Western Regional Market Developments:
Impact on Renewable Generation Investments and Balancing Costs

PREPARED BY:
Onur Aydin
Johannes Pfeifenberger
Judy Chang

Wind Power Finance & Investment Summit—Executive Briefing
San Diego, CA

February 7, 2017

THE Brattle GROUP
Regional Market Efforts in WECC

Motivated in part by renewable balancing needs and cost savings, several regional market initiatives are on-going:

- **Energy Imbalance Market (EIM):**
  - CAISO, PAC, NVE, APS, Puget Sound (participating); Portland General Electric, Idaho Power, Seattle City Light (committed); BANC, SMUD, LADWP, Baja California Norte (intent announced and analyzing)
  - CAISO+PAC+NVE: $20-25 million savings per quarter (approx. 25% NVE, 33% CAISO)

- **CAISO-PAC Regional Market Initiative:** setting up and proposing to implement full (Day-2) RTO market that could include much of WECC (SB 350 Study conducted)

- **Mountain West Transmission Group (MWTG):** Basin Electric Power Cooperative, Black Hills Corp., Colorado Springs Utilities, Platte River Power Authority, PSCo, Tri-State G&T and the Western Area Power Administration (WAPA)’s Loveland Area and Colorado River Storage projects analyzing Day-2 market in CO and WY
Operational Scope: EIM vs. Full Day-2 Market

Day-Ahead Unit Commitment
- De-pancaked transmission & scheduling charges
- Full grid utilization
- Reduced operating reserves
- Regionally optimized unit commitment
- Reduced additional commitment hurdle

Day-Ahead Market Dispatch
- De-pancaked transmission & scheduling charges
- Full grid utilization
- Reduced operating reserves
- Regionally optimized unit dispatch
- Avoided bilateral transaction cost

Intra-Day Adjustments
- De-pancaked transmission & scheduling charges
- Full grid utilization
- Reduced operating reserves
- Adjusted unit commitment and real-time bids
- Avoided bilateral transaction cost

Real-Time Market Dispatch
- De-pancaked transmission & scheduling charges
- Full grid utilization
- Reduced operating reserves
- Regionally optimized unit dispatch
- Reduced A/S needs
- Resolved uncertainties

Scope of SB350 Regional Day-2 Market Simulations
(without forecast errors, renewable uncertainty, real-time outages, etc.)
The West is Endowed with Low-Cost Wind & Solar

- Focusing on lowest-cost areas of the WECC can substantially reduce the cost of meeting RPS and carbon emissions goals across the region.

- Looking forward, without a regional market, balancing high concentrations of mostly one type of resource (e.g., solar in southern CA or wind in WY) is a significant challenge for the 39 balancing areas in the WECC.

CAISO’s Extreme “Duck Curve” in 2030

For example, with substantial solar additions, California would experience an extreme “duck curve” when total renewable generation exceeds total California load by more than 10,000 MW at times (negative net load), creating:

- Net imports of > 5,000 MW during the night
- Net exports of up to 8,000 MW plus ~13,000 MW of curtailments during the day
Thus, focusing on resource diversification can offer significant benefits:

- Regional diversification of resources (and load) reduces the investment and balancing cost in a future with high levels of intermittent resources

- Diversity of resources (and load) also increases the value of transmission that interconnects them
SB 350 Study: Resource Additions to Meet CA’s 50% RPS

The SB 350 Study developed plausibly-optimal resource additions to meet California’s 50% RPS by 2030 for CAISO-only and Regional-Market scenarios

- A significant amount of solar generation will be built in or close to California, unless the rules allow for more out-of-state resources to qualify

### 2020 WECC Resource Mix
(33% RPS in California, mostly already contracted)

### 2020–2030 Additions
Under Current Practice Scenario 1
(CAISO Standalone)
SB 350 Study: Impact of Regional Market on CA Procurement

If California became a part of a large western regional market, the optimal renewable resource procurement could shift to lower-cost generation.

- A western regional market that can integrate low-cost wind in WY and NM will also attract additional investments beyond RPS needs.

### 2030 Regional Market Impact (with Continued CA-Focused Procurement)

<table>
<thead>
<tr>
<th>Region</th>
<th>GWh/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>(5,000)</td>
</tr>
<tr>
<td>Northwest</td>
<td>(10,000)</td>
</tr>
<tr>
<td>Southwest</td>
<td>(15,000)</td>
</tr>
<tr>
<td>Rocky Mt</td>
<td>(20,000)</td>
</tr>
<tr>
<td>WECC non-US</td>
<td>(25,000)</td>
</tr>
</tbody>
</table>

### 2030 Regional Market Impact (with Regionally-Focused Procurement)

<table>
<thead>
<tr>
<th>Region</th>
<th>GWh/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>(5,000)</td>
</tr>
<tr>
<td>Northwest</td>
<td>(10,000)</td>
</tr>
<tr>
<td>Southwest</td>
<td>(15,000)</td>
</tr>
<tr>
<td>Rocky Mt</td>
<td>(20,000)</td>
</tr>
<tr>
<td>WECC non-US</td>
<td>(25,000)</td>
</tr>
</tbody>
</table>

* CP1 vs. Regional 2
* CP1 vs. Regional 3
With substantial solar development in the state, CAISO will shift from being a **net importer in all hours** (even in 2020) to having approximately **1,500 hours of net exports** reaching 8,000 MW by 2030.
Regional market operations would: (1) significantly reduce the number of curtailment hours and (2) increase prices and revenues obtained by CA LSEs during surplus generation hours.

Low/negative prices could impose significant costs on ratepayers due to surplus generation conditions, which can be mitigated by participating in a Regional Market.
SB 350 Study: CA’s Annual Savings from a Regional Market

Savings increase with: (1) higher RPS goals (e.g., 33% → 50% → 60%) and (2) greater reliance on lower-cost, out-of-state procurement.

The 55% and 60% RPS sensitivity cases conservatively assume that the California production, purchase, and sales cost savings would remain at the same level estimated under the baseline scenarios (50% RPS).
Trends in Renewable Additions

Investment in renewable generation significantly exceeds state RPS mandates in some regions, providing large environmental benefits.

- The majority of “beyond-RPS” investments have occurred in regions that: (1) offer access to low-cost wind or solar potential, and (2) have organized regional RTO/ISO markets.

2015 Wind Additions Mostly in RTO/ISO Markets

Wind-rich areas in RTO/ISO markets account for most of the recent renewables development

- AWEA data shows that the majority of the 2015 additions and projects under construction (shown on map) are in areas that offer both:
  - Access to very wind-rich areas
  - ISO-operated markets (ERCOT, SPP, MISO)

- Significantly less development in similarly wind-rich areas without ISO/RTO markets (e.g., WY, CO, MT, NM)

### Factors by which RTO/ISO Markets Facilitate Renewable Development

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
</table>
| Improved Market Design  | • Intra-hour energy markets, integrated with optimized day-ahead commitment and pre-dispatch of the entire region’s generating plants, maximize the energy value of intermittent resources  
• Increased pricing granularity in time (5-minute) and location (nodal) improves signals for resource dispatch while reducing balancing costs  
• Allows renewable resources to participate in energy market and ancillary services  
• Reduced curtailments through improved utilization of transmission infrastructure  
• Makes available more effective congestion management mechanisms, including allowing renewable generators to hedge their congestion exposures |
| Larger Geographic Market Footprint | • Allows access to and use of more renewable resources in larger regions’ lowest-cost locations  
• Improved day-ahead and intra-day forecasting of more diversified variable generation output  
• Large footprints of ISO/RTO markets reduce balancing need by taking advantage of: diversity of renewables output, a larger set of other generation resources, and increased liquidity in spot markets to reduce the cost of load-following/balancing services  
• Increased market liquidity facilitates forward contracting, risk management, and merchant entry |
| Improved Regional Transparency and Transmission Access | • Regional access and transparent pricing provide developers and investors confidence of fairness  
• RTOs offer scale advantage in: providing region-wide transmission access, planning regional transmission solutions, and allocating the costs of transmission projects  
• Streamlined “one-stop shopping” for interconnection and transmission service in larger region  
• Easier contracting for load-serving entities (including coops/munis) and commercial/industrial customers without their own transmission access to the region’s lowest-cost renewables |
Mr. Onur Aydin is a Senior Associate at The Brattle Group with an engineering background and over 10 years of experience in energy economics, electricity market modeling, and transmission planning. He assists a wide range of clients throughout the U.S. in regulatory, litigation, and business strategy matters. His recent engagements include assessments of wholesale power markets, ISO/RTO market expansion, generation asset valuation, integrated resource planning, energy risk management, transmission cost-benefit analyses, and renewable energy policies.

Mr. Aydin received his M.S. in Civil and Environmental Engineering from Massachusetts Institute of Technology in Cambridge, Massachusetts, and his B.S. in Civil Engineering (with high honors) from Bogazici University in Istanbul, Turkey.
SB350 Study – Authors and Contributors

**Senate Bill 350 Study**
The Impacts of a Regional ISO-Operated Power Market on California

**The California Independent System Operator**
Keith Casey, Mark Rothleder, Deb Le Vine, Shucheng Liu, Xiaobo Wang, Yi Zhang

**The Brattle Group**
Judy W. Chang, Johannes P. Pfeifenberger, Mark Berkman, Mariko Geronimo Aydin, C. Onur Aydin, David Luke Oates, Kai Van Horn, Lauren Regan, Peter Cahill, Colin McIntyre

**Energy and Environmental Economics, Inc.**
Arne Olson, Amber Mahone, Gerrit De Moor, Nick Schlag, Ana Mileva

**Berkeley Economic Advising and Research, LLC**
David Roland-Holst, Samuel Evans, Drew Behnke, Cecilia Han Springer, Sam Heft-Neal

**Aspen Environmental Group**
Brewster Birdsall, Susan Lee, Heather Blair, Tracy Popiel, Emily Capello, Scott Debauche, Fritts Golden, Negar Vahidi

Offices

CAMBRIDGE

NEW YORK

SAN FRANCISCO

WASHINGTON, DC

TORONTO

LONDON

MADRID

ROME

SYDNEY
About The Brattle Group

The Brattle Group provides consulting and expert testimony in economics, finance, and regulation to corporations, law firms, and governmental agencies worldwide.

We combine in-depth industry experience and rigorous analyses to help clients answer complex economic and financial questions in litigation and regulation, develop strategies for changing markets, and make critical business decisions.

Our services to the electric power industry include:

- Climate Change Policy and Planning
- Cost of Capital
- Demand Forecasting Methodology
- Demand Response and Energy Efficiency
- Electricity Market Modeling
- Energy Asset Valuation
- Energy Contract Litigation
- Environmental Compliance
- Fuel and Power Procurement
- Incentive Regulation
- Rate Design and Cost Allocation
- Regulatory Strategy and Litigation Support
- Renewables
- Resource Planning
- Retail Access and Restructuring
- Risk Management
- Market-Based Rates
- Market Design and Competitive Analysis
- Mergers and Acquisitions
- Transmission