Multiple Satellite Models for On-Site Long-Term References

Eva Plaza Sanz – Senior Renewable Energy Analyst
Peter Johnson – Senior Project Engineer
Lucy Tafur-Gamarra – Renewable Energy Analyst

Empowering Trust™

Global HQ: Chicago
Advisory US Offices:
Albany, San Diego

200,000+ MW
Total megawatts assessed

500+
RENEWABLE ENERGY EXPERTS

35+ *years of*
EXPERIENCE IN RENEWABLE ENERGY

ADVISED 90%
OF THE WIND INDUSTRY'S TOP PROJECT DEVELOPERS AND PLANT OWNERS

INDEPENDENT/OWNER'S ENGINEER FOR
500+
WIND AND SOLAR PROJECTS SINCE 2012

Forecast provider for
70+ GIGAWATTS
OF INSTALLED RENEWABLE ENERGY PROJECTS

Using multiple satellite models as long-term references for measure-correlate-predict analyses:
(1) improves accuracy of results and
(2) mitigates prediction risk.

Presentation Outline

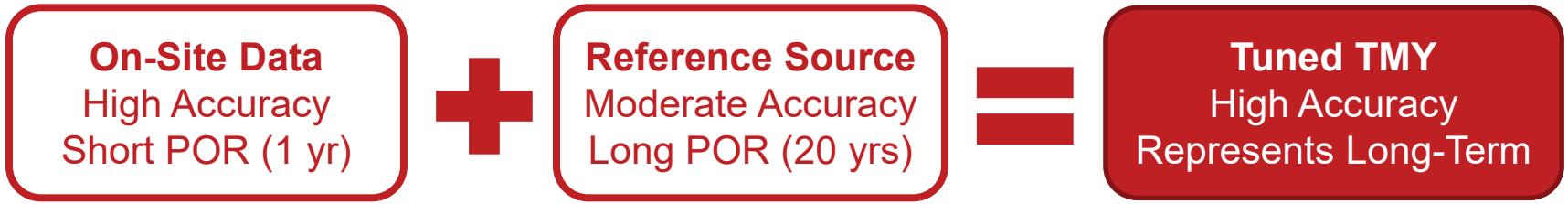
- Measure-Correlate-Predict Approach
- MCP with On-Site Weather Stations
- MCP with Operational Energy Estimates
- Why Multiple References are Important

Presentation Outline

- **Measure-Correlate-Predict Approach**
- MCP with On-Site Weather Stations
- MCP with Operational Energy Estimates
- Why Multiple References are Important

Measure-Correlate-Predict Approach

1. **Measure:** collect one year of high quality irradiance/power measurements
2. **Correlate** to long-term reference data from multiple satellite models
3. **Predict:** adjust modeled estimate for observed model bias
4. **Uncertainty** for measurements, correlation, long-term adjustment



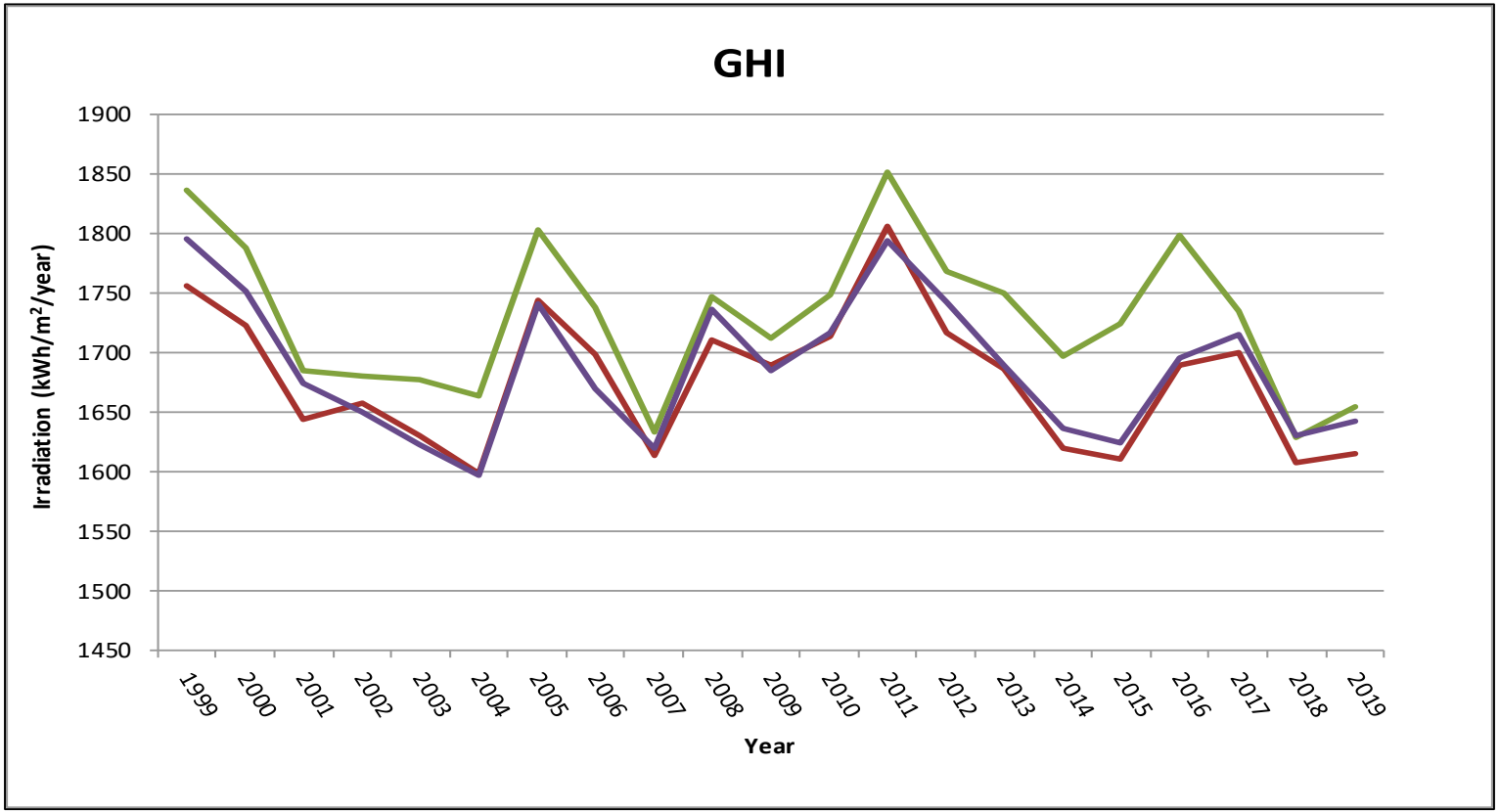
Presentation Outline

- Measure-Correlate-Predict Approach
- **MCP with On-Site Weather Stations**
- MCP with Operational Energy Estimates
- Why Multiple References are Important

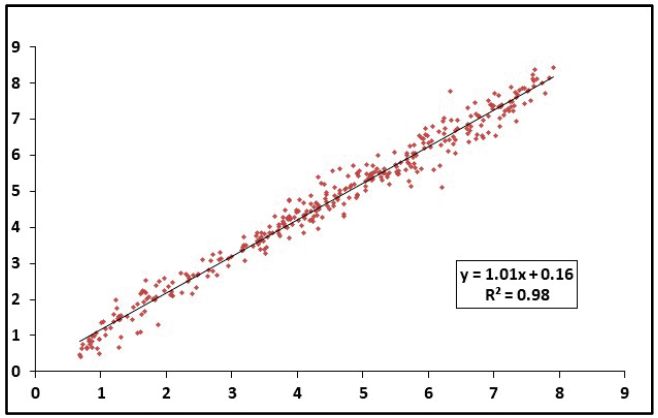
Solar Met Measurements

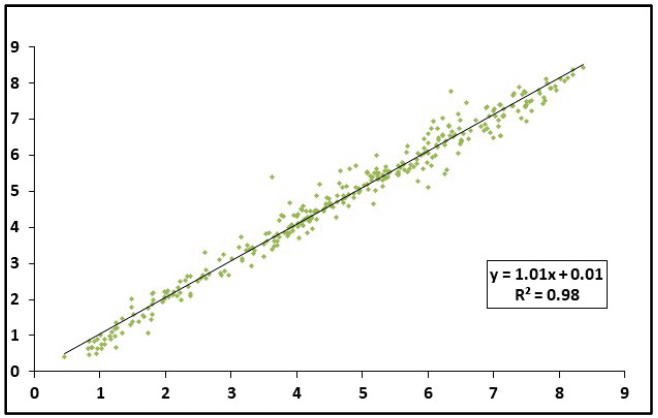
- Two Class A pyranometers: heating/ventilation
- Weekly maintenance for cleaning and leveling
- Weekly meteorological desktop screening
- At least one complete year of measurements, which mitigates seasonality risk
  - Modeled seasonal biases: may differ from annual biases in magnitude and direction
  - Shorter PORs result in more uncertainty than models themselves

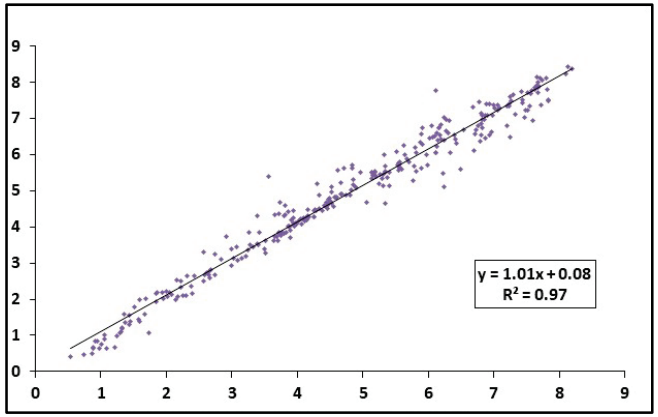
Measure-Correlate-Predict with Satellite Models



Measure-Correlate-Predict with Satellite Models







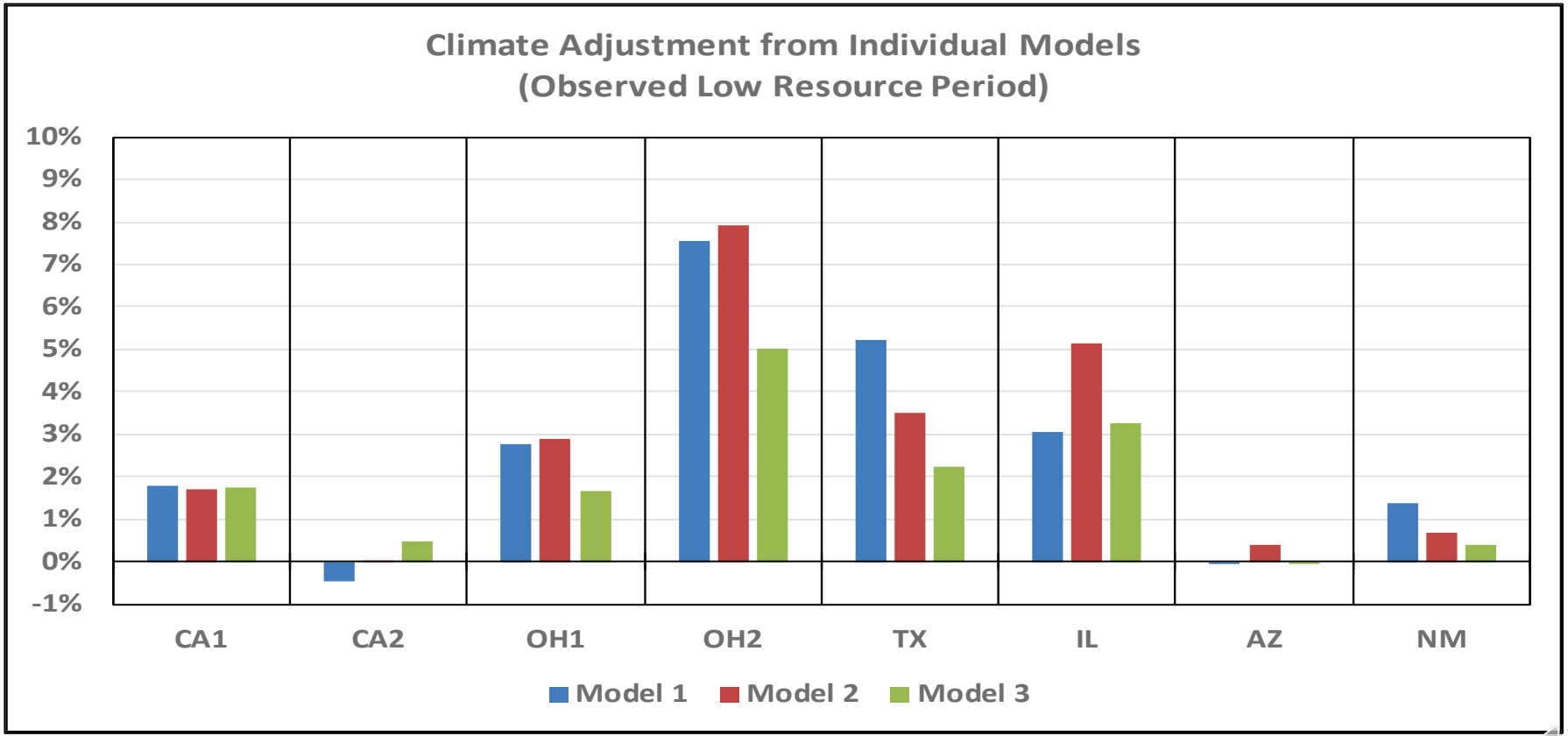
- Establish linear relationship: $y = m*x + b$
- R-squared: strength of correlation
- Input: modeled resource
- Output: long-term result

On-Site Solar Resource Assessment with MCP

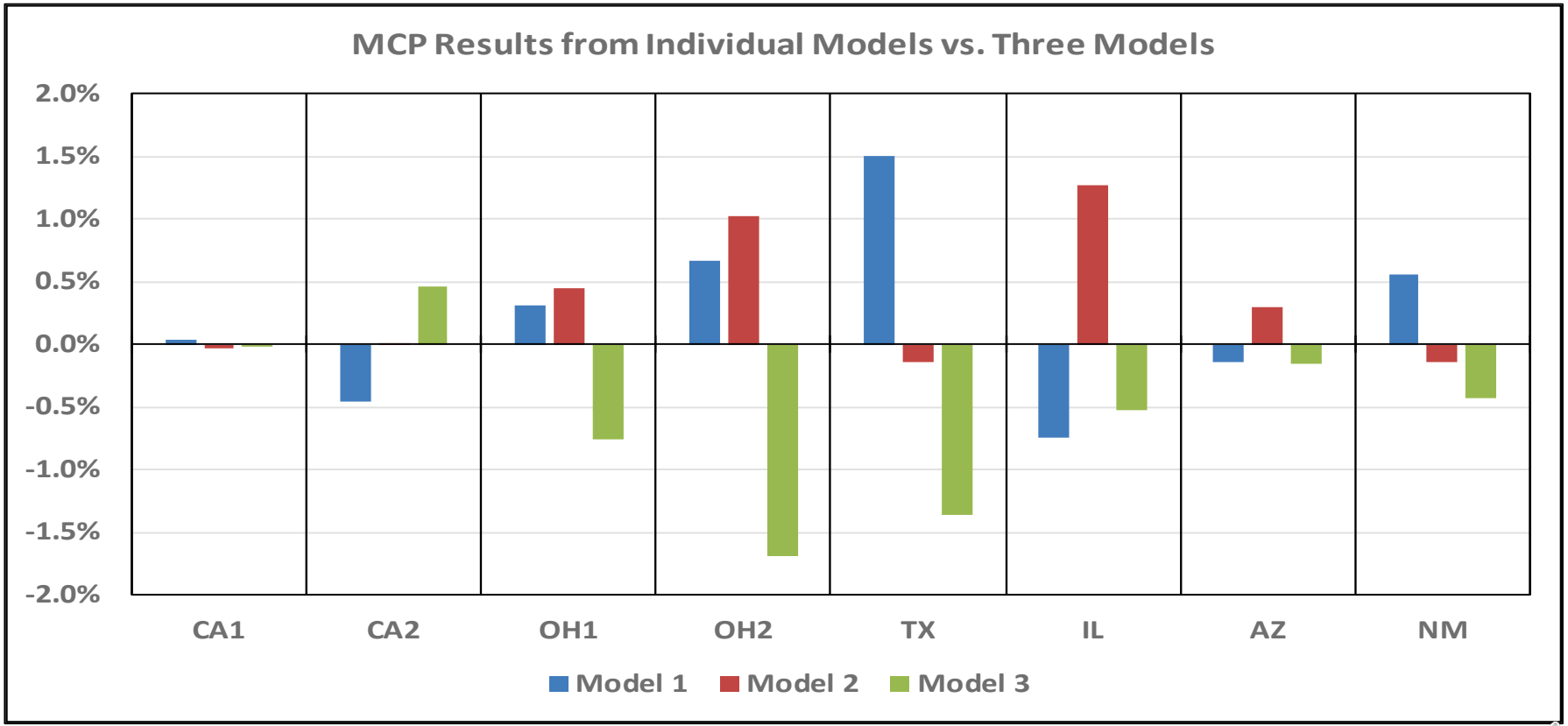
- Case study: UL reviewed 8 long-term Solar Resource Assessments using on-site data
  - Locations across contiguous USA
  - Three satellite modeled reference datasets for MCP

- Comparisons:
  - *Climate* of on-site period compared to long-term
  - *Predictions* from individual models vs. average of three models
  - *Risk* of using one model vs. three models

MCP with On-Site Weather Stations



MCP with On-Site Weather Stations



MCP with On-Site Weather Stations

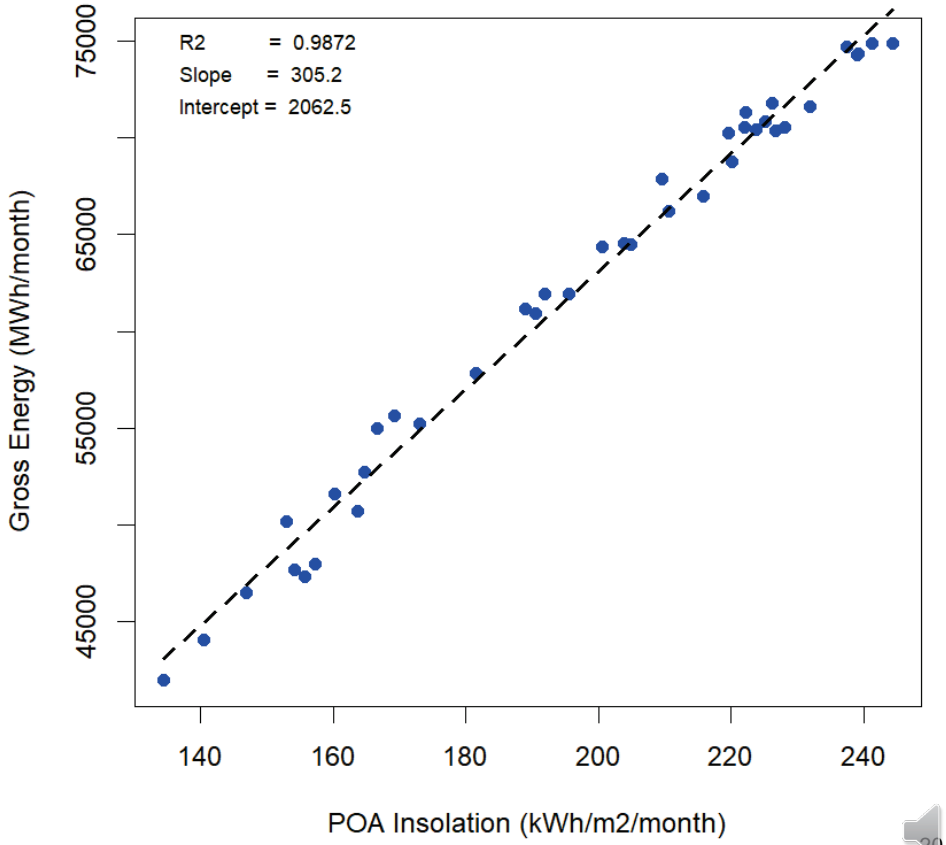
- All models usually show same direction of climate adjustment (e.g., observed periods being high or low)
- On average, long-term estimates ranged by 1.4% depending model selection (maximum difference of 2.9%)
- Sites in deciduous environments showed more of a range than sites in desert environments → greater need for model diversity depending on environment
- Multiple models for MCP mitigates risk of relying on one single model

Presentation Outline

- Measure-Correlate-Predict Approach
- MCP with On-Site Weather Stations
- **MCP with Operational Energy Estimates**
- Why Multiple References are Important

MCP with Operational Energy Estimates

- Correlation between POA irradiance and monthly energy
- Monthly correlations = less data points → higher correlation uncertainty
- Adjust for availability, curtailment, one-off events, degradation
- Can be completed on individual projects or a portfolio of projects



MCP with Operational Energy Estimates

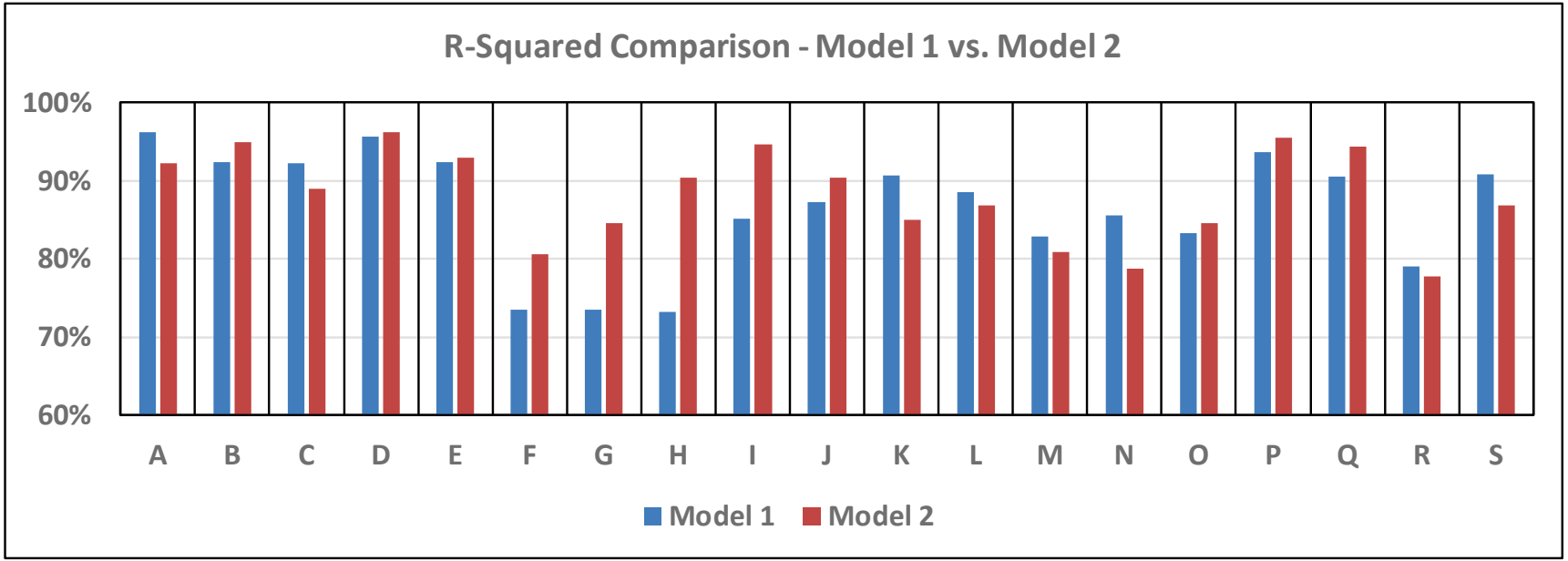
- Case study: UL completed OEPEs at approximately 20 projects across a large region of the world
  - MCP results for two separate modeled datasets
  - Evaluated (1) as individual projects, and (2) as a portfolio

- Hypotheses:

1. Does one reference dataset yield stronger correlations?
2. How different are results on a project-by-project basis?
3. How different are results on a portfolio basis?

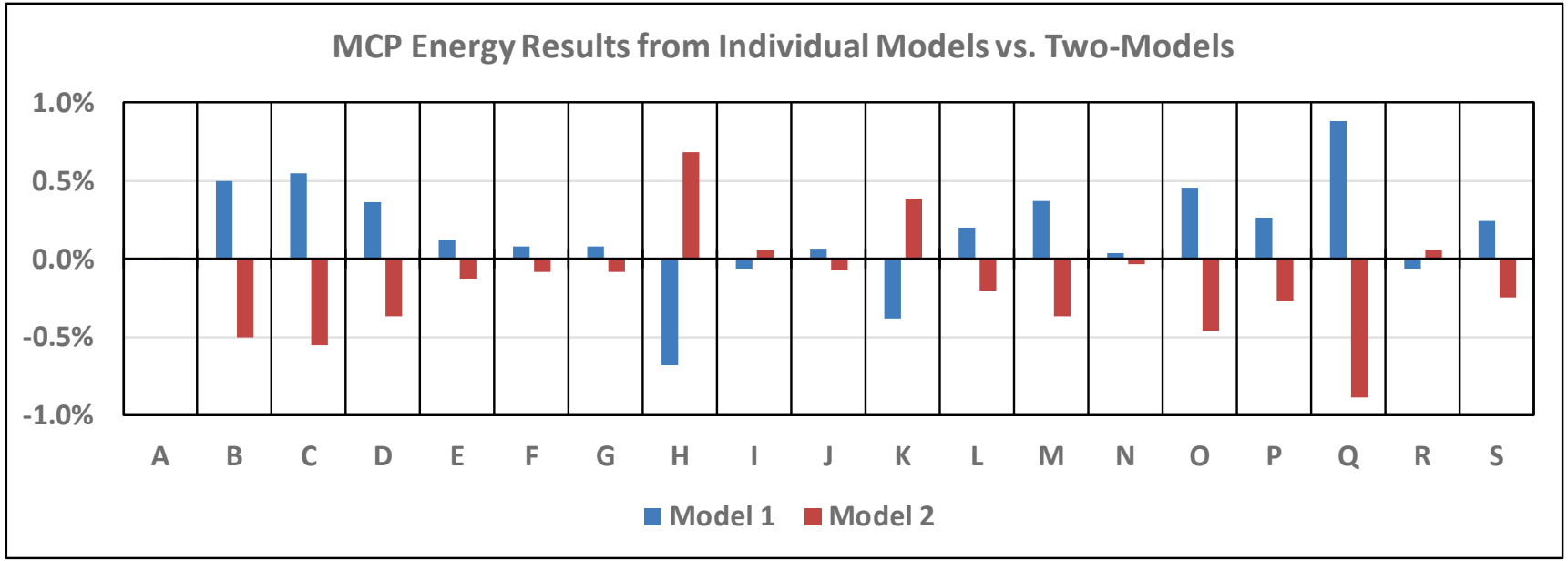
MCP with Operational Energy Estimates

1. **Strength of correlation:** Evaluating multiple reference models may result in excluding models at some sites when they have weaker correlations



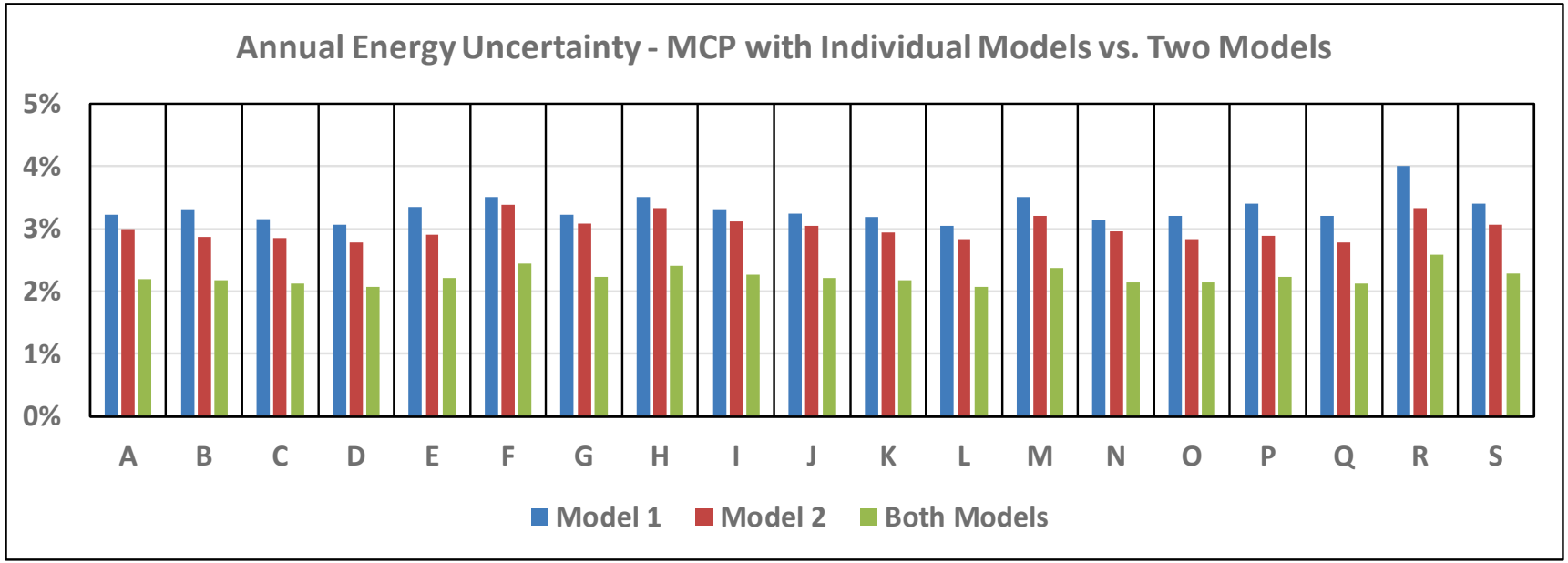
MCP with Operational Energy Estimates

2. **Difference in results for individual projects:** For individual projects, energy accuracy is improved by multiple models (max difference of 1.8%).



MCP with Operational Energy Estimates

3. **Uncertainty:** Reduced by 1-1.5% by using two models rather than a single model.



MCP with Operational Energy Estimates

3. **Difference in results for portfolio:**
   - More projects = greater modeled data cost
   - Portfolio energy differed by 0.3% (within uncertainty of analysis)
   - Uncertainty already mitigated by regional variation and portfolio benefit

Conclusion: portfolio analyses may be able to save on cost and effort by using a single model for the entire portfolio.

Presentation Outline

- Measure-Correlate-Predict Approach
- MCP with On-Site Weather Stations
- MCP with Operational Energy Estimates
- **Why Multiple References are Important**

Using multiple satellite models as long-term references for measure-correlate-predict analyses:
(1) improves accuracy of results and
(2) mitigates prediction risk.

Questions?

Eva.PlazaSanz@UL.com
Peter.Johnson@UL.com