METEOROLOGY FOR RENEWABLE ENERGY SYSTEMS

February 26-27, 2018
EUCI Office
4601 DTC Blvd
Denver, CO

EUCI is authorized by IACET to offer 1.0 CEUs for the course.
OVERVIEW

Renewable energy is growing at an astounding pace at the global level, with rapidly declining prices now making it the most cost-effective option for new generation on many energy grids today. This increasing growth of renewable energy is impacting the electric grid in multiple ways, challenging many of the assumptions upon which traditional utility planning and operation relies. As this trend continues, it becomes increasingly important to evaluate best practices of renewable integration and to identify techniques and resources that simultaneously improve the power quality of the grid in systems with escalating levels of renewable penetration.

A crucial – and often overlooked – component to ensuring a functioning grid for a clean energy future is understanding the relationship between atmospheric science and renewable energy systems. This course will evaluate how meteorology fits in the big picture in the future of the utility system, discussing how and where it is important, and presenting a ‘soup to nuts’ approach to studying, planning, and applying meteorology data for renewable project development and grid operations.

LEARNING OUTCOMES

- Evaluate the significance of atmospheric science in the transition to a renewable energy future
  - How the weather impacts renewable integration and operations
- Discuss meteorology impacts to the system — transmission and generation
- Identify strategic and technical meteorology needs in renewable energy systems
  - Fundamental best practices
  - Using meteorology to build a better system from front to back
  - Forecasting and data analytics
  - Asset management in renewable systems
- Review wind and solar resource assessment and forecasting
- Discuss processes to move away from deterministic forecasting to probabilistic forecasting
- Assess best practices to bridge the gap between atmospheric science and utility industries
AGENDA

MONDAY, FEBRUARY 26, 2018

8:00 – 8:30 am   Registration and Continental Breakfast

8:30 am – 5:00 pm  Course Timing

12:00 – 1:00 pm  Group Luncheon

I. Setting the Context: Power Systems and Weather Dependency
   • Weather Dependency in Utility Power Systems
     o Overview of weather impact on traditional systems
     - How do variables like wind, temperature, and humidity impact load, distribution, transmission and traditional generation
     - How do these variables interact?
     - What impact do extreme events have
     o An overview of weather impacts on renewable generation (wind, solar and hydro)
     - Similarities and differences in weather impacts of each
     - Comparison with weather impacts on traditional systems
     - Resource interactions and why they matter
   • The Current Siloed Approach to Meteorology in the Project Life Cycle
     o An overview of three chief ways that meteorology is typically utilized: Resource Assessment, Generation Forecasting and Asset Management
     o The consequences of the silos in the renewable energy transition
     - Project siting drivers
     - Current real and perceived challenges for each type of renewable

II. Renewable Energy Meteorology 101
   • Renewable Energy Meteorology Introduction
     o What causes the weather? How does it relate to wind, solar and hydro
   • Terminology Primer - Commonly Used Terms and Definitions
     o Climate and weather
     o Variability and uncertainty
     o Renewable resource drivers for wind, solar and hydro
     o Variability, uncertainty and their nuances
     o Prediction types and their time horizons
       - Time horizons
       - Prediction types

III. Renewable Energy Systems 101
   • Renewable Electricity Technologies
   • Understanding their potentials, limitations, and promising applications
   • Power Systems Integration
     o What are integration costs? What drives them?
     o Is renewables integration different? If so how?
     o Integration myths
     o Integration solutions (footprint, market speed/liquidity, dispatch interval/horizon, forecasting)
   • Getting Out of the Silos and Understanding the Need for a Systems Approach
     o Why is meteorology and climatology a key driver?
     o Where should it fit?
IV. Resource Assessment
- Assessment Purpose and End-users
- The Traditional Approach – Measure, Correlate and Predict (MCP)
  - Measurement campaign instruments and strategies
  - Spatial extrapolation: Why? How? Limitations
  - Placing the record in a historical context: Why? How?
  - Haircut time: The gross to net conversion process
    - Icing, electrical loss, parasitic loss, availability, cutouts
    - Wake loss evaluation
  - Evaluating sources of uncertainty
  - Site suitability and extreme condition assessment
- Shortcomings of the Traditional Approach
- Advanced Resource Assessment
  - Instrumentation: sodars, lidars, scanning lidars and their benefits
  - Mesoscale modeling and reanalysis data for spatial extrapolation and climatological adjustment
  - CFD modeling
  - Stability impacts
  - Rotor equivalent wind
- Primary Differences between Wind and Solar
- A Vision of Future Resource Assessment
- Climate Change

V. Meteorology Impacts on Renewable Energy
- A Deeper Dive into the way Different Meteorological Phenomena Impact Wind, Solar and Hydro
  - Scales of motion
  - Drivers of change
  - Large scale weather systems
  - Terrain induced flows: mountain/valley and sea-breeze
  - Transient features like fronts and troughs
  - Mountain waves
  - Mountain wakes
  - Gapflows
  - Convection (Thunderstorms)
  - Stability
  - Micro-climates
  - Extreme conditions: High winds, high/low temperatures, snow and ice
  - Cold waves including impacts on traditional energy
  - Hurricanes

VI. Renewable Energy Generation Forecasting
- Load, Wind and Solar Forecasting 101
  - The basic building blocks
  - The similarities and differences between wind, solar and load forecasting
  - Why load forecasting will allows be more accurate the wind and solar
- Foundational Numerical Weather Prediction
  - How do we forecast the planet’s weather
  - Initial conditions and boundary conditions. What are they? Where do they come from?
    - What is data assimilation
  - The impact of resolution
  - Modeling processes occurring at higher resolution than the model operates at
VI. RENEWABLE ENERGY GENERATION FORECASTING (CONTINUED)

- Creating a Power Forecast
  - How is a power forecast derived? What inputs are needed?
  - Methodologies utilized at different time horizons
  - Differences between wind and solar
  - Coupling of other earth system models
    - Land surface model and land use
    - Ocean models
    - Hydro models
- Ramp Forecast Tools and Situational Awareness
- Data….What Matters and What Doesn’t?

TUESDAY, FEBRUARY 27, 2018

8:00 – 8:30 am  Continental Breakfast

8:30 – 11:45 am  Course Timing

VII. Implementing a Renewable Energy Forecasting Solution
- What Determines Variable Energy Resources and Load Forecast Value?
- The Weather Forecast Value Chain
- Best Practices for Developing a Robust Forecasting Solution and Integrating it into Operations
- Evaluating Forecast System Performance
  - Why verify? What to verify
  - Typical verification metrics
  - Advanced verification metrics
- Renewable Energy Forecasting Trials – Do’s and Don’ts

VIII. Applications of Meteorology to Asset Management
- Know Your Fuel and Make Sure Your Fuel Gauge Works
- How to Access Real Plant Performance Against Budget
- Operations and Maintenance Planning
- Planning for Non-Renewable Units
- Building a Lower Risk Portfolio

IX. Transmission and Generation Planning for High Penetration Renewables
- Why Meteorology/Climatology are Critical Here
  - Resource attributes and diversity
- Revisit the Hydro Analogy
- Grid Co-Optimization Studies
  - What is the motivation? How do they work?
  - Insights into how much RE can be integrated and at what cost
  - Advantages of planning versus ad-hoc build out
  - Limitations of grid co-optimization methods
X. **Renewable Energy is About Systems – Pulling it All Together**
- A Short Case Study Example of Meteorology Adding Millions of Dollars of Value
- Demand Side Pricing Transparency, Aggregators and Demand Response
- Forecasting is NOT a Magic Bullet
- The Old and New Paradigms
  - Baseload, curtailment, reliability
  - Load and generation are not independent
- Incorporating Meteorology into System Design

## INSTRUCTORS

### Justin Sharp
**Principal and Founder, Sharply Focused Forecasting**

Justin Sharp is Principal and Founder of Sharply Focused Forecasting, consultants in all aspects of wind forecasting. He has 20+ years of experience as a meteorologist, with 13 years of energy sector. After completing his Ph.D. Justin began his energy career providing weather forecasts as inputs to load and hydro modeling systems at Bonneville Power Administration. In 2005, Justin joined PPM Energy (now Avangrid) where he founded, built and directed the operational meteorology division from the ground up. Tasks included reconciling commercial and operational data with meteorological data, and providing real time 24/7 trading and operations support from a renewable energy forecasting desk. He has played an active role in advocacy and policy discussions promoting the cost effective and reliable transition to a high renewables penetration electric system and had presenting at numerous workshops and informed policy discussions in a diverse range of areas including FERC, NOAA leadership, DOE, and the President’s Office of Science and Technology Policy. Justin is currently the Chair of the American Meteorological Society’s Renewable Energy Committee.

### Greg Poulos
**CEO & Principal Atmospheric Scientist, ArcVera Renewables**

Dr. Poulos is a co-founder of ArcVera Renewables, a technical consulting firm created through the merger of V-Bar and Chinook Wind in March 2017. He joined V-Bar in 2009, became an owner in 2011 and eventually led its global solar and wind energy consulting practice. Previously, he led Clipper Windpower’s first wind resource assessment group where he oversaw wind resource analysis for 10,000 MW under development. From 1993 to 2007 he was an entrepreneurial company founder; scientific researcher; field experimentalist; and leader at Los Alamos National Laboratory and the National Center for Atmospheric Research. Throughout his career, Dr. Poulos has focused on winds and atmospheric conditions near the surface of the earth and in complex terrain; high-resolution mesoscale modeling; large-eddy simulations; weather forecasting; and atmospheric observations using meteorological towers, sonic anemometers, sodar, 3-D lidar and profiling atmospheric radar. He holds a B.S. in Atmospheric Science from Cornell University, and an M.S. and a Ph.D. in Atmospheric Science from Colorado State University.
REQUIREMENTS FOR SUCCESSFUL COMPLETION OF PROGRAM

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

Case studies and PowerPoint presentations will be used in this program.

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.

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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 January 26, 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 EUCI 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, EUCI'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.