DNV Renewables Services

Global impact for a safe and sustainable future

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MANAGING RISK DNV

VALIDATION INFORMATION FOR PV POWER SYSTEM PROJECT REVIEW

Presented by : Jeff Newmiller

History : More than 145 years of managing risk

- DNV (Det Norske Veritas) was established in 1864 in Norway
- DNV is a leading international provider of services for managing risk
- DNV is a foundation and reinvests all profits in services, research and development
- Shipping → Maritime Wind → Renewable Energy → BEW Engineering

OVERVIEW

- Our perspective
  - Begin with client goal: energy production
  - Identify root causes of failures to meet goal in historical record
  - Review evidence that root causes have been addressed in new projects
- Categories of root causes
  - Capacity
  - Weather
  - Reliability
- Potential benefit of utility-scale test projects
  - Wide access to results

CLIENT GOALS : QUESTIONS

- How much energy will this system produce? (income)
  - First year?
  - Over time?
- How much will O&M cost? (expense)
- What are the risks for this project? (expense)
  - Performance
  - Reliability
  - Safety
  - Schedule
- Is the project proceeding according to plan? (income)
  - Plans are complete and correct?
  - Built according to plans?
  - Begin producing energy on schedule?

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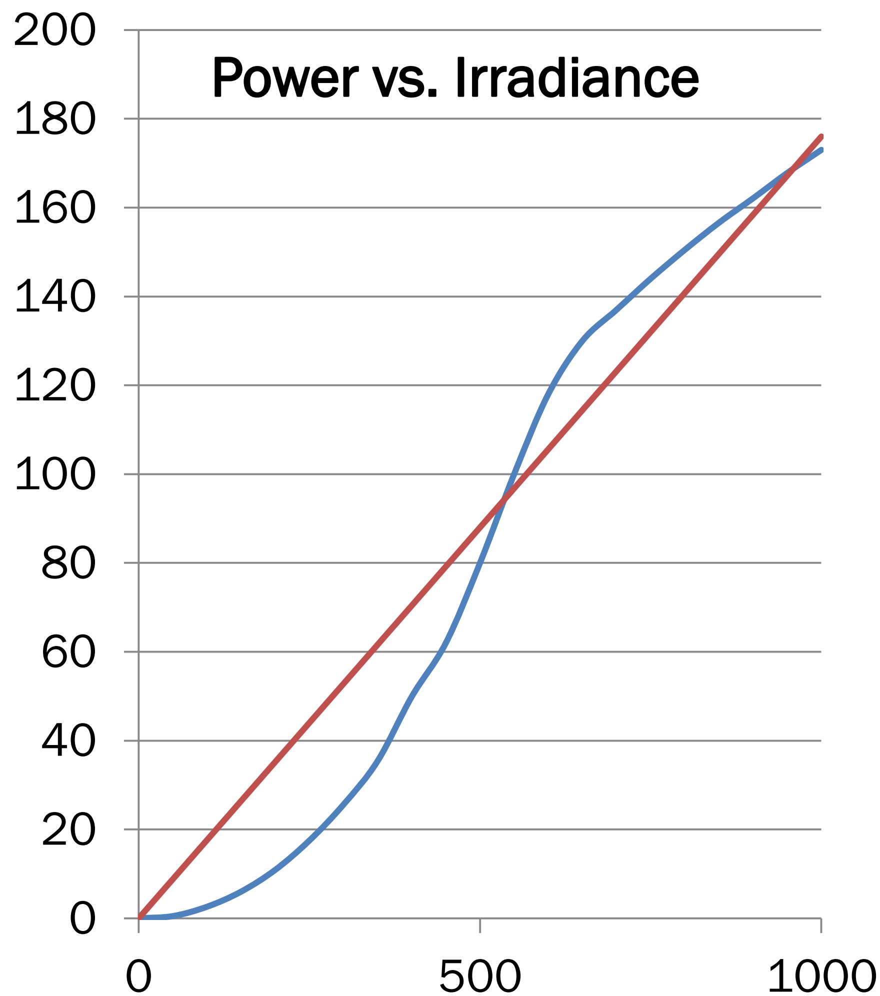
ROOT CAUSES : PERFORMANCE

- Energy production
  - Efficiency (Power Rating?)
    - At test conditions vs. real world variety of conditions
      - Irradiance Level
      - Temperature (ambient⟶module)
      - Spectrum
      - Exposure history
      - Sample-to-sample variation
  - In general, requires a combination of field data to identify and lab data to model



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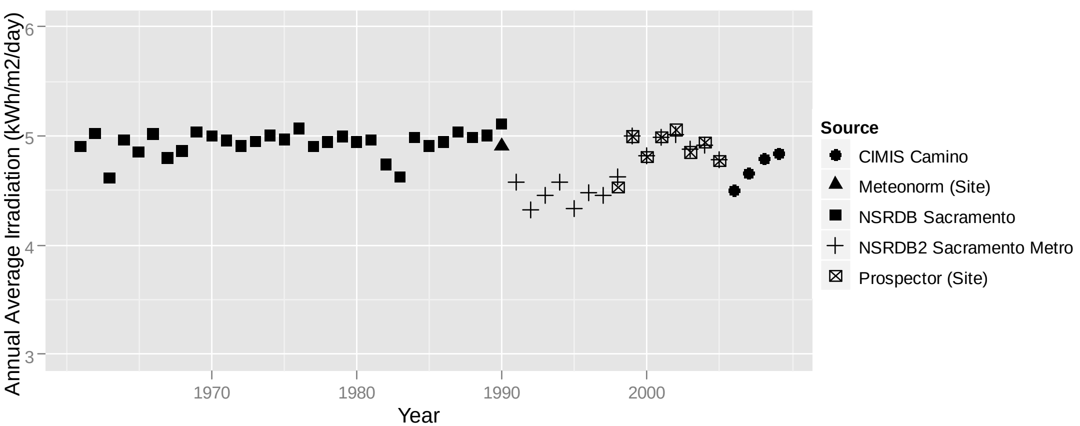
ROOT CAUSES: WEATHER

- More irradiance = more generation
- Interaction of weather with equipment yields energy
- BUT
  - Instrument accuracy?
  - Diffuse measurement?
  - Spectrum?
  - Length of history?



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ROOT CAUSES: MATERIALS RELIABILITY

- Stability
  - Photovoltaic Material
- Stability and Robustness
  - Encapsulation
    - Breach
    - Change in reflection / transmission / absorption properties

- Stability and Robustness
  - Structure
    - For some technologies, custom structure is essential
  - Electrical Infrastructure
    - Connector failure rates
    - Grounding Corrosion
      - Copper/Aluminum

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EVIDENCE: QUALIFICATION TESTING

- Is not “reliability testing” because it represents “minimum exposure”
  - IEC 61215 Mono/Poly Silicon
  - IEC 61646 Thin-film
- Bankability
  - Extended cycle test results
  - Fielded equipment failure rates

- Temperature cycling
- Damp-heat
- Hot-spot
- Reverse current
- Mechanical tests

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EVIDENCE: LABORATORY PERFORMANCE

- Parameters
    - STC
    - Varying Temperature
    - Varying Irradiance
    - Varying Diffuse Fraction
    - Before and After Exposures
        - Light/Dark
        - Hot/Cold
        - Electrical Polarity

- Statistics
    - Typical qualification and safety tests only determine performance approximately, and on at most a few samples
    - What is production stability for millions of samples?

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EVIDENCE: SAFETY TESTING

- NRTL Listing is norm for US demand-side generation (UL1703)
- For generation-only facilities, IEC standards may be more appropriate
- Lessons learned from NEC should not be forgotten
- Records of acceptance of installed systems by (more than one) local AHJ

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EVIDENCE: FIELD PERFORMANCE

- System Measurements
  - AC Power/Voltage
    - 60Hz
  - DC Voltage/Current /Power
  - Rapid sampling (1 sec)
  - Short Aggregation (1-5min)
  - Special Tests
    - String Current "Sign-Of-Life"
    - IV Curves
    - Periodic Flash IV Testing
- Environmental
  - Irradiance
    - GHI – broadband
    - DHI – BB or Silicon Detector
    - POA – BB and SD and Reference Cell
    - Spectrum
  - Temperature
    - Free Air ("Ambient")
    - Module
  - Wind
    - Free Air

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EVIDENCE: FIELD PERFORMANCE

- First year of performance
  - Basic measure of project viability
  - New technologies may have complicated modeling requirements: confirm models
  - Availability
- Degradation
  - Small effect builds over time
  - Difficult to confirm in less than 5 years
- Ground-measured weather data
  - High quality meteorological data is necessary for evaluation
  - Value of recorded data will be high
    - Future projects located near the test sites
    - Calibration of resource models
- Soiling
  - Site-dependent
  - Technology impact

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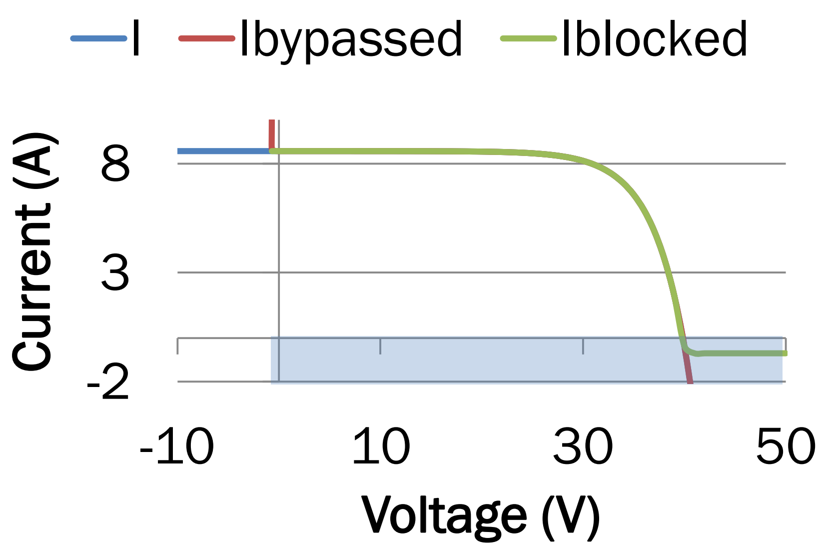
EVIDENCE: INSTALLATION/O&M

- Familiar technologies
  - Cheaper installation
  - Cheaper maintenance
  - Well-understood spares management
  - Shorter downtime



- Mitigation
  - Similarity to existing tech
  - Training
  - Clear documentation
- Evidence
  - Installed systems
  - Testimonials by construction teams

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EVIDENCE: MUTATION OF PROCESSES

- Common response when problems arise
  - “We don’t build it that way anymore.”
- Common pitch when selling newest model
  - “We have built lots of these”

- Problem
  - How to confirm that changes introduced to address problems have not reduced the advantages of the old product?
- Possible solution
  - Document mfr processes of fielded products
  - Hold documentation in escrow
  - Later compare processes of new product under NDA

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CONCLUSION

- New technology that fits existing physical profiles (e.g. framed flat plate) mostly needs performance, stability and reliability evidence (installation years)
- New tech that alters physical profile (e.g. concentrators, flexible substrate) also needs demo of constructability and O&M
- Field installations have limited environmental profile
  - Multiple locations needed to address Desert, Agricultural, Humidity, Sub-Freezing profiles

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