODIS, IMS, *etc.*
  - **FARMS** All-Sky Radiation Model, coupled with **REST2** Clear-Sky Radiation Model
  - **PATMOS-x** Cloud Properties Retrieval



Characteristics of Selected Sites

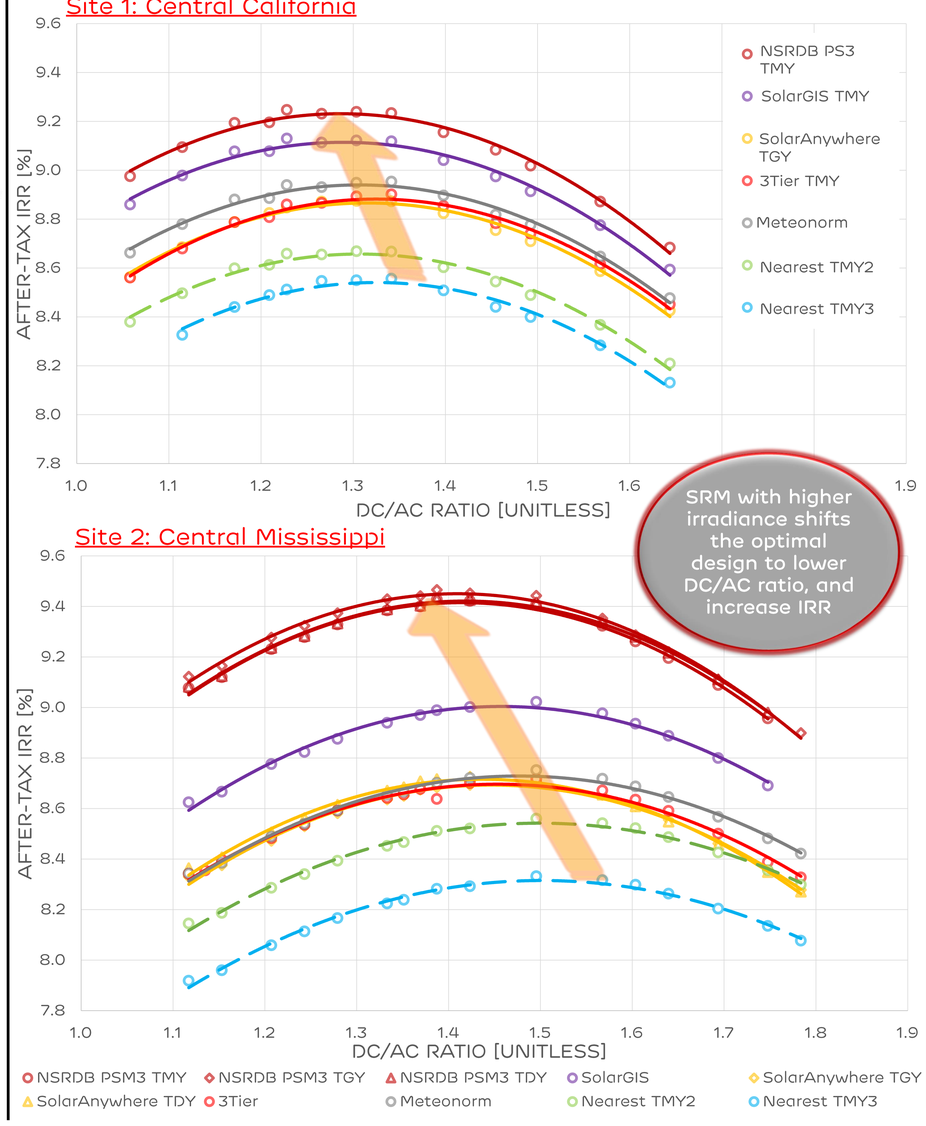


Monthly GHI & DNI of Selected Sites

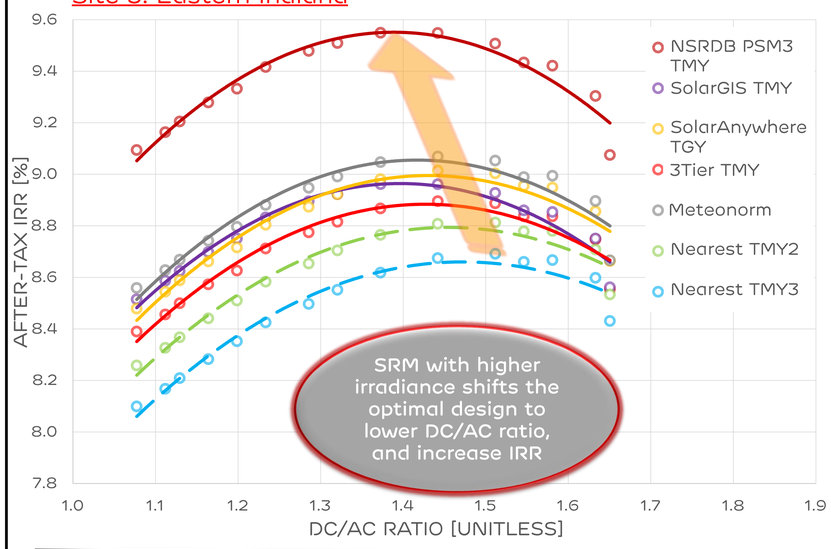


SRM Impact on Design Optimization

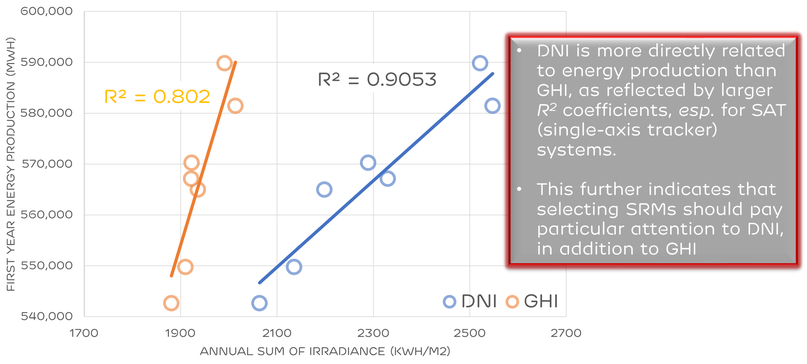
After-Tax IRR vs DC/AC Ratio



After-Tax IRR vs DC/AC Ratios – Cont.



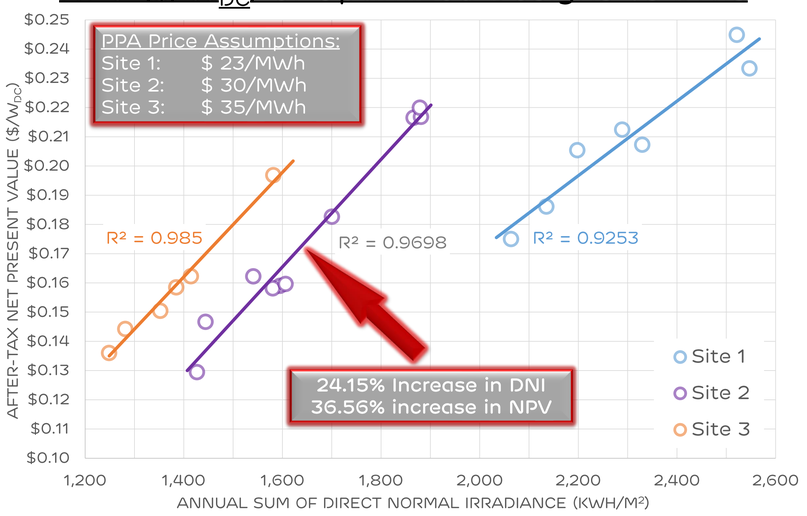
DNI GHI Impacts on Energy Production



- DNI is more directly related to energy production than GHI, as reflected by larger R^2 coefficients, *esp.* for SAT (single-axis tracker) systems.
- This further indicates that selecting SRMs should pay particular attention to DNI, in addition to GHI

SRM Impact on Project Economics

NPV ($/W$_{DC}$) of Optimized Designs vs DNIs



Key Takeaways / Summary

- Accurate evaluating solar resource models (SRMs) is of paramount importance to both design optimization and project economics.
- Project design in terms of optimal DC/AC ratio is strongly dependent on SRMs; higher irradiance in general enables designing at lower DC/AC ratio, and consequently better economics, *e.g.* higher IRR and NPV.
- Example site with high variations in DNI across SRMs (at Central Mississippi, 8.47% Coefficient of Variance), a 24.15% increase in DNI results in a 36.56% increase in NPV, which represents roughly $0.09/W$_{DC}$ difference. This means $9 Million difference for a 100MW$_{DC}$ project!!
- DNI is more directly related to energy production, *esp.* for single-axis tracker systems, therefore SRM selection should pay particular attentions to DNI, in addition to GHI.
- False SRM selection (as a result of such as merely looking at GHI alone, improperly averaging/balancing SRMs, *etc.*) could lead to false optimization on higher or lower DC/AC ratios with lower or higher project economics, respectively.