

UTILITY-SCALE SOLAR POWER PLANT FUNDAMENTALS

Design, Resource Planning & Procurement

April 18 – 19, 2018
Embassy Suites
Portland Washington Square
Portland, OR

“

“This course is a great way to introduce yourself to the ways the utility industry are incorporating solar power into their service territories and how the plants are designed on large scales.”

Substation Engineer,
Sargent and Lundy

POST-COURSE WORKSHOP

O&M Best Practices

FRIDAY, APRIL 20, 2018



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EUCI is authorized by IACET to offer 1.5 CEUs for the course and 0.7 CEUs for the workshop.

OVERVIEW

Utility-scale solar power plants increasingly present a cost competitive solution for utilities and IPPs alike. Industry experts confirm that trend will hold and perhaps even accelerate into the future as the demand for renewable energy resources escalates. Thus, the pool is expanding of utilities, developers and investors who must understand how to plan, develop, and interconnect these plants to the existing electric grid.

This course is designed to familiarize attendees with the key elements of planning solar power plant resources as well as their design and development, including an understanding of component function and selection, site selection, and design optimization. A broad review of development and capital cost deployment, coupled with energy production modeling techniques, will provide course participants with the basics of cost-of-energy analysis and how design decisions can impact overall plant economics. Instructors will also review procurement best practices, along with design and equipment procurement considerations for mitigating risk for long-term asset owners.

At the conclusion of the program, attendees should have a sound understanding of the important elements that serve as the foundation of utility-scale PV plant planning, optimization, and procurement.

LEARNING OUTCOMES

Attendees at this course will:

- Discuss the fundamentals of solar utility-scale generation and its distinctive requirements on transmission and distribution systems
- Review fundamental design and system integration requirements of utility-scale and large-scale commercial solar projects
- Assess cost estimating and EPC considerations
- Evaluate owner's engineer role and functions
- Examine energy modeling fundamentals
- Analyze design optimization considerations
- Evaluate risk assessment, risk allocation, and performance guarantees
- Describe third-party installation review, testing and commissioning
- Discuss linking O&M considerations to PV plant design
- Identify procurement considerations
- Assess resource planning for solar and technological advances
- Define core financial modeling elements



“Having a basic understanding of solar and having an electrical power industry background, this course delivered the right amount of detail and really took my knowledge to the next level.”

Solar Power Operations & Maintenance
Engineer, Southern Company



“Provided an excellent amount of information and tools to evaluate and plan PV resources.”

Senior Systems Analyst,
Entergy

TESTIMONIALS FROM PAST ATTENDEES

“I thought the session was very good and on task to help me learn more about utility-grade solar.”

Senior Energy Conservation Specialist,
Florida Public Utilities

“This course was a helpful tool to fill in some of the blanks in my knowledge of solar power plant design.”

Estimator, McCarthy
Building Co

“Well organized conference that provided basic and advanced information.”

Project Manager, Entergy

“Very beneficial for people in the renewable energy industry, regardless of experience level.”

Solar Development, E.ON North America

“Very fluid course – topics are relevant, yet diverse.”

Manager,
Brookfield Renewable

“Great program! Highly recommended!”

Technical Director, ICF

“Presenters conveyed strong subject matter expertise.”

Director – Generation & Optimization,
Brookfield Renewable

“Great intro course to the industry!”

Senior Electrical Engineer, Acciona Energy

“Awesome course! I will use the information I learned today going forward throughout my career.”

Business Developer, Engie Canada

“My second EUCI event that I experienced deep technical training and in-depth content.”

CEO, True South Renewables Inc

AGENDA

WEDNESDAY, APRIL 18, 2018

- 7:30 – 8:00 am** **Registration and Continental Breakfast**
- 8:00 – 8:15 am** **Overview and Introductions**
- 8:15 – 10:30 am** **Solar Building Blocks**
- History of solar technologies and industry overview
 - Photovoltaic solar modules
 - DC electrical - string and conductor sizing, protection
 - Inverters types and design considerations
 - AC collection and system protection
 - Transformers
 - Power plant control (SCADA) and monitoring
 - Other BOS components
- 10:30 – 10:45 am** **Morning Break**
- 10:45 am – 12:15 pm** **Cost Estimating and EPC Considerations**
- Site screening – what makes a cost-effective solar site?
 - o Terrain and soil conditions
 - o Hydrological impacts
 - o Environmental mitigation
 - o Labor and site access
 - o Interconnection location
 - Site surveys to reduce site risk
 - Construction permitting
 - Costs associated with the power system
 - o Civil works and site preparation
 - o Modules and DC collection
 - o Inverters and AC collection
 - o HV and Substation
 - o Other balance of system/plant costs
 - “Soft” costs
- 12:15 – 1:15 pm** **Group Luncheon**
- 1:15 – 2:15 pm** **Owner’s Engineer (OE/IE) Role and Functions**
- Development phase support
 - Permitting phase support
 - Interconnection request
 - EPC request for proposal (RFP) support
 - Construction/commissioning support
 - Support during operations
- 2:15 – 3:30 pm** **Energy Modeling Fundamentals**
- Overview of available modeling tools
 - Evaluating weather data
 - Module mounting and shading
 - Overview of modeling losses
 - Mechanics of generating an accurate energy model
 - Energy tests, capacity tests, and performance guarantees



“This course expanded greatly on the basic knowledge I already had for the design process of solar fields.”

Assistant Project
Manager, McCarthy
Building Co

AGENDA

WEDNESDAY, APRIL 18, 2018 (CONTINUED)

3:30 – 3:45 pm

Afternoon Break

3:45 – 5:15 pm

Design Optimization

- Inverter loading and tradeoffs
- Row spacing and tradeoffs
- Metrics and myths for evaluating optimal plant designs
 - o Lowest cost of energy
 - o AC capacity factors

5:15 pm

Program Adjourns for Day

THURSDAY, APRIL 19, 2018

7:45 – 8:15 am

Continental Breakfast

8:15 – 9:00 am

Risk Assessment, Risk Allocation, and Performance Guarantees

- Risk assessment and identification
 - o Best practices
 - o Natural hazards
 - o Contingent exposures
- Risk allocation
 - o Developer
 - o EPC contractor
 - o Vendor and supplier
 - o Interconnection
 - o Customer
 - o Lender and equity finance
- Insurance market
- Bonds, surety and guarantees

9:00 – 10:15 am

Third-party Installation Review, Testing and Commissioning

Commissioning is a way to formalize quality control of installed PV systems. The commissioning process begins at project inception (during the pre-design phase) and continues through the life of the facility. The commissioning process includes specific tasks to be conducted during each phase in order to verify that design, construction and training meet the owner's project requirements. This presentation will address the core elements of commissioning and how they should be executed:

- Verify that applicable equipment and systems are installed according to the contract documents, manufacturer's recommendations and industry accepted minimum standards
- Verify that installing contractors perform adequate operation checkout
- Verify and document proper performance of equipment and systems
- Verify that the operations and maintenance (O&M) documentation left on-site is complete
- Verify that the owner's operating personnel are adequately trained

10:15 – 10:30 am

Morning Break

AGENDA

THURSDAY, APRIL 19, 2018 (CONTINUED)

10:30 – 11:45 am

Thinking with the End in Mind: Linking PV Plant Design Considerations to O&M

Given the accelerating investment in solar PV by electric utilities — and their emphasis towards holistic costs over the life of the plant, as compared to maximizing return on upfront capital expenditures — this presentation qualitatively explores linkages between key decisions made during the initial design phase and their impact on life cycle operations and maintenance (O&M) costs to better inform “thinking with the end in mind.” Illustrative decisions include the effects of row spacing, racking and tracking choices, cable management solutions, soiling and vegetation management approaches, data monitoring and communications set up, inverter selection and engineering, inverter loading ratio, and others. Overarching findings are intended to convey a better understanding of a PV plant’s long-term ownership costs (including both CAPEX and OPEX considerations) to inform future utility investments and maximize their economic value. The presentation will also reflect on ways to improve upon future plant designs, based on existing lessons shared by a range of solar practitioners, and offer insights into future plant build and acquisition strategies.

11:45 am – 1:00 pm

Group Luncheon

1:00 – 2:00 pm

Procurement Considerations

- Supplier considerations
- Module warranty and degradation
- Quality, reliability, and testing protocols
- Role of third-party certifications
- Inspection services
- Crafting the RFP solicitation

2:00 – 3:30 pm

Resource Planning for Solar and Technological Advances

- Accurately assessing solar resources in the enterprise long-range plan
- Resource planning best practices
- Solar resource modeling assumptions
- Grid reliability services through solar
- Outlook and value proposition for solar + storage

3:30 – 3:45 pm

Afternoon Break

3:45 – 5:00 pm

Core Financial Modeling Elements

- Overview of development timeline and costs
- Overview of operational costs
- Review of energy production inputs
- Review capital cost inputs and bid evaluation
- Own vs. procure analysis

5:00 pm

Course Adjourns



“Very informative. Well worth the two days of time spent. Years of experience taught in a few hours.”

Engineer II, Hawaiian Electric

POST-COURSE WORKSHOP

O&M Best Practices

FRIDAY, APRIL 20, 2018

OVERVIEW

As utility-scale solar installations merge into the generation mainstream, greater attention is turning to solar operations and maintenance. In just a few short years, the technology has matured so rapidly that a solid body of best practices is emerging from the lessons learned.

This workshop offers a comprehensive treatment of operational processes and maintenance practices that solar owners and asset stakeholders will find essential. It will address the distinctions of scope, scale and responsibilities associated with utility-scale solar installations. It will delve into the key system components and their critical requirements. Controls management, forecasting, performance engineering and analyses, training and risk assurance metrics are examined in detail. Maintenance measures will be spelled out by function. And risk exposures, with their commensurate remedies, will be set forth.

LEARNING OUTCOMES

Attendees will cover materials and engage in discussions that will allow them to:

- Define the O&M roles and functions with regard to various types of owners and stakeholders
- Review the scope, scale and responsibilities of O&M for the different types of solar installations
- Examine the O&M requirements for primary system components
- Discuss operations best practices associated with...
 - o Controls
 - o Alarms
 - o Forecasting
 - o Performance engineering and analysis
 - o Compliance and training
- Evaluate and apply best practices associated with critical maintenance metrics, such as...
 - o Cleaning and vegetation management
 - o Supply chain management
 - o Spares and tools
 - o Warranty enforcement
 - o Most common field problems
 - o Technology upgrades and longevity
- Review cost metrics and ranges for O&M in North America

POST-COURSE WORKSHOP AGENDA

FRIDAY, APRIL 20, 2018

7:45 – 8:15 am **Registration and Continental Breakfast**

8:15 – 8:30 am **Overview and Introductions**

8:30 – 10:00 am **O & M / Asset Management Foundations**

- Describing O&M service options, their plusses and minuses
 - o Turnkey EPCs
 - o Dedicated providers
 - o Asset owner (in-house) division
- Scoping elements
 - o Geography
 - o Climatic, seasonal and environmental variances
 - o Regional and national commonalities and variations
- Operations and maintenance – Challenges
 - o Agreements - not standard within industry
 - Scope of services and responsibility
 - Cost Model
 - Protocol for additional services (and cost estimate)
 - Guarantees
 - > Performance guarantee may appear in EPC, O&M, or separate agreement
 - > LDs for availability shortfalls – availability calculation method critical
 - o Equipment warranty lengths
 - o Limited experience with aging PV systems
- What happens when storage is added?
- Calculating levelized cost of energy (LCOE) in solar

10:00 – 10:30 am **Networking Break**

10:30 – 11:45 am **PV Plant O&M Practices and Pricing**

- Basis for increasing focus on O&M
- Scope, applicable scale, responsibilities of contract parties
- Key factors that frame the O&M budgeting process
 - o Employed performance levels and strategies
 - o Contractual structures
 - o Contract provisos
 - o Budget development terms
- PV budget ranges for O&M components and costs
- Budgeting process improvement opportunities

11:45 am – 12:45 pm **Group Luncheon**

POST-COURSE WORKSHOP AGENDA

FRIDAY, APRIL 20, 2018 (CONTINUED)

12:45 – 1:45 pm

Operations (O&M) Best Practices

- Reliability metrics
 - o MTBF and MTRS
 - o Response time
- Data collection
- Monitoring
- System and component performance mgmt and reporting
- Physical processes
- Staffing
- Controls and alarms
- System enhancement
- Testing methods (curve tracing, thermal imaging of connectors/transformers, etc.)
- Predictive diagnostics
- Emergency planning and response
- Supply chain and protocols
- Spare parts inventory
- Curtailment
- Remote tie-in at switchgear location
- Weather station(s)
- Physical security considerations and allowances
- Establishing and maintaining reserve funds

1:45 – 2:45 pm

Maintenance (O&M) Best Practices

- Metrics and practices
 - o Diagnostic
 - o Preventive
 - o Corrective/reactive
 - o Condition-based
- Monitoring systems
 - o Cleaning and vegetation management
 - o Supply chain management
 - o Sub-station
 - o Spares and tools
 - o Useful life and life expectancy
- Vehicular/equipment access
- Safety
- Warranty enforcement
- Most common field problems
- Technology upgrades and longevity

2:45 – 3:00 p.m

Afternoon Break

POST-COURSE WORKSHOP AGENDA

FRIDAY, APRIL 20, 2018 (CONTINUED)

3:00 – 4:00 pm

Managing the O&M Process

- Documentation
- Training
- Execution
- Work management
- Scheduling
 - o Access and transparency
 - o Equipment
 - o Site

4:00 – 5:00 pm

Utility Scale PV Performance Analytics

- Analytics
- Reporting
- Plant health assurance
- Data quality
- Plant energy forecasting

5:00 pm

Workshop Adjourns

COURSE INSTRUCTORS

Matt Brinkman

Solar Business Unit Manager, Burns & McDonnell

Matthew Brinkman is the Solar Business Unit Manager at Burns & McDonnell. In that capacity, he is responsible for business development, resource allocation, and business planning related to utility-scale solar projects. He manages a multi-disciplinary group of 70-plus engineers and directs a \$20 million annual budget for utility capital projects. His team specializes in capital and operations & maintenance projects at existing power plants, and utility-scale solar plants. Mr. Brinkman's team has worked on some of the largest and most lauded solar projects in the nation, including serving as the Owner's Engineer on the largest solar thermal plant in the world (392 MW Ivanpah) and the largest solar PV project in the United States (580 MW Solar Star). Mr. Brinkman was appointed by Governor Janet Brewer to serve on the Arizona governor's Solar Advisory Task Force.

Michael Bolen

Senior Project Manager – Solar Generation, Electric Power Research Institute (EPRI) invited

Michael Bolen is a Senior Technical Leader at the Electric Power Research Institute (EPRI). For the past two years, he has managed EPRI's Solar Generation team (Program 193C), whose mission is to provide members thought leadership and expert guidance on solar research, development, demonstration, and deployment. The team works on a broad range of activities and time-scales, a cradle-to-grave approach that spans field-testing novel solar technology to assessing end-of-life valuation, disposal, and/or recycling options. Prior to joining EPRI, Mr. Bolen was an Advisor to the U.S. Dept. of Energy (DOE) in the Solar Energy Technology Office for three years, directing the efforts of the SunShot Initiative. He worked as a post-doctoral researcher at the National Renewable Energy Laboratory (NREL) as well, contributing multiple technical innovations. He earned an MBA, M.S. and PhD degrees in Mechanical Engineering at Purdue University.

COURSE INSTRUCTORS (CONTINUED)

Torrey Graf

Senior Electrical Engineer – Solar Group, Burns & McDonnell

Torrey Graf is a senior electrical engineer in the Solar Group at Burns & McDonnell. Mr. Graf's responsibilities include providing electrical design, value engineering analysis, construction monitoring, commissioning/performance field engineer and energy production modeling for energy, government, municipal, and various other projects. He has developed an understanding of solar inverters for the PV market both for established and emergent technologies, as well as a deep expertise in the operation of PV power generation and their systems. Mr. Graf holds a Master of Science in Electrical Engineering from Arizona State University.

Eran Mahrer

VP Markets – Origination and Government Affairs, First Solar

Eran Mahrer serves as the VP Markets – Origination and Government Affairs for First Solar. He leads First Solar's origination activities among utilities, IPPs and other asset owners, while ensuring that the company's government affairs efforts are focused on supporting and growing robust markets for utility-scale solar PV. He joined First Solar in 2014, after serving as the Executive VP of Strategy and Programs for the Solar Electric Power Association (SEPA) for three years, where he led the organization's efforts in driving utility and solar industry strategies and practices in support of solar energy. Mr. Mahrer also led the organization's efforts in educational programming, overseeing SEPA's research agenda and working closely with utility leadership, regulators, developers, as well as other key stakeholders to position solar as part of the utility's core resource strategy. Prior to joining SEPA, Mr. Mahrer served as Arizona Public Service Co's (APS's) Director of Renewable Energy and Resource Portfolio Planning. In his 11 years with APS, he led the company's renewable energy strategy, renewable and customer program resource planning as well as the company's regulatory interface on many renewable matters, and implemented all its renewable programs.

Will Persyn

Vice President and Senior Account Executive – Power & Utility Practice, Aon Global Power

Will Persyn is Vice President and Senior Account Executive for Aon's Power & Utility Practice – Western Region. He quarterbackes the client relationship to identify and deploy the most impactful Aon resources to deliver mutually agreed-upon Aon Client Promise Plans. Mr. Persyn has over 15 years of Risk Management experience. Prior to joining Aon, he spent over ten years as the insurance, risk management, claims, and compliance manager with full responsibility for the strategic planning and leadership of the risk and insurance programs for a diversified, publicly traded company with over \$12 billion in assets. Their holdings included Arizona's largest electric utility, the US's largest nuclear power plant, commodity trading floor operations, a diverse renewable energy portfolio, unregulated energy services operations, real estate development and construction, and golf course operations. He spent five years at Willis where he ultimately led its Power, Utility & Renewable Energy practice.

Austin Quig-Hartman

Senior Manager – Origination, First Solar

Austin Quig-Hartman has more than 14 years of experience in the solar industry. As Senior Manager for Origination at First Solar, he oversees technical aspects of the firm's US business development organization from origination through contract execution. Prior to joining First Solar in 2014, Mr. Quig-Hartman managed the design team at SunPower. Mr. Quig-Hartman earned a B.S. in Mechanical Engineering from California Polytechnic University.

Robert Wanless

Vice President – National Accounts, M + W Group

Robert Wanless is Vice-President of National Accounts at M + W Energy, which is a company of the M + W Group. He has been associated with the organization for three-and-a-half years. He previously worked for SOLON Corp, a producer of solar power modules and solar systems for rooftop, roof integrated and greenfield installations specializing in the turnkey development, construction, and maintenance of commercial and utility-scale solar systems. Prior to that, Mr. Wanless worked as a senior analyst at Arizona Public Service (APS), as a northeast energy trader for Pacific Gas & Electric, and at the Ontario Power Generation. He also served as a board member on the Arizona Governor's Solar Energy Advisory Task Force for 3 years.

REQUIREMENTS FOR SUCCESSFUL COMPLETION

Participants must sign in/out each day and be in attendance for the entirety of the course to be eligible for continuing education credit.

INSTRUCTIONAL METHODS

PowerPoint presentations and test cases will be used to present course information.

PROCEEDINGS

The proceedings of the course will be published, and one copy will be distributed to each registrant at the course.

EVENT LOCATION

A room block has been reserved at the Embassy Suites Portland Washington Square, 9000 SW Washington Square Road, Tigard, OR 97223, for the nights of April 15-19, 2018. Room rates are US \$149 plus applicable tax. Call **1-503-644-4000** for reservations and mention the EUCI event to get the group rate. The cutoff date to receive the group rate is March 25, 2018 but as there are a limited number of rooms available at this rate, the room block may close sooner. ***Please make your reservations early.***

IACET CREDITS



EUCI has been accredited as an Authorized Provider by the International Association for Continuing Education and Training (IACET). In obtaining this accreditation, EUCI has demonstrated that it complies with the ANSI/IACET Standard which is recognized internationally as a standard of good practice. As a result of their Authorized Provider status, EUCI is authorized to offer IACET CEUs for its programs that qualify under the ANSI/IACET Standard.

EUCI is authorized by IACET to offer 1.5 CEUs for the course and 0.7 CEUs for the workshop.

REGISTER 3, SEND THE 4TH FREE

Any organization wishing to send multiple attendees to this course may send 1 FREE for every 3 delegates registered. Please note that all registrations must be made at the same time to qualify.

Please make checks payable to: "PMA"

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PLEASE REGISTER

SPECIAL BUNDLE PRICE: UTILITY-SCALE SOLAR POWER PLANT DESIGN FUNDAMENTALS COURSE AND WORKSHOP:

APRIL 18 – 20, 2018: US \$2295
Early bird on or before March 30, 2018: US \$2095

UTILITY-SCALE SOLAR POWER PLANT DESIGN FUNDAMENTALS COURSE ONLY:

APRIL 18 – 19, 2018: US \$1495
Early bird on or before March 30, 2018: US \$1295

POST COURSE WORKSHOP: O&M BEST PRACTICE ONLY

FRIDAY, APRIL 20, 2018: US \$995
Early bird on or before March 30, 2018: US \$895



How did you hear about this event? (direct e-mail, colleague, speaker(s), etc.)

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OR Enclosed is a check for \$ _____ to cover _____ registrations.

Substitutions & Cancellations

Your registration may be transferred to a member of your organization up to 24 hours in advance of the event. Cancellations must be received on or before March 16, 2018 in order to be refunded and will be subject to a US \$195.00 processing fee per registrant. No refunds will be made after this date. Cancellations received after this date will create a credit of the tuition (less processing fee) good toward any other EUCL event. This credit will be good for six months from the cancellation date. In the event of non-attendance, all registration fees will be forfeited. In case of course cancellation, EUCL's liability is limited to refund of the event registration fee only. For more information regarding administrative policies, such as complaints and refunds, please contact our offices at (201) 871-0474.