Integrating Renewable Energy Into the Western U.S. Grid: Challenges and Opportunities

State-Federal RPS Collaborative

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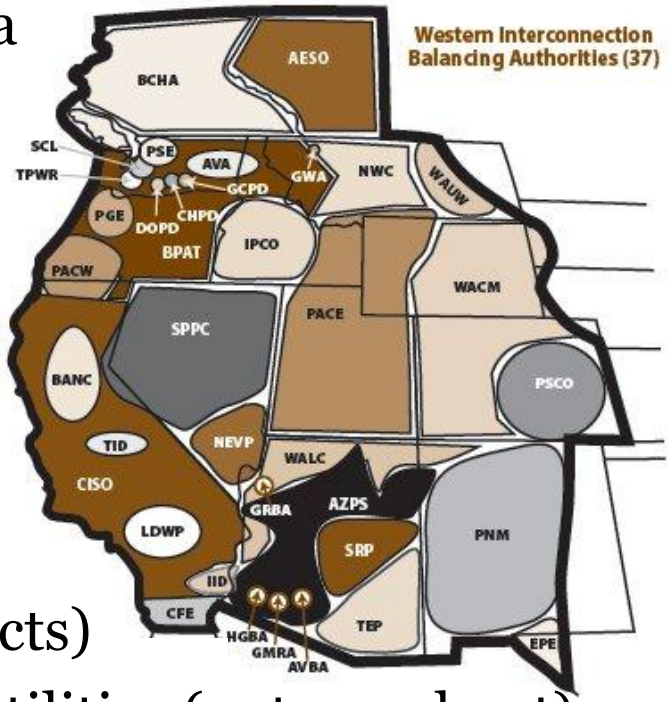
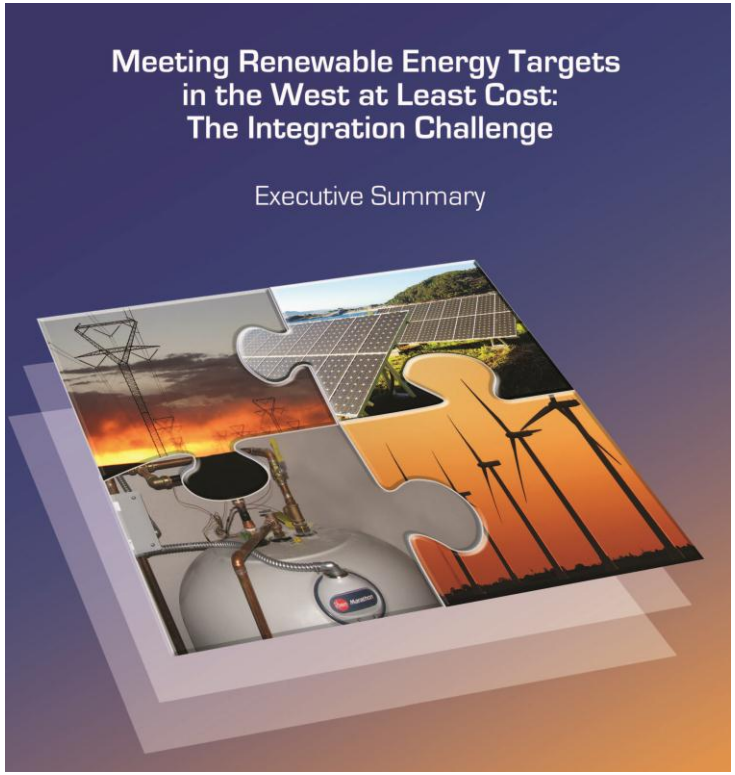
Western U.S. Electric System

- 37 balancing authorities* in the Western Interconnection
- 14 states, 2 Canadian provinces, N. Baja
- Outside organized energy markets (AESO, CAISO) + some pilots, energy and transmission are scheduled hourly
- 2 federal agencies market power from dams, own/control much transmission
- Utilities choose resources based on their long-term plans and competitive bidding (utility-owned plants or contracts)
- Transmission development largely by utilities (not merchant)
- State renewable energy standards in place today will more than double renewable resources in Western U.S. by 2022, compared to 2010



**Balancing authorities maintain load-interchange-generation balance within their area and support interconnection frequency in real time*

- New Western Governors' Association report explores ways to reduce costs for integrating wind and solar resources, barriers and possible state actions
- By RAP (lead), Exeter Associates & National Renewable Energy Laboratory
- Funded by Energy Foundation and U.S. Department of Energy



- Technical committee helped with scope, resources, review
- Focuses on operational and market tools, flexible demand and supply resources (not storage or expanding transmission)

Executive summary: http://www.westgov.org/index.php?option=com_joomdoc&task=doc_download&gid=1602
Full report: http://www.westgov.org/index.php?option=com_joomdoc&task=doc_download&gid=1610

Integration Challenges for Renewable Energy

- **Variability** – *The range of expected generation and load*
  - Variability is reduced with more resources spread over a wider area because of the diversity of weather patterns.
- **Uncertainty** – *When and how much generation and load will change*
  - Operators plan based on forecasts of loads and generation sources.
  - Uncertainty of wind and solar output is due to unknown changes in weather.

SunEdison facility, Aurora, Colo.

NREL

- **Conventional units also impose integration costs.**
  - For example, new inexpensive baseload plants can cause other units to incur cycling costs and lower their capacity factor.

How Can Grid Flexibility Be Increased?

- **Improved institutional flexibility**
  - Fast energy markets and short scheduling intervals for transmission
  - Balancing wind and solar resources over a large geographic area to net out changes in load and generation
  - Use advanced solar and wind forecasting techniques
  - Make better use of existing transmission capacity
- **A more flexible generating fleet**
  - Cost-effective modifications of existing plants may be possible to improve load-following capability (ramp rate up and down, lower minimum load and faster startup capability)
  - For new generating plants, focus on flexibility
- **Demand response** – Some loads can respond rapidly (up and down) with automation
- **Adequate transmission**
- **Energy storage** – Such as pumped hydro, batteries, compressed air, plug-in electric vehicles

Broad Conclusions of Report

- The Western grid is operated inefficiently.
  - Hourly scheduling
  - Insufficient automation
- We're spending more than needed for integration.
  - Carrying too many reserves, and dispatching higher cost generation when lower cost generation is available
- Integrating high levels of renewable resources reliably and affordably will require unprecedented cooperative action.
- States can accelerate efforts to reduce costs, such as:
  - Asking utilities and transmission providers what they are doing to put in place the recommendations in the report
  - Convening parties to discuss benefits of least-cost delivery of wind and solar resources and develop solutions to institutional barriers

1. Improve Institutional Flexibility

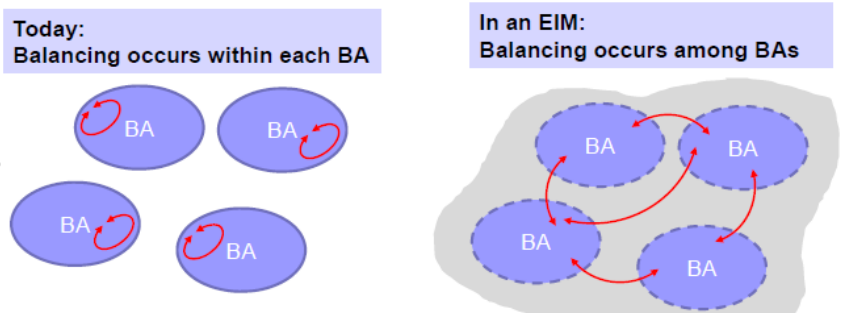
- Expand subhourly dispatch and scheduling
  - Some 30-min. pilots in Western U.S. New FERC rules require all transmission providers to offer 15-minute scheduling or consistent/superior alternatives.
  - **Key recommendations**
    - Evaluate costs/benefits, standardize intra-hour scheduling across West
- Facilitate dynamic transfers
  - They allow the balancing authority receiving energy from wind or solar in another area to manage the intra-hour integration.
  - **Key recommendation**
    - Prioritize transmission improvements to increase transfer capability
- Improve reserves management
  - **Key recommendations**
    - Expand reserve-sharing
    - Explore calculating reserves dynamically
    - Assess benefits of using contingency reserves* for wind
    - Equip more generation with Automatic Generation Control**

**Contingency reserves are generation or demand resources available as needed to maintain electric service reliability during unforeseen events, such as an unscheduled power plant outage.*
***AGC is equipment that automatically adjusts generation from a central location.*

• Implement an energy imbalance market

Imbalance energy = Scheduled energy - actual energy delivered

- Under proposed Western U.S. EIM, initial operating conditions for each hour would still be based on traditional bilateral transactions
- EIM would re-dispatch generation every 5 minutes to manage grid constraints and supply imbalance energy from least-cost resources
- Generation would be dispatched *across* balancing authority areas to resolve energy imbalances using the full geographic diversity in the EIM footprint.
- **Key recommendations**
  - Further study costs and benefits
  - Address governance issues and concerns
  - Define rates and terms for transmission service agreements
  - Support Northwest Power Pool's evaluation of an EIM and West-wide efforts to design an EIM for the broadest footprint



PUC EIM Group: http://www.westgov.org/PUCeim/index.htm; NWPP initiative: http://www.nwpp.org/mci/

- Improve weather, wind and solar forecasting
  - Wind and solar forecasts allow better scheduling of other resources
  - <1/2 of Western balancing authorities use wind and solar forecasts
  - **Key recommendation**
    - Encourage use of forecasts for day-ahead schedules/dispatch (uncommon in West now), not just same-day unit commitment
- Take advantage of geographic diversity
  - Spreading wind and solar plants over a larger area lowers aggregate variability and forecast errors, reducing reserves needs
  - **Key recommendations**
    - Consider sites that minimize variability of aggregate output and better match utility load profiles.
    - Support right-sizing* of interstate lines that access renewable resources from stakeholder-designated zones – when project benefits exceed costs.

Alstom 2010. Photo courtesy of DOE/NREL

**Right sizing – Increasing project size, voltage or both to account for credible future resource needs*

2. Explore Demand Response That Complements Variable Generation

- Some customer loads are flexible.
- Consider direct load control (e.g., for electric water heaters) and real-time pricing with automation to shift loads up and down to complement wind and solar resources.
- **Key recommendations**
  - Test value propositions to assess customer interest in strategies for demand response that complements wind and solar
  - Encourage participation of third-party aggregators
  - Allow demand response to compete on a par with supply-side alternatives for meeting resource needs

See papers by LBNL and Navigant: http://eetd.lbl.gov/ea/ems/sg-pubs.html; http://www.calmac.org/publications/7-18-12_Final_White_Paper_on_Use_of_DR_for_Renewable_Energy_Integration.pdf

3. Develop a More Flexible Generating Fleet

At high levels of wind and solar, simply counting megawatts is inadequate for determining capacity needs. Instead, consider flexible capabilities:

- Assess whether some existing generating plants can be retrofitted to increase flexibility
  - Lower min. loads, reduce cycling costs, increase ramp rates
- Focus on flexibility for new generating plants
  - **Key recommendations**
    - Rethink resource adequacy analysis to reflect flexibility needs
    - Amend guidance for planning
    - Use competitive procurement to evaluate alternative flexible capacity solutions

See new RAP paper, *What Lies Beyond Capacity Markets?*
http://raponline.org/document/download/id/6041

About RAP

The Regulatory Assistance Project (RAP) is a global, non-profit team of experts that focuses on the long-term economic and environmental sustainability of the power and natural gas sectors. RAP has deep expertise in regulatory and market policies that:

- Promote economic efficiency
- Protect the environment
- Ensure system reliability
- Allocate system benefits fairly among all consumers

Learn more about RAP at www.raponline.org

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