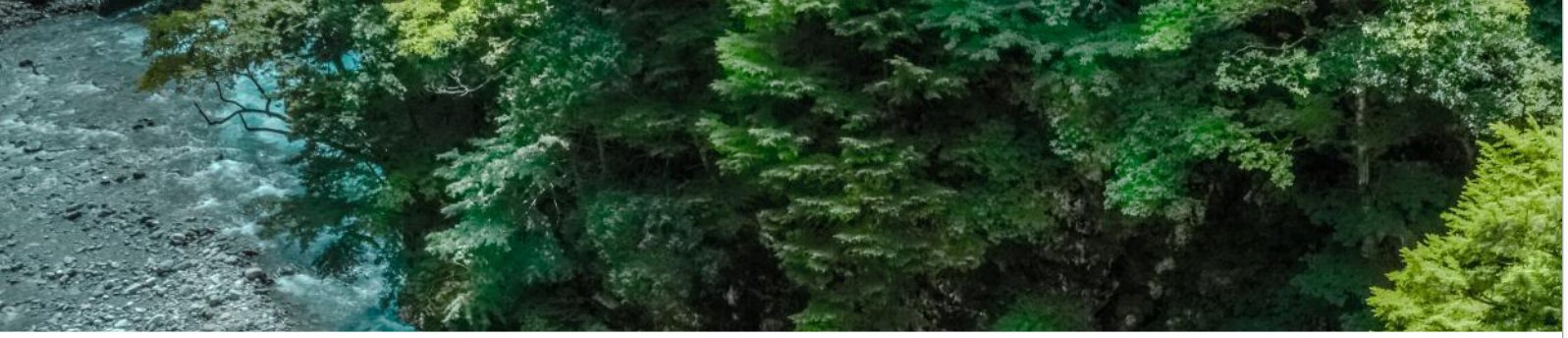


# 2018 Fall Technical Workshop

Denver, CO
October 1-3, 2018

ESIG
ENERGY SYSTEMS
INTEGRATION GROUP

# Meeting Overview – Day 1

- **Pre-Workshop Tutorial on Monday Morning**
  - Inertia Ain't All It's Cracked Up to Be
    - *Chairs, Derek Stenclik and Matt Richwine, GE*
- **Monday Afternoon – Working Group Meetings**
  - Research and Education WG – Chair, Mark O'Malley, NREL
    - *ESI roadmap*
  - Reliability WG – Chair, Sebastian Achilles/Jason MacDowell, GE
    - *Reliability challenges with high VG penetration*
  - System Planning WG – Chair, Aaron Bloom, NREL
    - *Planning for wide scale adoption of distributed PV in RTO markets*
  - Distributed Energy Resources (DER) WG – Chair, Debbie Lew, GE
    - *Experiences in planning and operation with high penetrations of DERs*
  - System Operation and Market Design WG – Chair, Aidan Tuohy, EPRI
    - *Recent developments in system operation with VG*
- **Monday evening ESIG Board meeting 6:00 pm**

# Meeting Overview – Day 2

- **Tuesday Sessions**
  - Welcome and Opening Remarks - Alice Jackson, President, Xcel Energy PSCO
  - Plenary: Managing a High Penetration Renewable Power System
    Moderator: Goran Strbac, Imperial College, London
  - Session 2A: Market Design and System Operations for Storage, Flexibility, and Beyond: View from the Front Lines
    Moderator: Sonia Aggarwal, Energy Innovation
  - Session 2B: Energy Storage Developments
    Moderator: Rashid Abdul, WEG Transformers
  - Session 2C: Resilience, Price Formation and Market Design
    Moderator: Bethany Frew, NREL

# Meeting Overview – Day 2 cont.

- **Tuesday Sessions cont.**
  - Session 3A: Panel Discussion on Beyond LCOE Study

    Moderator: Mark O'Malley, NREL
  - Session 3B: Electric Transportation and ESI

    Moderator: Obadiah Bartholomy, SMUD
  - Session 3C: Planning for Future Energy Systems

    Moderator: Bruce Rew, SPP
- **Networking Reception 6:30 pm – 8 pm**

# Meeting Overview – Day 3

- **Wednesday Morning Networking Breakfast: 7-8 am**
  - Initiative of Beth LaRose, GE board member, with support of Aaron Bloom and Bethany Frew, NREL
  - Purpose: to promote an inclusive conversation with a focus on gender diversity, early career issues, and industry role models
- **Wednesday Sessions**

  - Session 4A: Innovative Methods to Improve Flexibility

    Moderator: Russ Philbrick, Polaris Optimization

  - Session 4B: Distribution System Developments

    Moderator: Debbie Lew, GE

  - Closing Plenary: Long Term ESI Planning Considerations

    Moderator: William D'haeseleer, KU Leuven

  - Adjourn: 12:30 pm

# Renewable Energy is Very Competitive

- Lazard reports on lowest unsubsidized energy costs at end of 2017 for:

| | |
|---|---|
| Simple Cycle GT | $156/MWh |
| Rooftop residential solar | $187/MWh |
| Nuclear | $112/MWh |
| Coal | $60/MWh |
| Combined Cycle GT | $42/MWh |
| Utility scale solar | $43/MWh |
| Wind energy | $30/MWh |

- Other reports from industry pubs on recent PPA prices:

| | |
|---|---|
| Utility scale solar | $23-$40/MWh |
| Wind energy | $11-$24/MWh |

# Storage Systems are still struggling, but starting to show promise…

- Lazard reports at end of 2017 on estimated lowest unsubsidized energy costs for a range of storage systems (5 kw to 100 MW):

**Peaker Replacement (4 hr @ 100 MW)**
- Lithium Ion $282/MWh

**Distribution Substation (6 hr @ 10 MW)**
- Lithium Ion $272/MWh

**Microgrid (4 hr @ 1 MW)**
- Lithium Ion $375/MWh

**Commercial BTM (2 hr @ 125 kw)**
- Lithium Ion $891/MWh

**Residential BTM (2 hr @ 5 kw)**
- Lithium Ion $1,028/MWh

# An Industry Maturing - Global

- Global wind capacity end of 2017: 540 GW
- Global PV capacity end of 2017: 400 GW
- Global VG installations in 2017
  - Wind 53 GW
  - PV 92 GW
- Ballpark estimates for 2018 global VG installations
  - Wind 60 GW
  - PV 100 GW

# Recent Industry Trends

- Wind and solar PV system prices continue to fall. In Jan '18, Xcel announces amazing results from solicitation, with median prices for 2023 delivery:
  - wind at $18.10/MWh
  - wind plus battery at $21/MWh
  - PV at $29.50/MWh
  - PV plus battery at $36/MWh
- Latest Mexican auction (Nov '17) average PPA PV price of $19.70/MWh. Lowest wind price came in at $17.70/MWh.
- Corporate demand for carbon-free energy is increasing. Bloomberg NEF reported that corporations globally have acquired 7.2 GW of clean energy thus far this year, 20% greater than total for 2017
- Low energy market prices continue to drive market redesign efforts in US and Europe amid concerns over capacity adequacy, flexibility, and ERS
- Growing recognition globally of the need for greater system flexibility required to enable integration of high shares of renewable energy
- Increasing incidences of entities announcing 100% renewable goals

# Recent Industry Developments

- EIM reports total benefits at end of Q2 2018 of $402 million since its inception in November 2014. EIM includes CAISO, Pacificorp, NV Energy, APS, PSE, PGE, Idaho Power and Powerex.
- FERC Order 841 issued in February 2018 requires ISOs to revise market rules to allow participation of energy storage devices >100 kw in the wholesale electricity markets
- FERC Order 842 issued in February 2018 requires all new generating facilities to install governor controls in support of PFC as a condition of interconnection.
- FERC Order 845 in April 2018 recognizes storage as a resource and streamlines the interconnection process
- IEEE 1547 has been approved and gone to implementation!
- Hawaii and California pass 100% initiatives, RE100 up to 152 members
- DNV GL *Energy Transitions* report says electric load could double by 2050

# NextEra Energy Earnings Call

From an article by David Roberts reporting on the NextEra Energy earnings release conference call of January 26, 2018 by CEO Jim Robo:

- Robo predicted that by the early 2020s, it will be cheaper to build new renewables than to continue running existing coal and nuclear plants.
- 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: 3.0-4.0 cents per kilowatt-hour
  - Variable operating costs of existing coal or nuclear plants: 3.5-5.0 cents per kilowatt-hour
- If those predictions hold up, it is game over for coal (and nuclear, unless it gets support based on its low carbon emissions). No one will ever build another coal plant in America, and the ones still running would likely shut down sooner than scheduled.

*David Roberts, Vox.com, Jan 29, 2018*

# Xcel Clean Energy ERP Filing

- Xcel Energy Colorado submitted Electric Resource Plan (ERP) to CO state regulators on June 6, 2018
- The plan includes "unprecedented low pricing“, with wind at levelized cost between $11-18/MWh, solar between $23-$27/MWh, and solar-plus-storage between $30-$32/MWh
- The plan would add more than 1,800 MW of solar and wind, paired with 275 MW of battery storage, and 383 MW of existing gas assets

# Xcel ERP Filing Impact on Coal

- Comanche Units 1 and 2 produce a total of 660 MW of coal-fired generation, approximately one-third of Xcel Colorado's remaining coal fleet. The Comanche units would be retired in 2022 and 2025, 11 years and 10 years early respectively,  as part of the plan
- Through the combination of renewables, gas and energy storage, Xcel expects to increase system reliability, even as coal generation comes offline.

# Xcel ERP Filing Bottom Line

- ERP states the clean energy proposal is more compelling because “it delivers lower costs along with substantial environmental and renewable energy gains”
- Favorable economics are influenced by:
  - Robust pool of low-cost renewable bids
  - Transmission access due to early coal retirements
  - Low-cost gas and battery bids that offer flexibility and help meet peaking requirements
- “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.

# As If That Wasn't Enough…

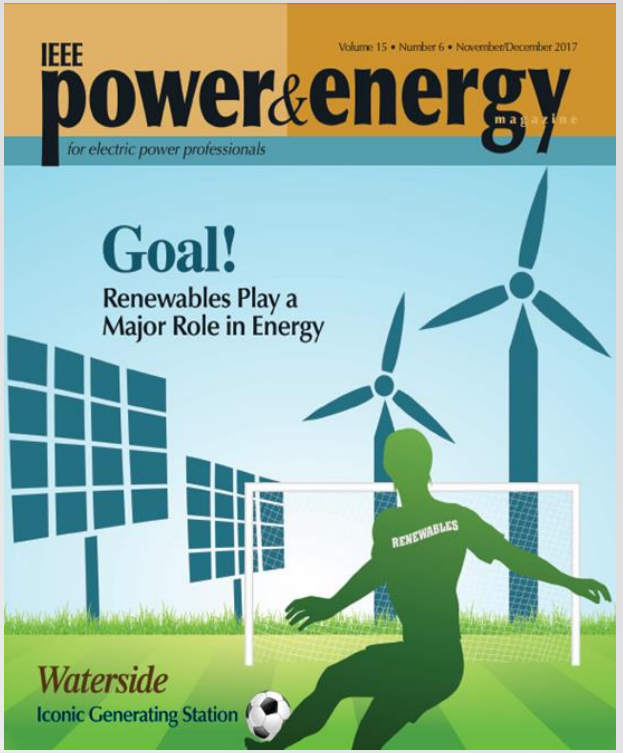
- BP's latest Energy Outlook forecasts a peak in oil demand for the first time—while renewables will grow even faster than previously expected.
- Peak oil driven by the rise of shared and autonomous electric vehicles. Under the Evolving Transition (ET) scenario, which assumes that policies and technology 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:
  - Canada
  - Germany
  - Ireland
  - Colombia
  - United Kingdom
  - Faroe Islands – Kingdom of Denmark
  - Texas




- Take the time to make some new friends!

- Looking forward to another great meeting!

# Upcoming 2018-2019 Meetings

**2019 Spring Technical Workshop**
March 19 – 21, 2019
Hyatt Regency Tamaya Resort & Spa
Bernalillo, NM
(near Albuquerque)

**Second International Conference on Energy Systems Integration**
March 25 - 26, 2019
Imperial College
London, England

**2019 Forecasting Workshop**
June 4-6, 2019
Embassy Suites - Downtown Denver
Denver, Colorado

**2019 Fall Technical Workshop**
October 28 – 30, 2019
Charlotte, NC

# Thank You!

**Charlie Smith**

**Executive Director**

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**Connect with @ESIG**

**www.esig.energy**