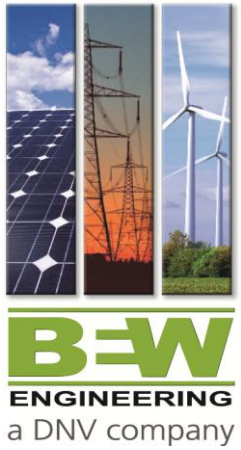


INDEPENDENT ENGINEER PERSPECTIVE

DIFFERENTIATING QUALITY PV

SAN FRANCISCO, CA

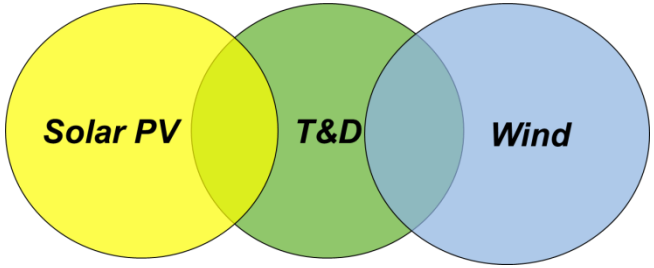
MARCH 6, 2012

Presented by : Ray Hudson – Director Solar Energy

MANAGING RISK

BEW Engineering Overview

- BEW Engineering
  - Founded 2002 predecessor solar experience back to 1980s
  - San Ramon, CA, San Francisco, CA, Boston, MA, Seattle, WA, Houston, TX, Fort Collins, CO
- Acquired by DNV in 2010
  - Worldwide consultancy
  - Headquarters in Oslo, Norway
- DNV acquired KEMA in February, 2012
  - International Energy consultancy



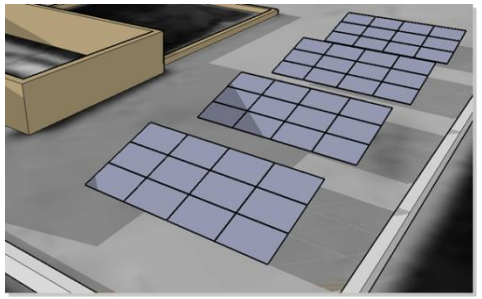
KEMA
DNV

BEW ENGINEERING
a DNV company

BEW PV Services Today

- Technical Due Diligence – System-Level Evaluation
  - Before, during and after construction
  - Independent Engineering clients
    - Banks
    - Other financial institutions
  - Owner's Engineering clients
    - Developers
    - Equity holders

- Technology Review "Bankability"– Key Component Review
  - Equipment manufacturers
    - Modules
    - Inverters, mounting systems
    - Mounting and Tracking systems
    - BOS



- PV System Design
    - Commercial
    - Utility Scale
- Other (testing, research, training, resource measurement…)

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BEW TYPICAL SYSTEM REVIEW ELEMENTS

- Site evaluation
  - Topography, Shading, Soiling
- Solar resource determination
  - Long term
  - Variability P(X)
- Design and equipment review
  - Good practices
  - Safety
- Energy estimate – used for financial modeling
- Document review
  - Contracts
  - Permits
- O&M cost estimate
- Construction review
- Overall Risk Assessment
- Inspection
- System Test
- Performance Evaluation
- Final Completion

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BEW IE PERSPECTIVE

- Clients need objective advice from an Independent Engineer
- Expertise and experience in PV systems, components, and history
- Objective
- Thorough
- Incorporate best available information
- Use best available methods
- Goal is accuracy!

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INDEPENDENT ENGINEER VIEW

- Types of investors – different perspectives
  - Long-term financing
    - Concerned with long-term performance (5-20+ years)
  - Construction finance – short-term loan
    - Want to ensure completed project can be sold
- Long-term revenue stream depends on
  - Installed cost
  - Energy generation
  - O&M costs
  - Contract items (PPA energy rate, performance guarantee,…)
  - Economic factors (Interest rate, ITC, other incentives…)
- Identify and quantify project risks and uncertainty
  - Uncertainty in long term vs annual
  - Downside cases
- DETAILS MATTER!
  - Must be considered appropriately

GAPS AND OPORTUNITIES FOR IMPROVEMENT

- Component Modeling – better data
  - Modules
  - Inverters
- Resource data
  - Key input to energy modeling
  - More and better sources
- Field system performance data
  - Feedback for refining system energy prediction methodology
  - Detailed review of individual long term systems
- O&M cost modeling
  - Additional and more complete data for improving models
- Uncertainty and Risk Analysis
  - Standardized methods and terminology
  - Understanding limitations
- Contractual agreements
  - Standardization opportunities

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Predicting Energy Generation – PV Component Modeling

- PV Module
  - PV datasheets are essentially useless for modeling – insufficient data
  - Lack of transparency from manufacturers
  - Third party data needed for model
    - Data is needed from a statistically significant population of modules
    - Data is needed for specific model and power rating (i.e. don't use 260W data for 280W module)
    - IV curves over range of irradiance levels (100W/m^2 to 1200W/m^2)
    - IV curves over a range of temperatures (0C to 80C)
    - Measurements and models of seasonal variability for thin film
    - Reflection properties of glass
- Inverter
  - Thanks to CEC requirements, independent performance test data readily accessible for efficiency
  - Challenge for non-UL listed inverters to provide same data quality - standardization
  - Standards for derating on other factors (Voltage, temperature, elevation…)
  - Reliability data
  - O&M Cost data
- Degradation
  - Measurements of module light-induced degradation
  - Measurements of module long-term degradation
  - Measurement of system long term degradation

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Thank you!

Further information at www.bewengineering.com

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IE/OE MENU

Task/Description	Client Input
SITE EVALUATION Evaluate site for suitability/feasibility of proposed installation; potential impact of the following on system construction and operation: • Solar Resource • Topography/shading • Site/soil condition • Security • Environmental factors • Military, other considerations	Site Visit, availability of site host personnel
DESIGN & EQUIPMENT REVIEW Review design for code compliance and conformance to customary solar engineering practice. Evaluate key Components: • Modules • Inverters • Tracker design • Balance of system • System integration	Design drawings, project schedule, product Spec and Warranty Sheets. Interviews w/ engineers and designers
PERFORMANCE ESTIMATE Estimate system performance: • Site-specific solar resource • System power ratings (dc/ac,STC/PTC, etc.) • 1st -year energy production • Life time energy production, including degradation	Performance data, designer assumptions, Performance Guarantee

Task/Description	Client Input
PERMIT STATUS REVIEW Identify key permit and schedule milestones. Evaluate on-going status of permits including: • Building permits, easements, grading, dust, etc. • Incentive reservations & proof of progress • Utility interconnection/net metering/ FERC/ISO • Environmental permits	Permit submittals and approvals
CONSTRUCTION SUPPORT REVIEW Review and investigate Construction Support, identify potential hurdles & recommend solutions: • EPC Construction review • Supply & service contract terms & conditions • Key subcontractors • Installation schedule • Performance guarantee review	Supply & service contracts, project schedule, key subs list
O&M REVIEW Review and investigate Operations and Maintenance, identify potential hurdles and recommend solutions: • O&M cost estimate • O&M contract terms & conditions • O&M Manual • Key subcontractors	O&M Contract & Manual
OVERALL RISK ASSESSMENT Summarize project risk in terms of potential impact on: • Construction schedule • System performance • Long term reliability • Performance guarantee review	Schedules & Contracts

Task/Description	Client Input
SITE INSPECTION Visit site to: • Verify as-built installation • Evaluate workmanship • Verify permit compliance • Verify schedule conformance • Perform or witness sub system testing • Develop punch list and check status as necessary	Construction drawings and project schedule
SYSTEM TEST Witness or review data set to: • Verify minimum period of continued operation • Assess actual vs. predicted output • Other contractual measure of acceptable performance	System fully operational and access to performance data where applicable
PERFORMANCE EVALUATION Complete or spot evaluation of array, tracker, inverter through the use of: • Spot voltage and current measurements • IV curves • As-installed array and system ratings • Independent performance monitoring	System fully operational
FINAL COMPLETION Verify the completion accuracy of all items to be declared listed on the Final Completion Notice, such as: • System ready for full, unattended commercial operation • System passed inspections with AHJ • Utility interconnection installation evaluation complete • System tests passed successfully	Notice of Interim Completion prior to visit, Notice of Final Completion issued by the installer

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