

# BUILDING A WORLD OF DIFFERENCE

## STANDARDS FOR ACCEPTANCE TESTING AND MODEL VALIDATION

**EVAN RILEY**

2013 Sandia PV Performance Modeling Workshop  
Santa Clara, CA. May 1-2, 2013

Published by Sandia National Laboratories with the Permission  
of the Author

1 May 2013



**BLACK & VEATCH**  
Building a world of difference.®



# SOLVING THE WORLD'S COMPLEX CHALLENGES

**BLACK & VEATCH CORPORATION IS A LEADING GLOBAL ENGINEERING, CONSULTING AND CONSTRUCTION COMPANY**

- **Founded in 1915**
- **Global workforce of more than 9,000**
- **More than 100 offices worldwide**
- **Projects in more than 100 countries on 6 continents**
- **\$2.6 billion in annual revenues in 2012**
- **Employee-owned corporation**
- **Engineering News-Record ranking: #2 – Top 20 in Power**

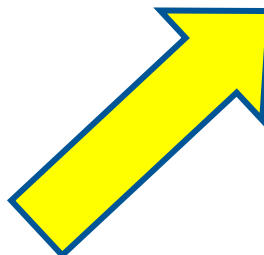
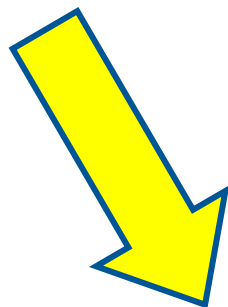


## B&V PV HIGHLIGHTS

- Recognized industry leadership in Independent Engineering (IE)
- Owner's engineer for over 1,000 MW of projects
- Development support for more than 1,500 MW of utility scale PV systems
- Independent Engineer for over 3,000 MW of PV capacity
- Automation of the nation's largest municipal solar incentive program
- Development of largest municipal feed-in-tariff
- EPC on multiple utility scale PV projects

**Black & Veatch has been involved with half of the utility-scale PV facilities currently operating in North America**

# ENERGY PRODUCTION ESTIMATES



# WHAT DO YOU NEED FOR AN ACCEPTANCE TEST?



1. Measurement methodology
  2. Target or expected value
  3. Reference conditions (sometimes confusingly referred to as reporting conditions)
- A method to compare measured and expected (will there be a tolerance?)





Source: SolFocus

# ACCEPTANCE / PERFORMANCE TESTS

- **Capacity Tests**

- ASTM E2848-2011 and WK37888 (Old PVUSA Test, 1995)
- Power Performance Index Method (Regression using temperature corrected power)
- Sandia Method (Not regression based)

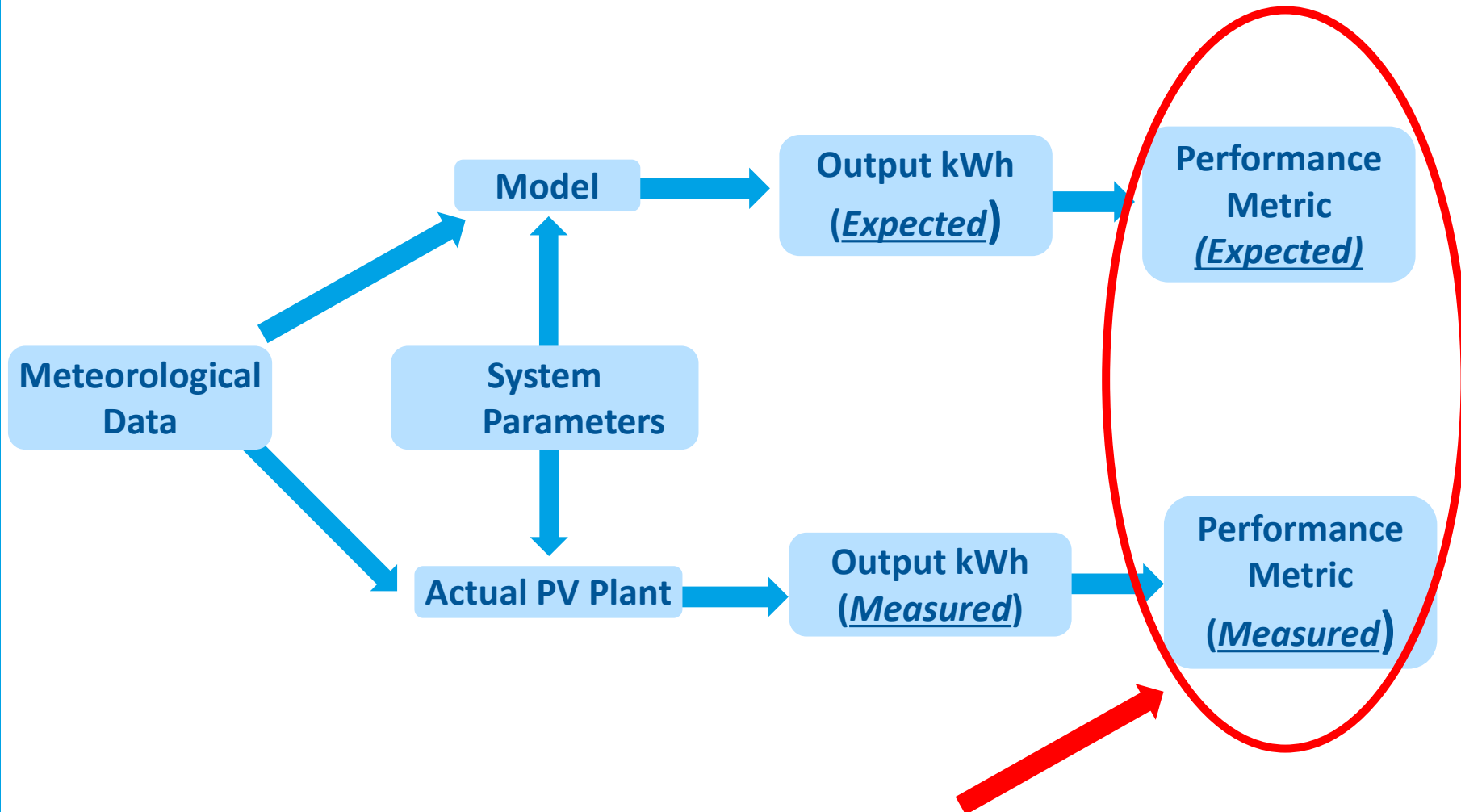
- **Performance Ratio Tests**

- Performance Ratio IEC61724
- Temperature adjusted performance ratio
- Weather adjusted performance ratio

- **Adjusted Energy Test**

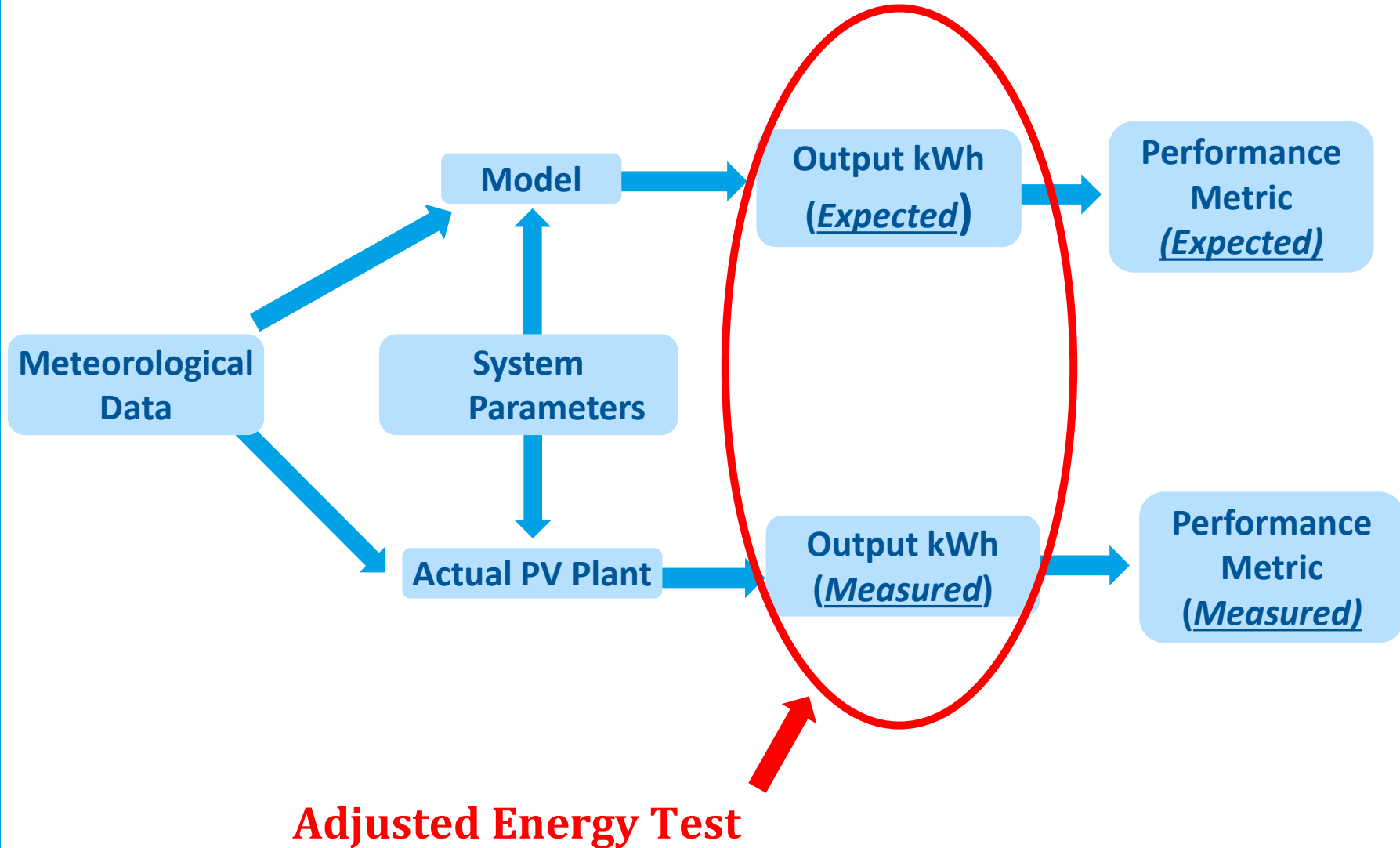
- Standard in the works

# WHAT IS PERFORMANCE TESTING?



**Capacity tests, performance ratio tests**

# WHAT IS PERFORMANCE TESTING?







Source: Cogenera

## CAPACITY TESTS

- **Old PVUSA Test**
  - Used extensively in industry
  - Measure using ASTM E2848-2011
  - Set target and reporting conditions using WK37888
- **Power performance index**
  - Used extensively in industry
  - No standard, discussion of incorporating into ASTM E2848
  - Seasonality in results
- **Sandia Method**
  - Used in the industry
  - No standard

# PERFORMANCE RATIO TESTS

- **Standard Performance Ratio Test**

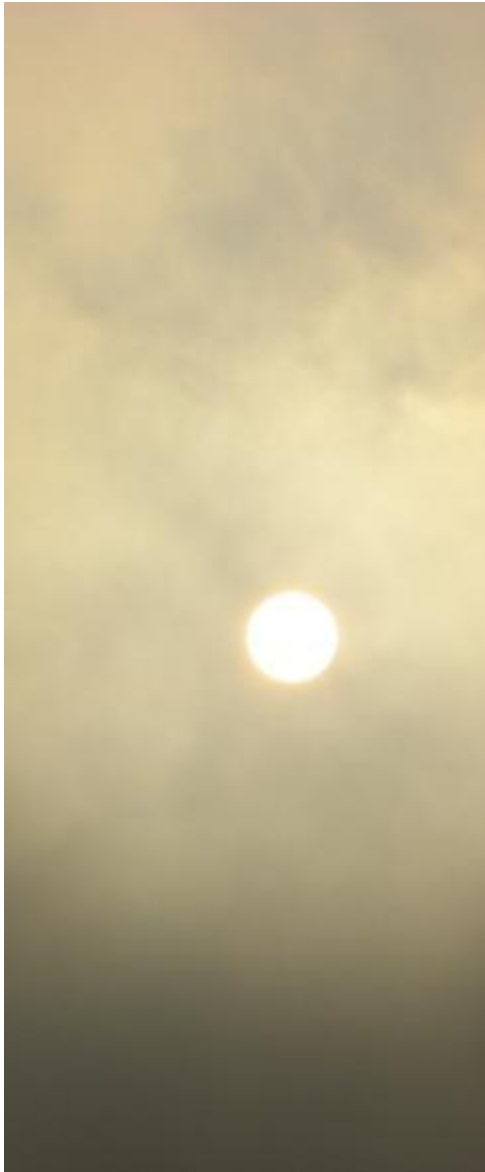
- Used extensively in the industry
- IEC 61274 (not comprehensive)
- No reference conditions, seasonality in results

- **Temperature Adjusted Performance Ratio Test**

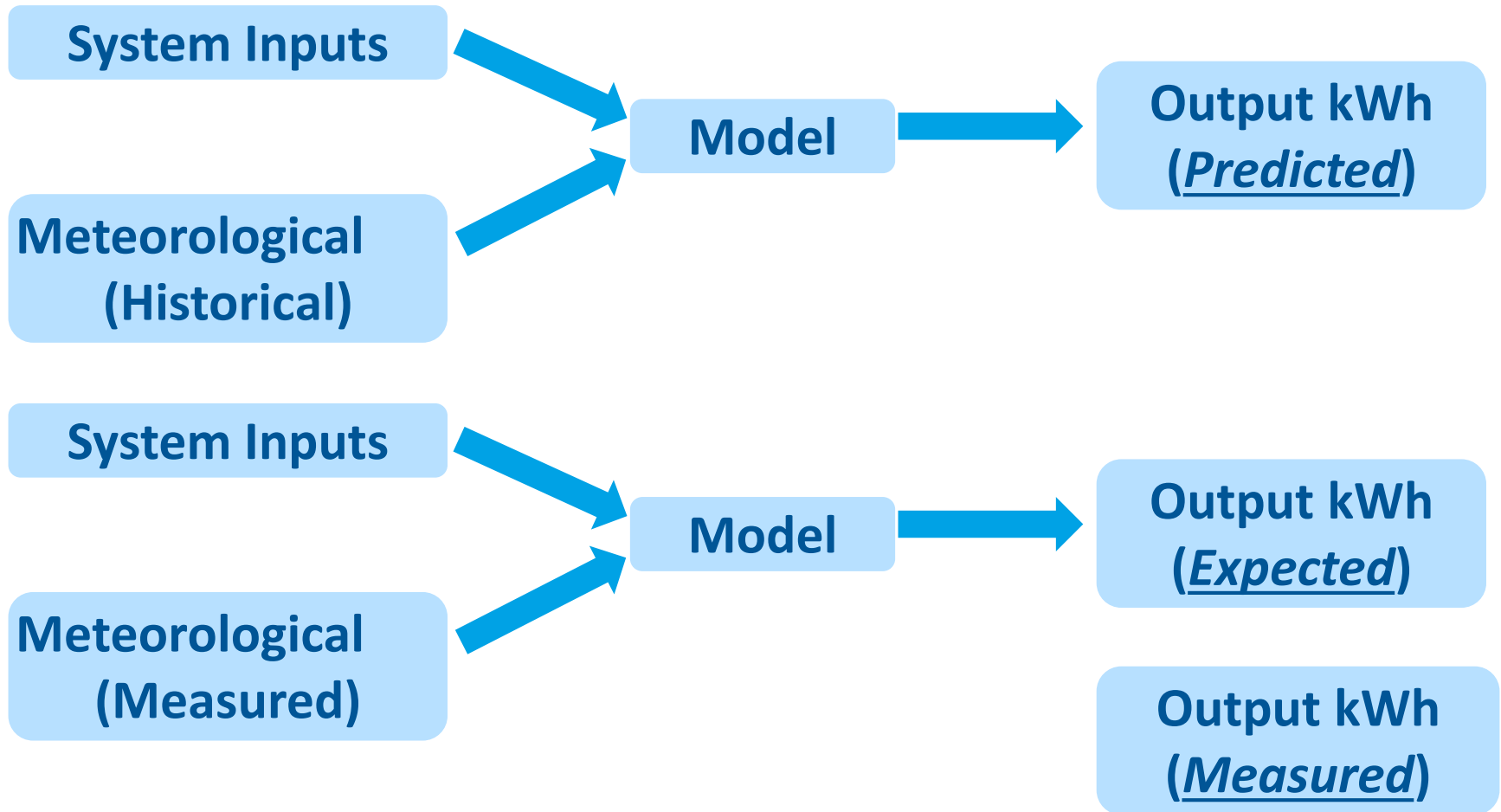
- Used extensively in the industry
- No standard
- Irradiance weighted temperature is the reference condition

- **Weather Adjusted Performance Ratio Test**

- Used in industry
- No standard



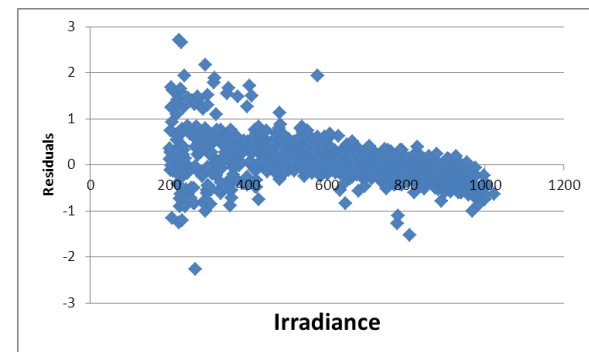
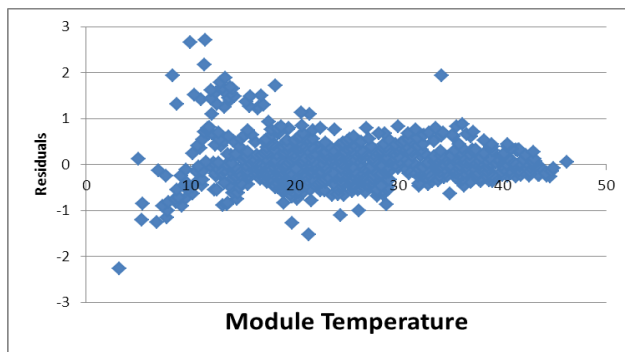
# LONG TERM ADJUSTED ENERGY TEST



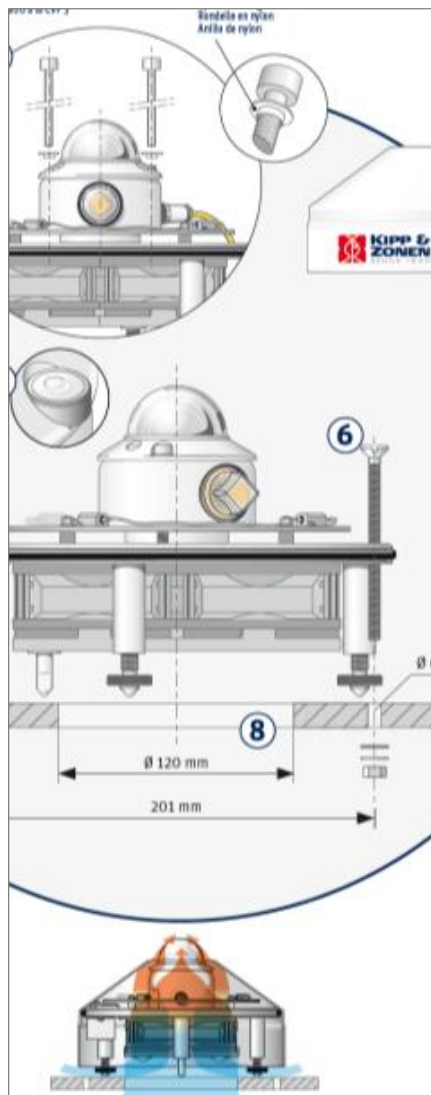
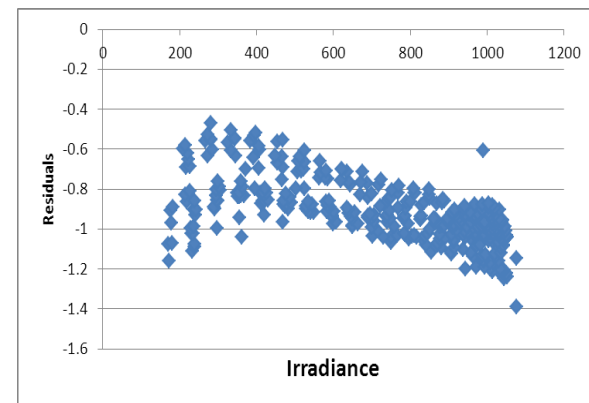
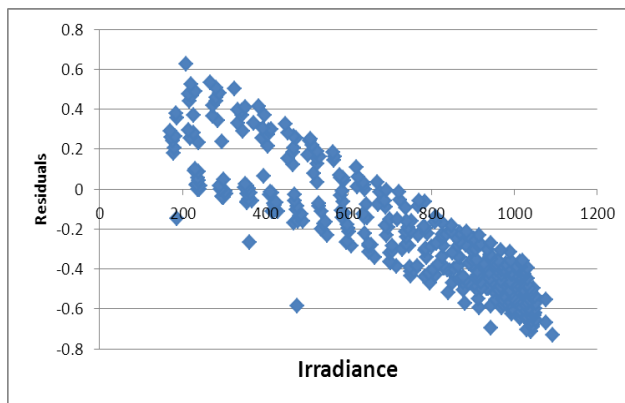
Measured kWh is the compared to Expected kWh

# SYSTEM MODEL VALIDATION

Good



Not so Good



Source: Kipp & Zonen

# RISK ALLOCATION



# CONTACT

**Evan Riley**

**+1 913-458-9871**

**RileyE@bv.com**





Building a **world** of difference.®

**Together**



**BLACK & VEATCH**

[www.bv.com](http://www.bv.com)