Meteorology and Market Design For Grid Services Workshop

Denver, CO
June 4-6, 2019

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

Meeting Overview – Day 1

- **Tuesday Morning Pre-Workshop Tutorial on Electricity Markets and Forecast Utilization**
  - Chairs, Erik Ela and Aidan Tuohy, EPRI
- **Tuesday Afternoon – Opening of the Workshop**
  - Introductions, Mark Ahlstrom, President, ESIG Board
  - Welcome and Opening Remarks, Martin Keller, NREL Lab Director
  - Overview, Charlie Smith, Exec Dir, ESIG
- **Plenary Session: Common Ground – Forecasting and Market Design for Clean Energy Futures**
  - Moderator: Bethany Frew, NREL
- **Tuesday Evening Networking Reception**

Meeting Overview – Day 2

- **Wednesday Morning Sessions**
  - Forecasting Session 1: DOE Solar Forecasting 2 Program
    - Moderator: Tassos Golnas, DOE
  - Markets Session 1: Hybrid Resources and VPPs
    - Moderator: Erik Ela, EPRI
  - Forecasting Session 2: Forecasting for DER Applications
    - Moderator: Bri-Mathias Hodge, NREL and UC Boulder
  - Markets Session 2: Forecasting and Market Design for Grid Services
    - Moderator: Eric Gimon, Energy Innovation

Meeting Overview – Day 2 cont.

- **Wednesday Afternoon Sessions**
  - Forecasting Session 3: Solar and Wind Forecasting R&D Part 1
    - Moderator: Craig Collier, DNV-GL
  - Markets Session 3: Current and Future Market Revenue Streams
    - Moderator: Mark O'Malley, NREL
  - Forecasting Session 4: Solar and Wind Forecasting R&D Part 2
    - Moderator: Jeff Lerner, Vaisala
  - Markets Session 4: Innovation of Services and Markets
    - Moderator: Elaine Hale, NREL

Meeting Overview – Day 3

- **Thursday Morning Sessions**
  - Forecasting Session 5: IEA Wind Task 36 – Wind Forecasting
    - Moderator: Caroline Draxl, NREL
  - Markets Session 5: System Operation and Extreme Weather Events
    - Moderator: Josh Novacheck, NREL
  - **Closing Plenary Session: Global Perspectives on Forecasting and Market Design**
    - Moderator: Aidan Tuohy, EPRI
  - Closing Remarks: Charlie Smith
  - Adjourn: 12:30 pm

Renewable Energy is Very Competitive

- Lazard reports on lowest unsubsidized energy costs at end of 2018 for:

Rooftop residential solar	$160/MWh
Simple Cycle GT	$152/MWh
Nuclear	$112/MWh
Community Solar	$73/MWh
Coal	$60/MWh
Combined Cycle GT	$41/MWh
Utility scale solar	$36/MWh
Wind energy	$29/MWh

- Other reports from industry pubs on recent PPA prices:

Utility scale solar	$22-$35/MWh
Wind energy	$11-$25/MWh

Storage Systems Definitely Making Progress

- Lazard reports at end of 2018 on estimated lowest unsubsidized energy costs for a range of storage systems (10 kw to 100 MW):

Peaker Replacement (4 hr @ 100 MW)
- Lithium Ion $204/MWh

Utility Scale PV + Storage (PV @ 40 MW + storage of 20 MW @ 4 hr)
- Lithium Ion $108/MWh

C&I BTM Standalone (2 hr @ 1 MW)
- Lithium Ion $829/MWh

C&I BTM PV + Storage (PV @ 1 MW + storage of .5 MW @ 4 hr)
- Lithium Ion $315/MWh

Residential BTM PV + Storage (PV @ 20 Kw + storage of 10 Kw @ 4 hr)
- Lithium Ion $476/MWh

- Xcel Energy CO June 2018 ERP: **PV plus battery at $30-32/MWh**
- NextEra projects at NV Energy: **PV plus battery at $<30/MWh**

An Industry Maturing - Globally

- Global wind capacity end of 2018: 600 GW
- Global PV capacity end of 2018: 512 GW
- Global VG installations in 2018
  - Wind 54 GW
  - PV 109 GW
- Ballpark estimates for 2019 global VG installations
  - Wind 60 GW
  - PV 120 GW

Recent Industry Trends

- Corporate demand for carbon-free energy is increasing. Bloomberg NEF reported US corporations acquired over 6 GW of clean energy in 2018
- RE100 corporate membership hits 158 at end of 2018
- Sierra Club *Ready for 100* campaign reports increasing commitments to 100% renewable goals;
  - 109 cities, 11 counties
- Five states and DC have legal requirements:
  - HI – 100% clean energy by 2045
  - CA – 100% clean energy by 2045
  - NM – 100% clean energy by 2045
  - WA – 100% clean energy by 2045
  - CO – 100% clean energy by 2050
  - DC – 100% renewable energy target by 2035
- Eight states to watch for 100% clean energy targets by 2050:
  - MN, WI, IL, MA, NJ, PA, NC, MI

Recent Industry Developments

- EIM reports total benefits at end of Q4 2018 of $565 million since its inception in November 2014. EIM includes CAISO, Pacificorp, NV Energy, APS, PSE, PGE, Idaho Power and Powerex
- Record coal plant retirements of 16 GW in 2018
- Sunrun clears ISO-NE capacity auction with 20 MW VPP with aggregation of residential PV and storage, first ever
- FPL unveils plans to build what it says will be the largest solar-powered battery plant in the world, 409 MW / 900 MWh Manatee Energy Storage Center, to begin operation in 2021
- Grid operators file responses to FERC deficiency letters in early May on integrating storage into wholesale markets (FERC Order 841)
- DNV GL *Energy Transitions* report - electric load could double by 2050
- Energy Web Foundation creating *"blockchain of blockchains"* to facilitate global energy trading

Some Recent Headlines…

- MidAmerican To Become First 100% Renewable Energy Utility with Wind XII Project
  - *Wind XII will transform our 100% renewable energy vision from a bold dream into a reality.* Adam Wright, MidAmerican President and CEO
- Even in Indiana, New Renewables are Cheaper than Existing Coal Plants
  - NIPSCO found it can save customers more than $4B over 30 years by moving from 65% coal today to eliminating it by 2028 and replacing it with mostly wind, solar and storage.
- PacifiCorp Shows 60% of It's Coal Units Are Uneconomic
  - Further analysis of options required
- Idaho Power targets 100% carbon free energy by 2045, joining the ranks of Xcel

NextEra Energy Earnings Call – Jan 2019

From an article by Christian Roselund reporting on the NextEra Energy earnings release conference call of January 25, 2019

- CEO Jim Robo predicted that solar and wind plus storage will be cheaper than coal, oil or nuclear, that this will be massively disruptive to the conventional fleet, and that it will provide opportunities to developers well through the next decade
- Here are the costs Robo anticipates early in the next decade:
  - Unsubsidized new wind: 2.0-2.5 cents per kilowatt-hour
  - Unsubsidized new solar: 2.5-3.0 cents per kilowatt-hour
  - Storage will add .5-1 cents per kilowatt-hour to cost of solar
- Lowest average cost of CC plant around 4 cents per KWh, and you still have the uncertainty of the fuel cost

Xcel Energy Clean Energy Plan

- In June 2018, Xcel Energy Colorado submitted a plan to retire two coal units 10 years early and replace them with $2.5B of wind, solar and batteries, while reducing cost and emissions and improving reliability
- *"I will tell you, it's not a matter of if we're going to retire our coal fleet in this nation, it's just a matter of when,"* Xcel Energy CEO Ben Fowke said on stage at EEI Annual Convention in San Diego in preview of the plan.
- In December of 2018, Xcel Energy announced a commitment to achieve 100% carbon-free electricity across its 8 state territory by 2050, a first for the industry
  - *Plans to cut carbon emissions 80% below 2005 levels by 2030 will be fairly easy and affordable*
  - *Getting all the way to 100% is the tough part*

As If That Wasn't Enough…

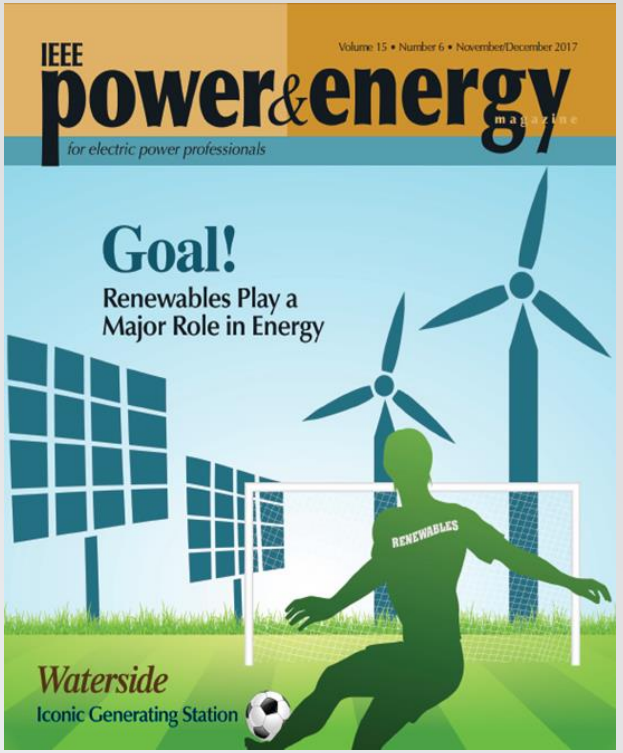
- BP's 2018 Energy Outlook forecasted a peak in oil demand for the first time—while renewables will grow even faster than previously expected.
- Peak oil driven by the rise of shared and autonomous electric vehicles. Under the Evolving Transition (ET) scenario, which assumes that policies and technology continue to evolve at a speed similar to that in recent past, oil demand slows and then plateaus in the late 2030s.
- Several other energy research groups have upped their EV forecasts in recent years. However, BP's latest projection ranks among the most ambitious.

Renewables are the Way of the Future

BP Outlooks for 2035

Onward and Upward

- A warm welcome to visitors from afar:
  - Australia
  - Japan
  - Korea
  - Germany
  - France
  - Spain
  - Norway
  - United Kingdom
  - Denmark
  - Canada
  - Texas



- Take the time to make some new friends!
- Looking forward to another great meeting!

Upcoming 2019-2020 Meetings

2019 Fall Technical Workshop
October 28 – 30, 2019
Hilton Charlotte Center City
Charlotte, NC

2020 Spring Technical Workshop
March 17-19, 2020
Loews Ventana Canyon Resort
Tucson, AZ

2020 Meteorology & Market Design for Grid Services Workshop
June 9-11, 2020
Curtis Hotel - Downtown Denver
Denver, CO

2020 Fall Technical Workshop
October 26 – 28, 2020
Sheraton Austin at the Capitol
Austin, TX

Thank You!

Charlie Smith

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Connect with @ESIG

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