

Clean Power Research

International Solar Energy Society Webinar Quantifying Gains in Solar **Project Value from Quality** Satellite & Ground Data

May 23, 2017 Skip Dise, Clean Power Research

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Forces Shaping the Energy Transformation





Distribution Optimization

TODAY'S FOCUS

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Quality & Type of Ground Measurements



Use of SolarAnywhere Satellite Data

Impacts on Project Uncertainty



Gains in Project Value

Return on Ground Campaign



BEYOND THE SCOPE





TMY3 or other public data set comparisons



Shifts in P50 from satellite to ground tuning



Factors unrelated to solar resource uncertainty



Bank negotiated financial terms



Probability of Exceedance methods



TIGHTENING UNCERTAINTY OF P99

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Investment in Ground Measurements Can Increase P99

BASELINE SolarAnywhere

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- Version 3.2
- Data Validated and Widely Accepted
- Uncertainty Rate Known and Accepted
- Long History and Data Currency
- Spatially Precise
- Built for Solar

ACROSS

REPRESENTATIVE CLIMATE ZONES



Source: https://www.solaranywhere.com/validation/leadership-bankability/

BEST PRACTICES FOR GROUND MEASUREMENT

- High quality, maintained instrumentation
- Redundant irradiance measurements
- 1 year minimum campaign, 2 preferred¹
- Weekly technician visits
- Actionable data quality program
- Descriptive metadata

1. Alfi, James, et al. Importance of Input Data and Uncertainty Associated with Tuning Satellite to Ground Solar Irradiation, Photovoltaic Specialists Conference (PVSC) 2016 IEEE 43rd.





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Secondary Standard GHI







Secondary Standard GHI + GroundWork PVSOIL





Secondary Standard GHI + GroundWork PVSOIL + Diffuse





Secondary Standard GHI + Diffuse + DNI

Factor		Data Source	Uncertainty
	Solar Resource	Ground and/or satellite irradiance	3.0-5.0%
	Interannual Variability	Satellite history	2.5-8.0%
	Transposition to Plane of Array	<i>Decomposition:</i> modeled or ground diffuse irradiance <i>Transposition:</i> calculated	3.5-12.7%
00	Soiling	Estimated or ground soiling studies	1.0%-4.0%
Energy Simulation, Plant Loss and Degradation			



Root Sum of the Squares



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Source	Ground	Tuned Satellite
SolarAnywhere V3.2 GHI	n/a	5%
Secondary Standard GHI	$3.5\%^{1}$	2.6%
Component Sum GHI	$2.1\%^{2}$	2.6%

- Satellite data is tuned with ground data
- Component sum GHI eliminates cosign error of secondary standard pyranometer

1. Habte, A. et al., Method to Estimate Uncertainty in Radiometric Measurement Using the Guide to the Expression of Uncertainty in Measurement (GUM) Method, NREL, March 2015 ASR Science Team Meeting



INTERANNUAL VARIABILITY

Source	Low Interannual Variability	High Interannual Variablitity
SolarAnywhere V3.2	2.5%	8.0%

- Uncertainty is climate dependent (example site shown here)
- Annualized and 4-month cumulative distribution functions (CDFs)



Yearly Dissection	Data Points	Avg (µ)	Std dev (o)	RE (σ/μ)
Whole Year	18	2,029,496	57,712	2.84%
Four-month	5,832	2,029,023	50,270	2.48%



Source	Uncertainty
Modeled Diffuse	$12.7\%^{1,2}$
Measured Diffuse	8.0% ³
Measured Tracking DNI/Diffuse	2.1%

- Uncertainty comprises Decomposition and Transposition to POA
- Decomposition models estimate DHI and DNI given GHI
- Can estimate or measure DHI
- Transposition to POA is calculated based on plant type

1. Gueymard, C.A., From Global Horizontal To Global Tilted Irradiance, Solar 2008 ASES

2. Lave, M et al., Evaluation of Global Horizontal Irradiance to Plane of Array Irradiance Models at Locations across the United States, Sandia PV Performance Workshop

3. Badosa, J. et al., Solar Irradiances measured using SPN1 radiometer, Atmospheric Measurement Techniques





Source	Uncertainty	
Estimated	4.0%	e
Measured – GroundWork PVSOIL	1.0%	

- Blanket annual estimate between 1-5%
- Measured soiling allows for determination of soiling ramp rates
- Can confidently model:
 - Monthly estimates
 - Max soiling value
 - Frequency of precipitation (cleaning) events



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QUANTIFYING GAINS: FINANCIAL ASSUMPTIONS

Assumption	Value
CapEx Cost	\$1.50/ watt
Unlevered ATIRR	7%
Gross Margin	75%
Debt Term	20 years
Debt Rate	5%
Debt Size	1.0 P99 DSCR
NPV Discount Rate	8%



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Ground Measurements	Project Uncertainty	NCF _{p99} %	\$/W Gain	ROI on 25MW
Satellite Only	10.2%	19.5%	Baseline	Baseline
Satellite + Secondary Standard GHI	8.6%	20.5%	\$0.011	5.3X
Satellite + Secondary Standard GHI + Soiling	8.4%	20.6%	\$0.012	5.0X
Satellite + Secondary Standard GHI + Diffuse + Soiling	6.6%	21.7%	\$0.022	8.8X
Satellite + Secondary Standard GHI +DNI/Diffuse + Soiling	4.9%	22.7%	\$0.035	8.3X

QUESTIONS & ADDITIONAL RESOURCES

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• Literature:

- https://www.solaranywhere.com/validation/leadership-bankability/

- Recorded Webinar:
 - http://go.cleanpower.com/SA_GroundWork_Webinar_Registration.html
- 5 Factors of Bankable Solar Resource Data:
 - <u>https://www.cleanpower.com/2016/infographic-five-factors-bankable-irradiance-data/</u>
- Company Websites:
 - <u>https://www.grndwork.com</u>
 - <u>https://www.cleanpower.com</u> or <u>https://www.solaranywhere.com</u>





Questions and Answers

Thank you for joining us

Additional Questions? Skip Dise, skipdise@cleanpower.com

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Note: Today's presentation is being recorded and will be provided within 48 hours.



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Poll Question







Poll Question

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Poll Question

- Solar industry leader for MET equipment and services
- Early entrant working with NREL in 2008
- HQ in Monterey California
- Shop in Southern California
- US, Mexico and Canada
- 40 full time staff

