solar energy

June 2012

Solar Input Data for PV Energy Modeling

Marie Schnitzer, Christopher Thuman, Peter Johnson

Company Snapshot

- Established in 1983; nearly 30 years of renewable energy industry experience
- Independent assessments on 50,000+ MW
- Project roles in over 80 countries

- Over 100 professional staff
- Experts in meteorology, spatial analysis, environment, and engineering
- Seasoned project managers and field technicians

Agenda

1. Why is Solar Data Uncertainty Important?
2. What Data are Available?
3. How do Available Data Differ?
4. Case Study Results

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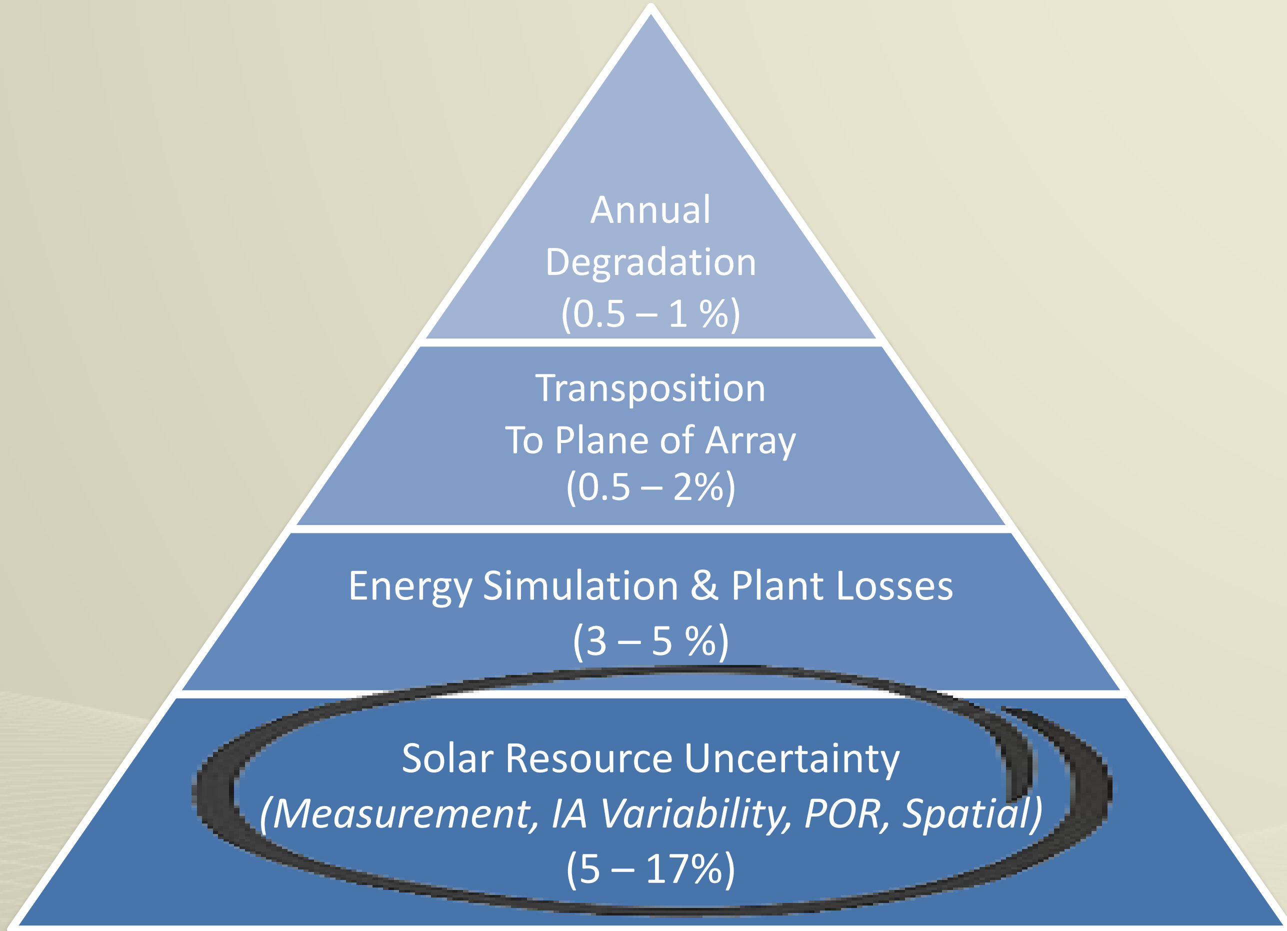
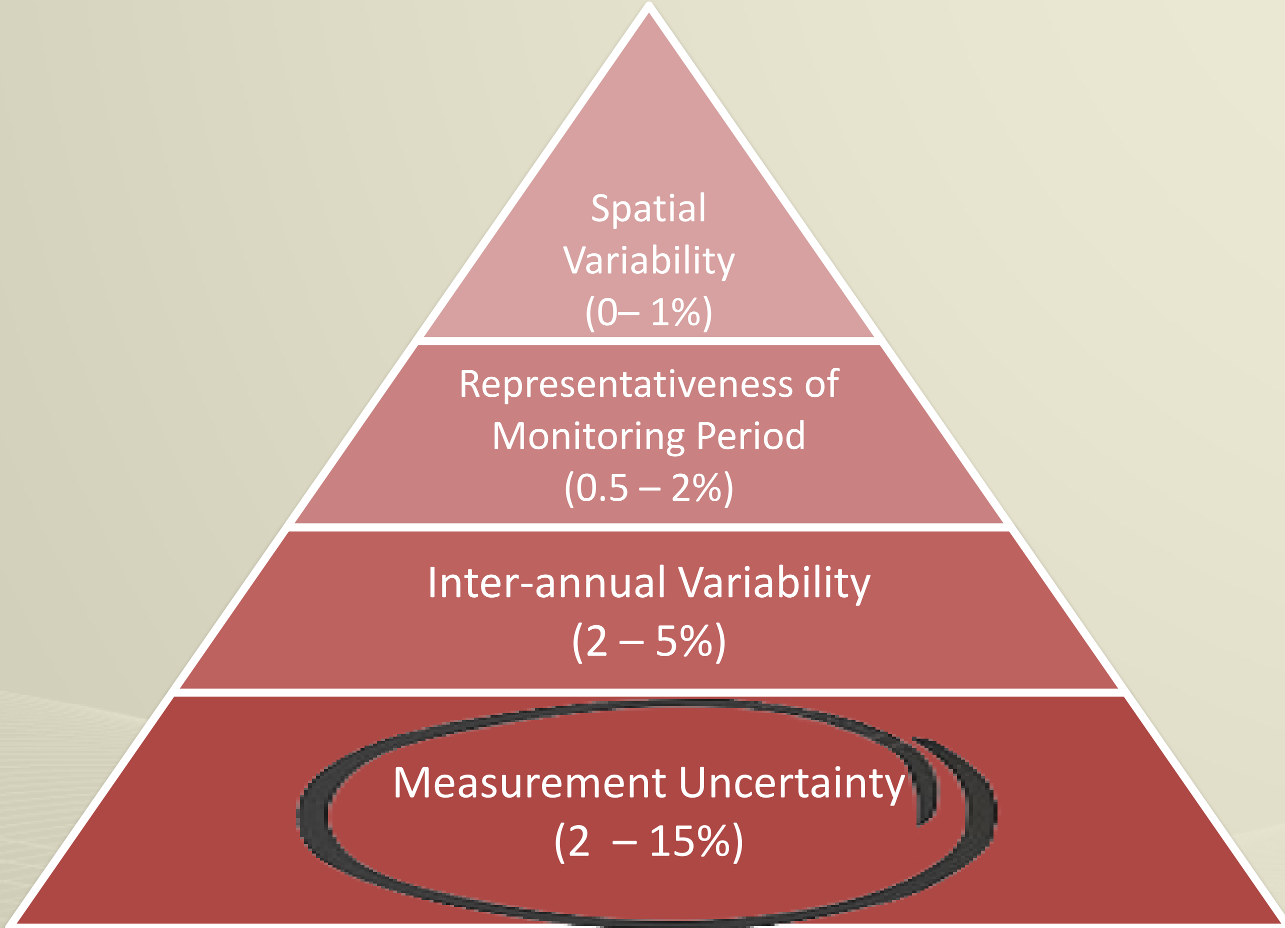
Sources of Energy Uncertainty



Sources of Solar Resource Uncertainty



Reducing measurement uncertainties in the solar resource assessment will make the project more attractive and less risky to outside investors

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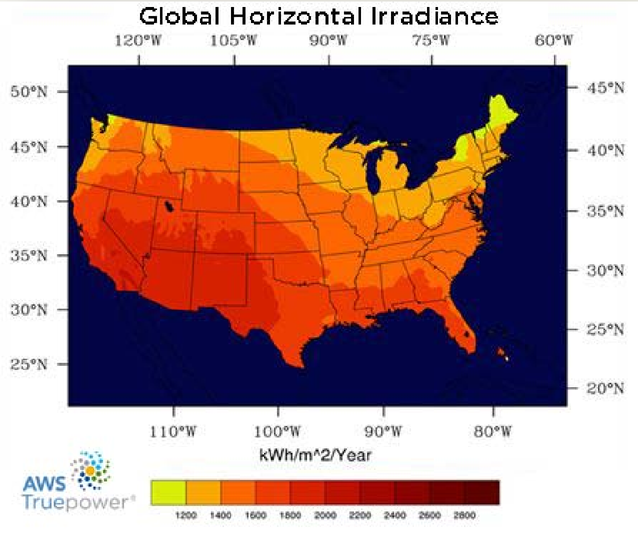
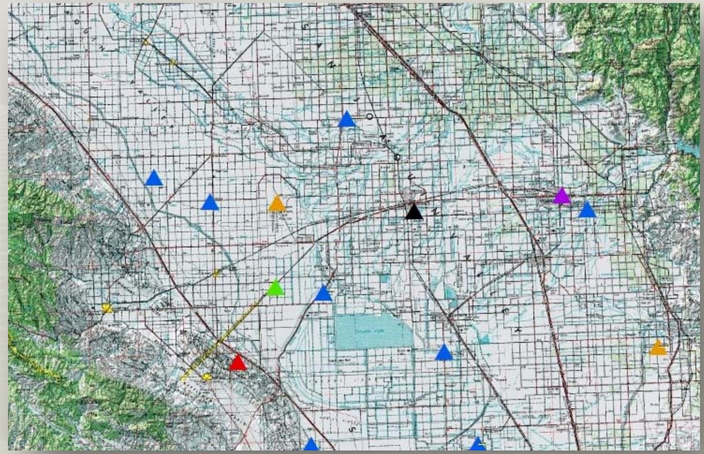
Data Sources

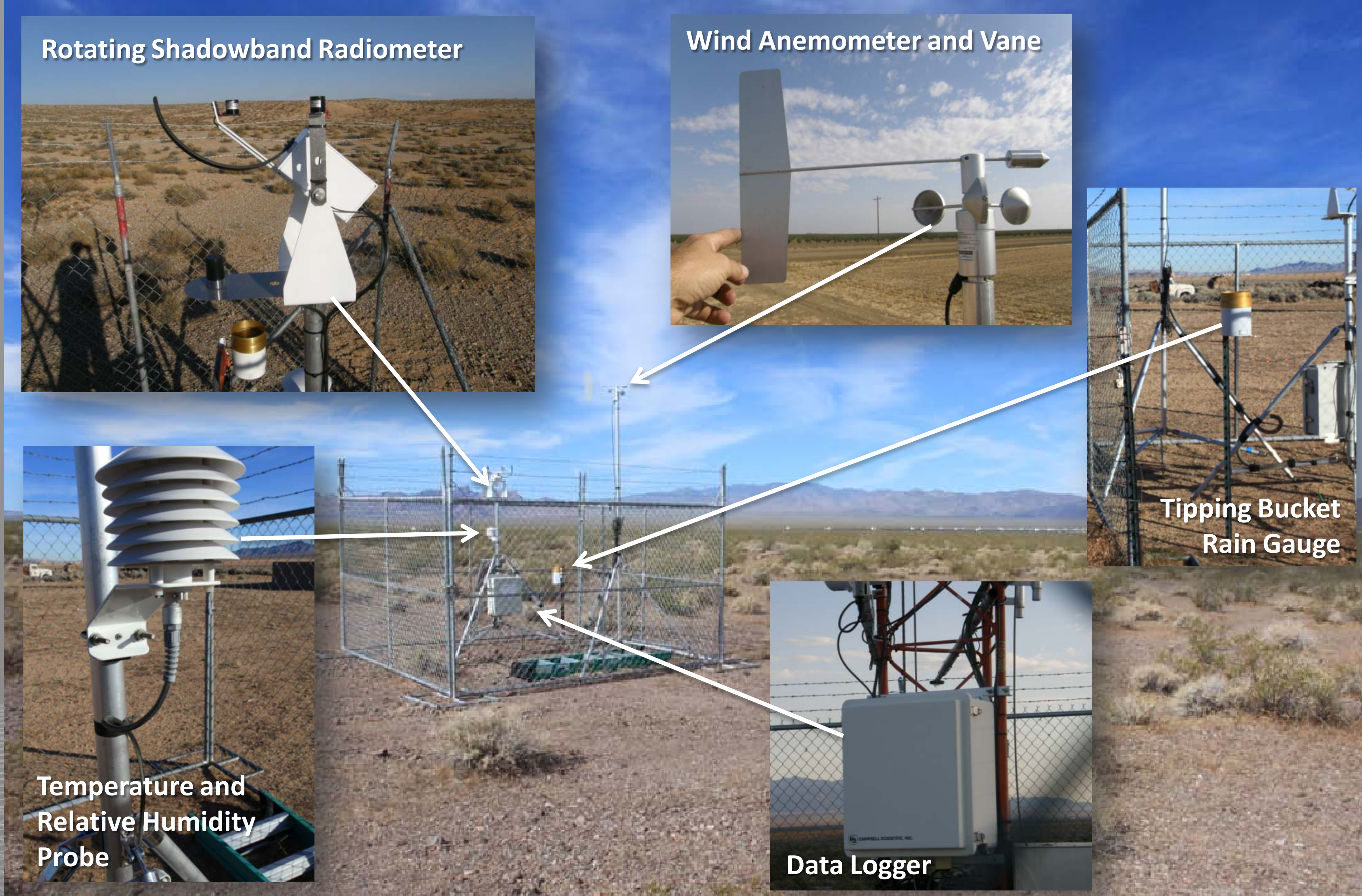
On-site Measured Data

Modeled Data – Various Sources



Nearby Reference Station Data





An Example Solar Resource Monitoring System

On-Site Monitoring Best Practices

Measurement Plan

- Solar instrumentation
- Meteorological: temperature, wind speed, precipitation
- Sampling/recording rate
- Measurement period

Installation and Commissioning

- Site selection
- Sensor verification
- Communications and data QA
- Documentation

Site Maintenance

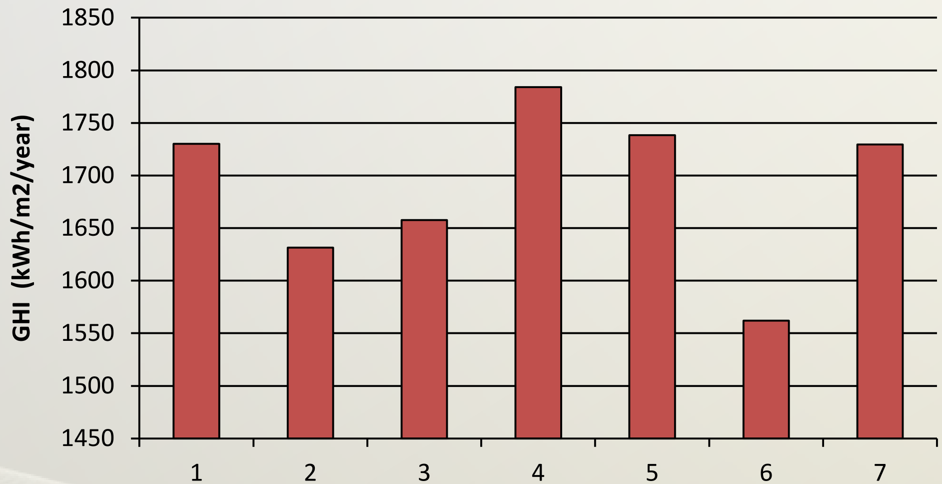
- Regular schedule
- Clean, level instrumentation
- Site security

Data Validation and Quality Control

- Regular system monitoring
- Comparison with reference data and concurrent satellite data
- Visual data screening
- Clear sky / extreme values

Modeled Data Sources

- US National Solar Radiation Database (NSRDB)
  - Mostly modeled solar data using numerical and satellite models
  - NSRDB TMY3 data set for specific locations in U.S



Long Term GHI from TMY3s near Dallas, TX

  - 14% difference in a 60km radius around Dallas, TX
- Other sources of public and private modeled data (Meteonorm, NASA, others)

Data Source Advantages and Limitations

Data Source	Advantages	Limitations and Risks	Intended Use
On-Site Measurements	• Site-specific data • Customized for project needs • Station details well-known • Reduced uncertainty	• Shorter period of record (correlate with long-term data)	• High-confidence resource and energy estimates • Bankable reports • In-depth characterization of seasonal and diurnal climate
Observed Reference Station	• Ground measurements • Period of record may be longer • Publicly available	• Scarcity of sites • Location compared to project site • Uncertainty: quality of O&M, instrumentation, inconsistencies in data	• Confirm trends • Identify regional biases • Correlation with on-site data
Modeled	• Grid-cell specific • Publicly available • High data recovery	• Grid resolution • Regional biases • Greater uncertainty	• Initial prospecting • Smaller projects • Correlation with on-site data

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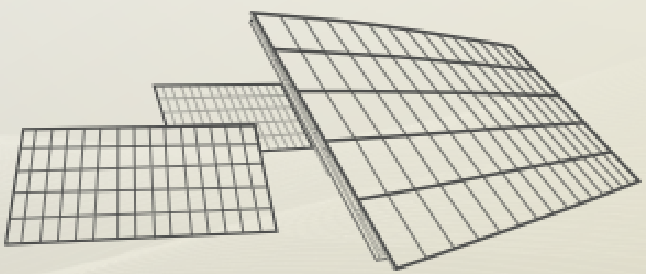
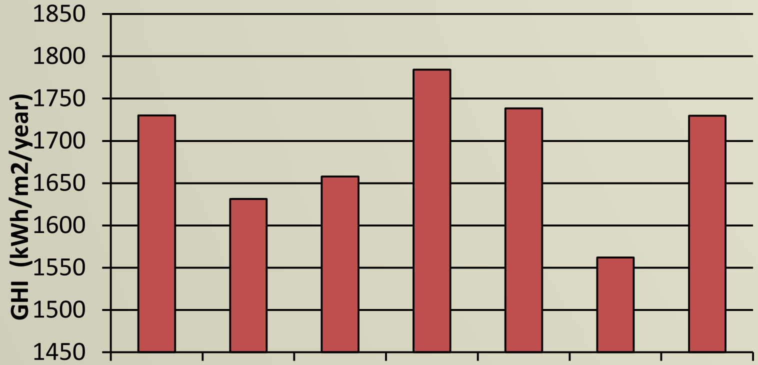


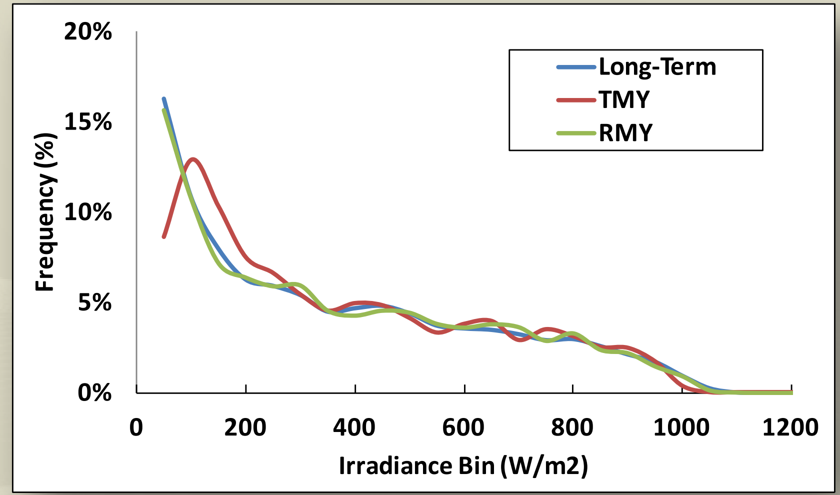
How do Available Data Differ?

Variation in Magnitude



Long Term GHI from TMY3s near Dallas, TX

Variation in Distribution



Comparison of Modeled and On-Site Data Sets

- Obtained Long-term GHI estimates from seven modeled data sources.
- Compared to long-term GHI estimate measured at NREL-sponsored stations.
- Compared frequency distribution of modeled and measured data sets.

How do Available Data Differ?

Variation in Magnitude

Data Source	Resolution	Avg Absolute Diff from NREL Station	Max Absolute Diff from NREL Station	Standard Deviation
SUNY	10 km	2.9%	9.1%	4.0%
CPR	10 km	2.0%	9.2%	3.5%
Meteonorm	Interpolation	4.2%	10.8%	5.7%
Closest TMY3	NA	3.6%	6.9%	4.1%
Closest Class I TMY3	NA	1.8%	2.7%	1.4%
Closest TMY2	NA	2.4%	6.0%	2.5%
NASA SSE	1 degree	2.4%	5.0%	2.7%

- Up to 10.8% variation from measured long-term.
- When translated to energy, this difference has a similar percentage impact on the projected energy output.

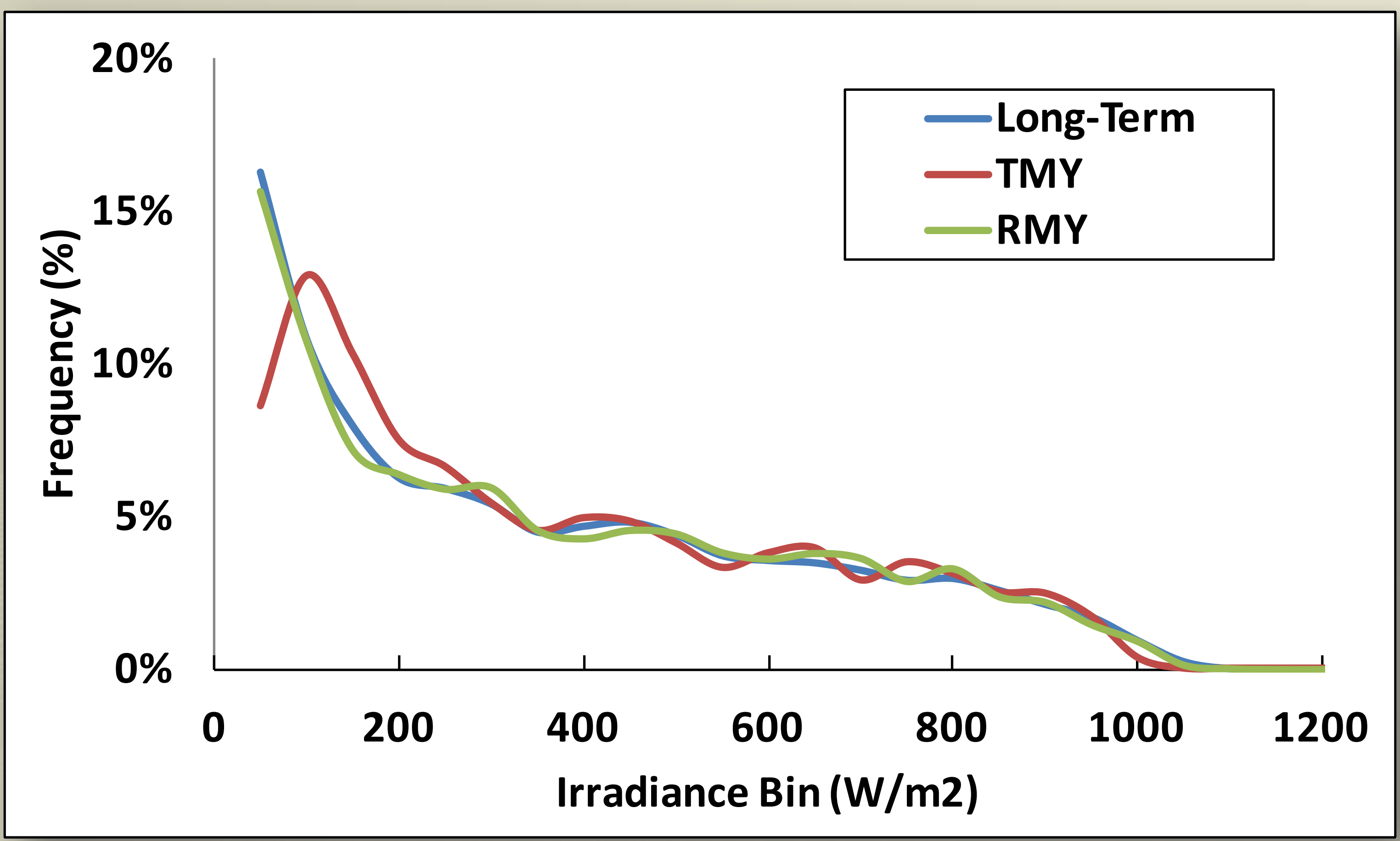
How do Available Data Differ?

Variation in Distribution

- Typical Meteorological Year (TMY) using satellite-modeled data.
- Compared to on-site distribution in a representative meteorological year (RMY) scaled to same long-term GHI.
- RMY = one year of on-site measurements scaled to long-term GHI.

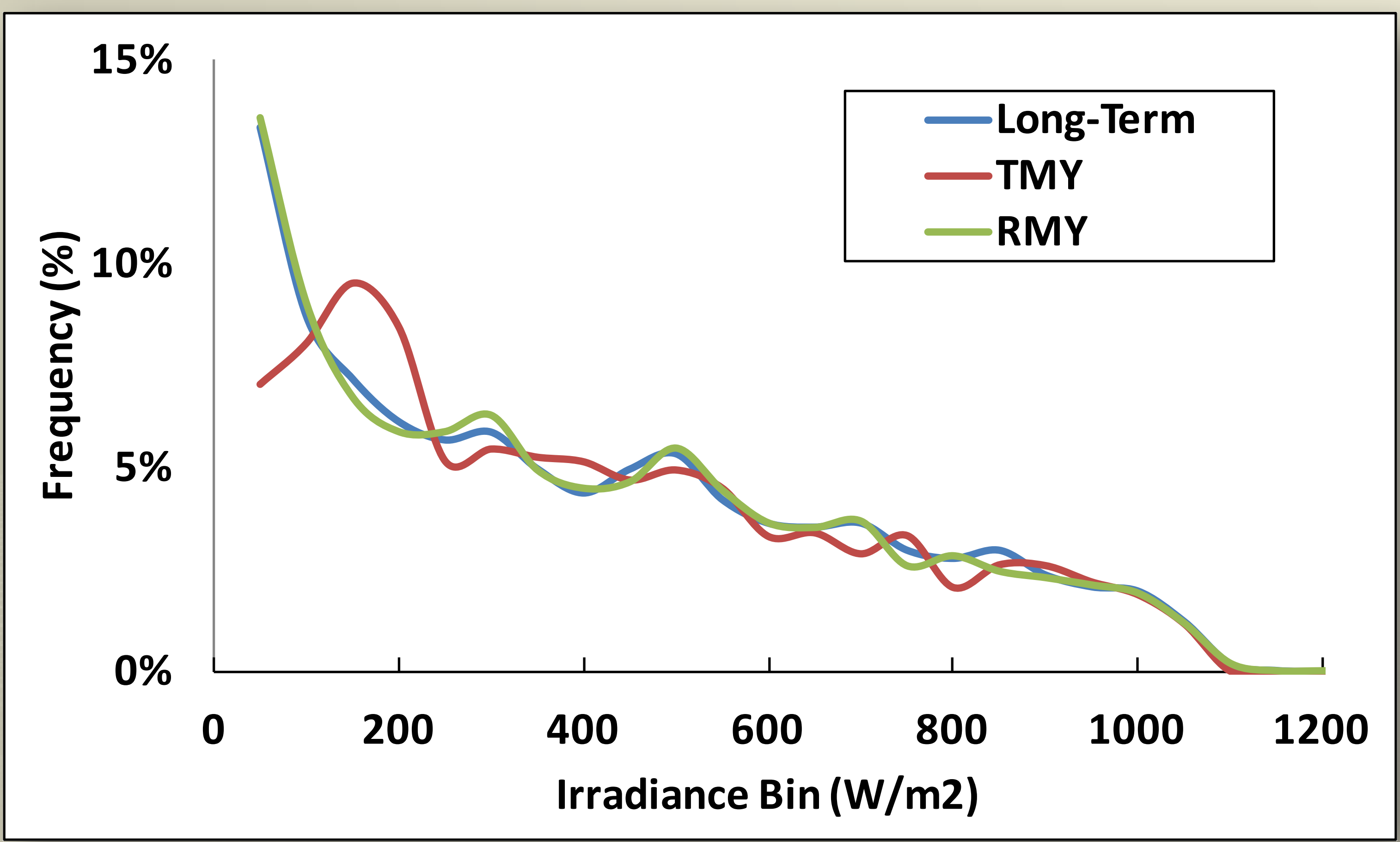
How do Available Data Differ?

Variation in Distribution



How do Available Data Differ?

Variation in Distribution



How do Available Data Differ?

Variation in Distribution

- Variation can result in up to 4% in energy production estimates.
- When translated to energy, this difference has a similar percentage impact on the projected energy output.
- Strengths and limitations exist for each data set.

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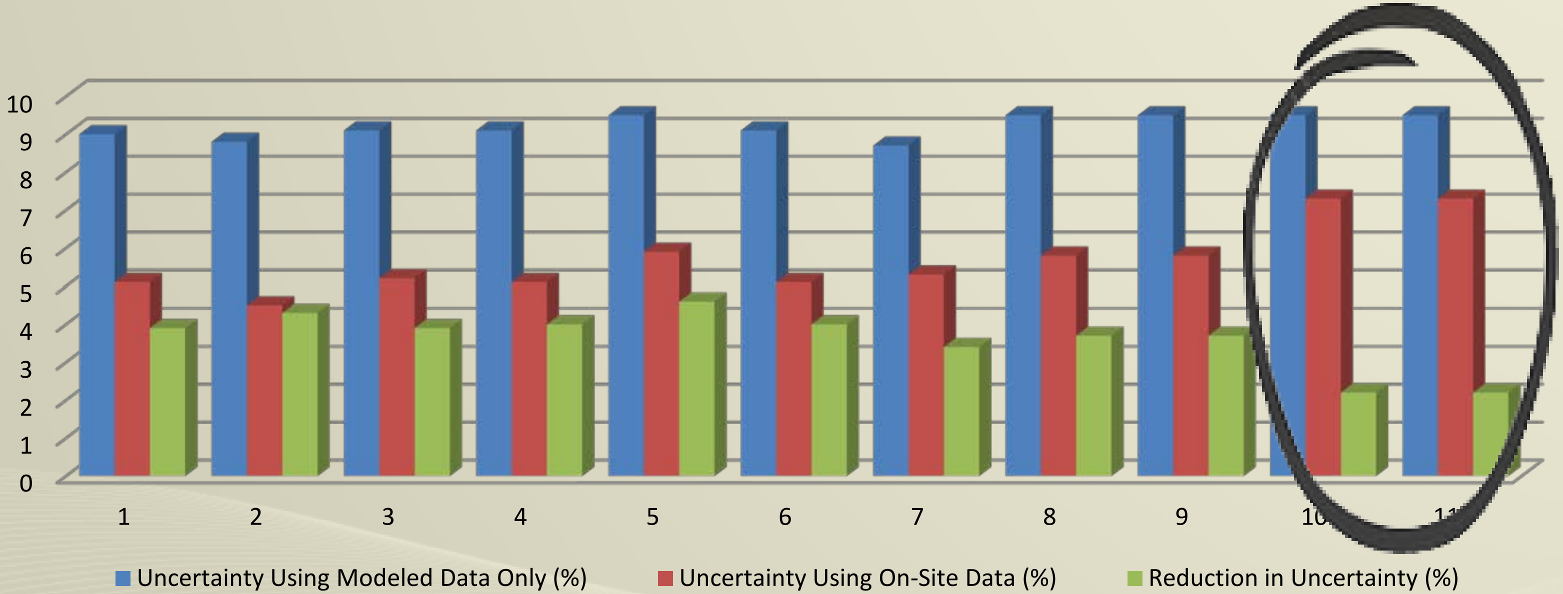
The Case Study

Approach

- 11 sites with 1-2 years of on-site measured data
- 2 solar energy assessments for each site
  - Modeled data alone
  - On-site measurements projected over project life
- Uncertainty assessment for each scenario

Uncertainty Difference: Modeled vs. Onsite

Average uncertainty reduction of over 3.5%, range from 2.2% to 4.6%
(3.9% reduction excluding outliers for maintenance practices)



Sites 10 and 11 represent monitoring programs that didn't employ best practices, corresponding to higher uncertainty.

What Does it Mean?

Based on this case study, combined project uncertainty (solar resource and energy uncertainty) was compared for modeled data and on-site data:

Solar Data Source	Solar Resource Uncertainty (from case study)	Typical Uncertainty for Energy	Combined Project Uncertainty
Modeled Data	8.7 - 9.5%	5.0%	10.0 – 11.0%
On-Site Measured Data*	4.5 – 5.9%	5.0%	6.7 – 7.7%

*Represents on-site monitoring program following best practices.

Effect of Uncertainty

On-Site Solar Data

↓

Reduced Uncertainty

↓

Higher Confidence in Project Return

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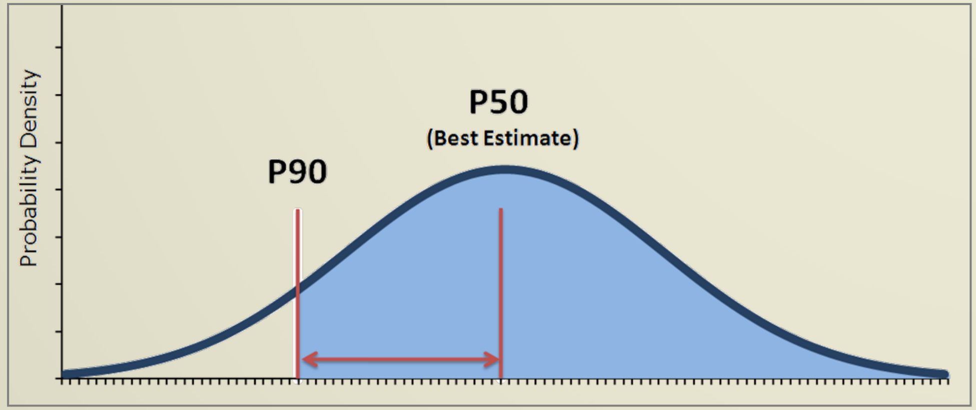
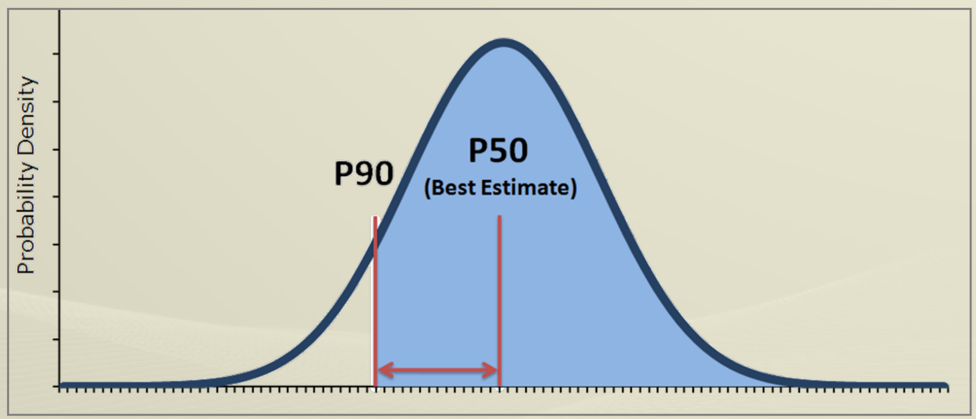
Project More Attractive To Investors





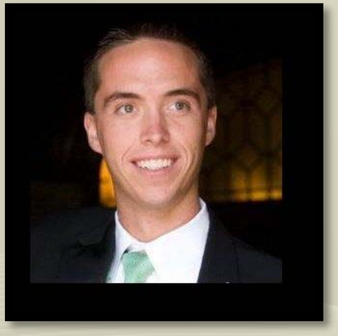
On-site monitoring can increase the P90 by over 5% and the P99 by over 10%.

Conclusions

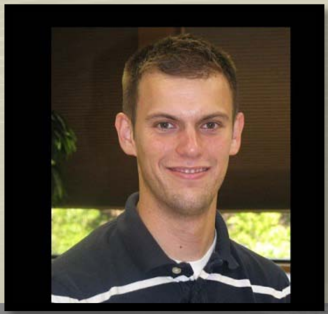
- Site-specific measurements increase accuracy of P50.
- Site-specific measurements better reflect solar frequency distribution than modeled data sources.
- On-site monitoring with best practices reduces energy uncertainty by 3.5% or greater.
- On-site monitoring can increase the P90 by over 5% and the P99 by over 10%.
- **On-site monitoring = greater confidence in energy estimates.**

Author Biographies

Marie Schnitzer, Senior Director of Investor and Solar Services
Ms. Schnitzer has been involved in the management of renewable and alternative energy power generation programs since the early 1990s. Ms. Schnitzer provides strategic leadership and technical expertise in the development of the company's solar program, including resource and energy assessment, project consulting, due diligence, independent engineering, operational assessment and forecasting. Ms. Schnitzer holds a B.S. degree in Chemical Engineering and a M.S. in Business Administration.



Christopher Thuman, Senior Meteorologist
Mr. Thuman supports the application of meteorological measurement and analysis techniques for the solar industry. His background includes solar and wind resource measurement, solar monitoring system installation and maintenance, energy production estimates, project loss estimates, and project uncertainty. Mr. Thuman currently oversees the monthly data acquisition, analysis, and project management for over 30 solar monitoring systems. Mr. Thuman holds a B.S. degree in Meteorology and a M.S. in Environmental Science.



Peter Johnson, Engineer
Mr. Johnson is actively involved in supporting solar resource data collection and validation activities at AWS Truepower. He is involved with solar energy modeling, including energy assessment, loss assumptions, and uncertainty estimates for multiple utility-scale projects in the U.S. and abroad. He holds a B.S. degree in Mechanical Engineering.

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Questions

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