

Western Regional Market Developments:

Impact on Renewable Generation Investments and Balancing Costs

PREPARED BY:

Onur Aydin

Johannes Pfeifenberger

Judy Chang

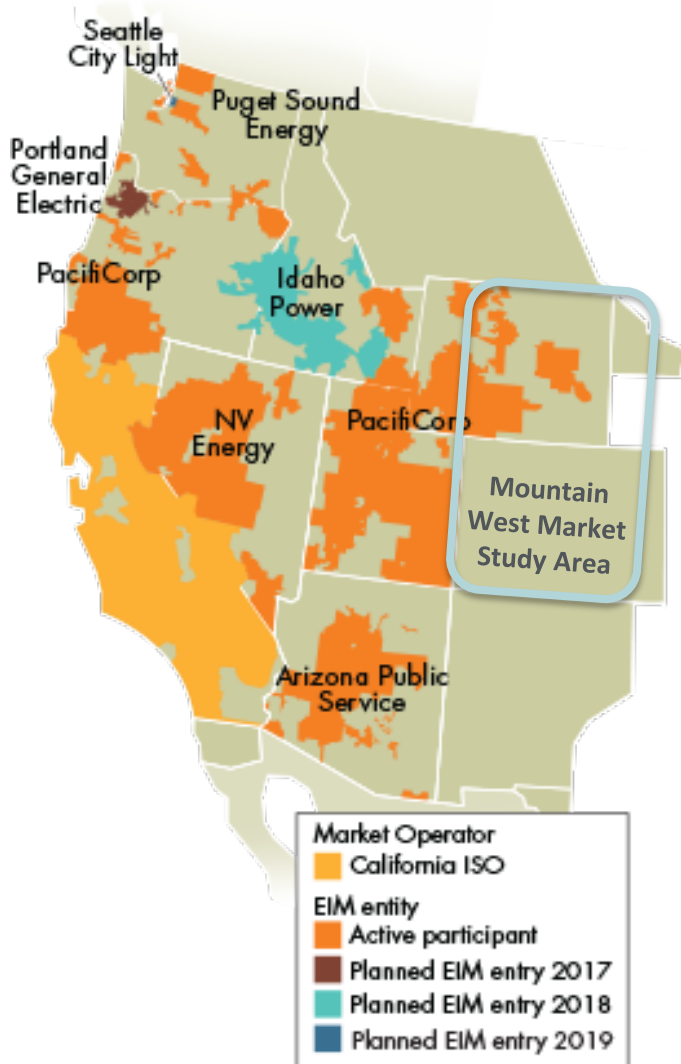
**Wind Power Finance & Investment Summit—Executive Briefing
San Diego, CA**

February 7, 2017

THE **Brattle** GROUP

Regional Market Efforts in WECC

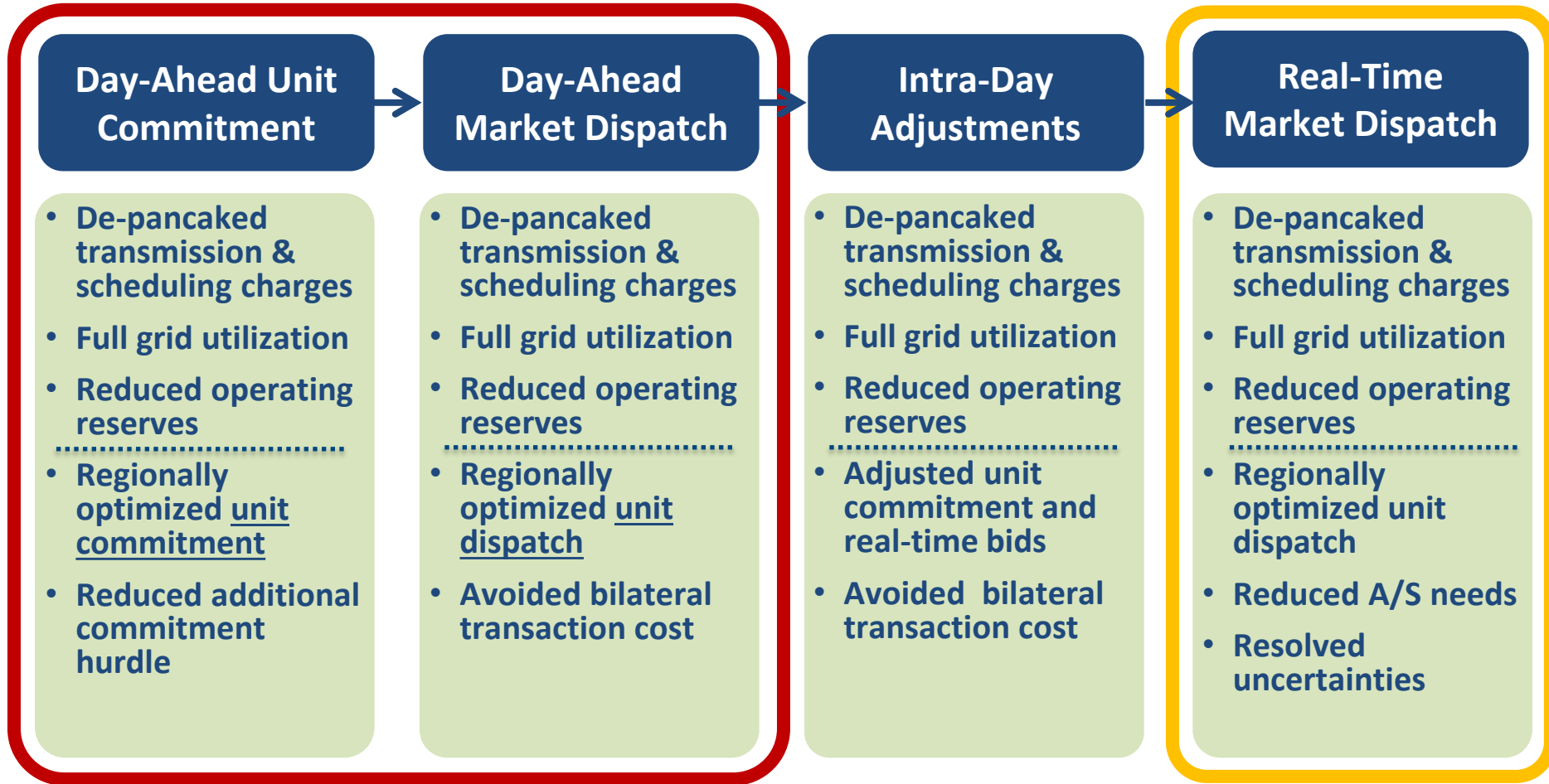
EIM and Regional Markets



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



Scope of SB350 Regional Day-2 Market Simulations

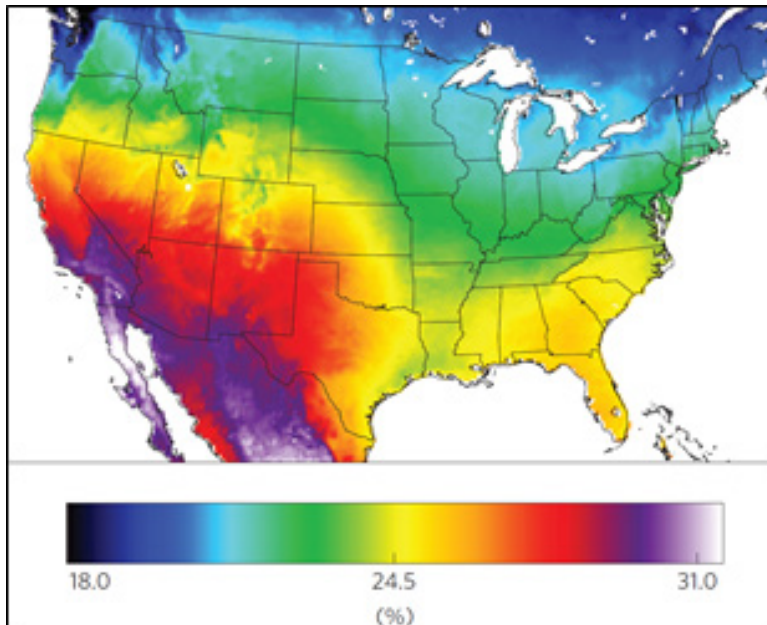
(without forecast errors, renewable uncertainty, real-time outages, etc.)

EIM

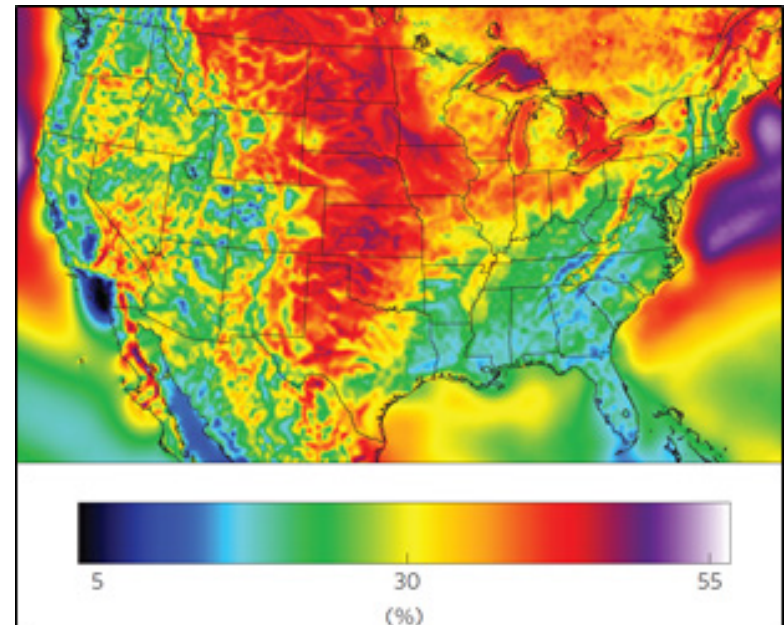
The West is Endowed with Low-Cost Wind & Solar

- 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

Solar PV Capacity Factors



Wind Capacity Factors



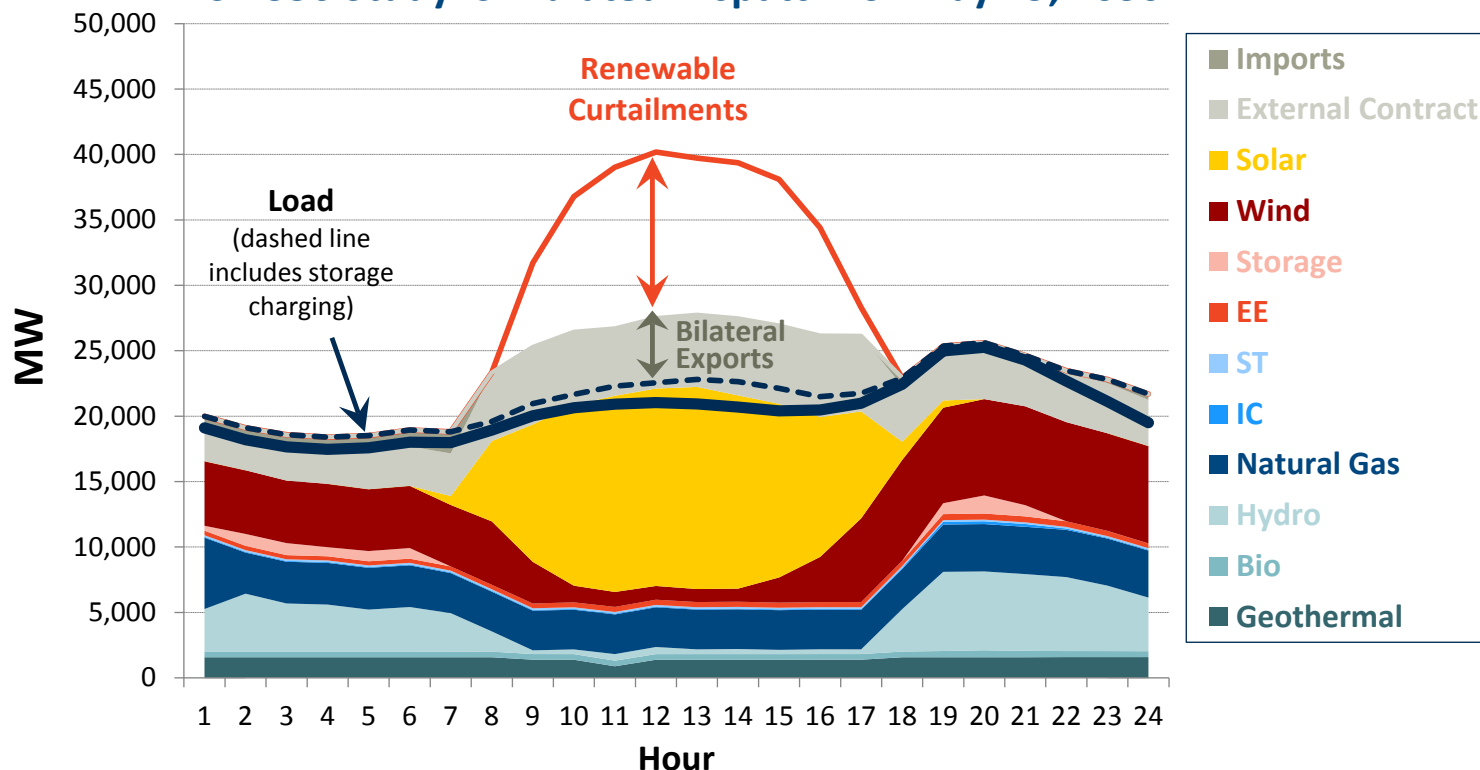
Source: MacDonald, Alexander E, Christopher T.M. Clack, et al., "Future cost-competitive electricity systems and their impact on US CO₂ emissions," Nature Climate Change (Jan 2016); DOI: 10.1038/NCLIMATE2921. (Reproduced with permission from Earth System Research Laboratory, NOAA.)

CAISO's Extreme "Duck Curve" in 2023

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

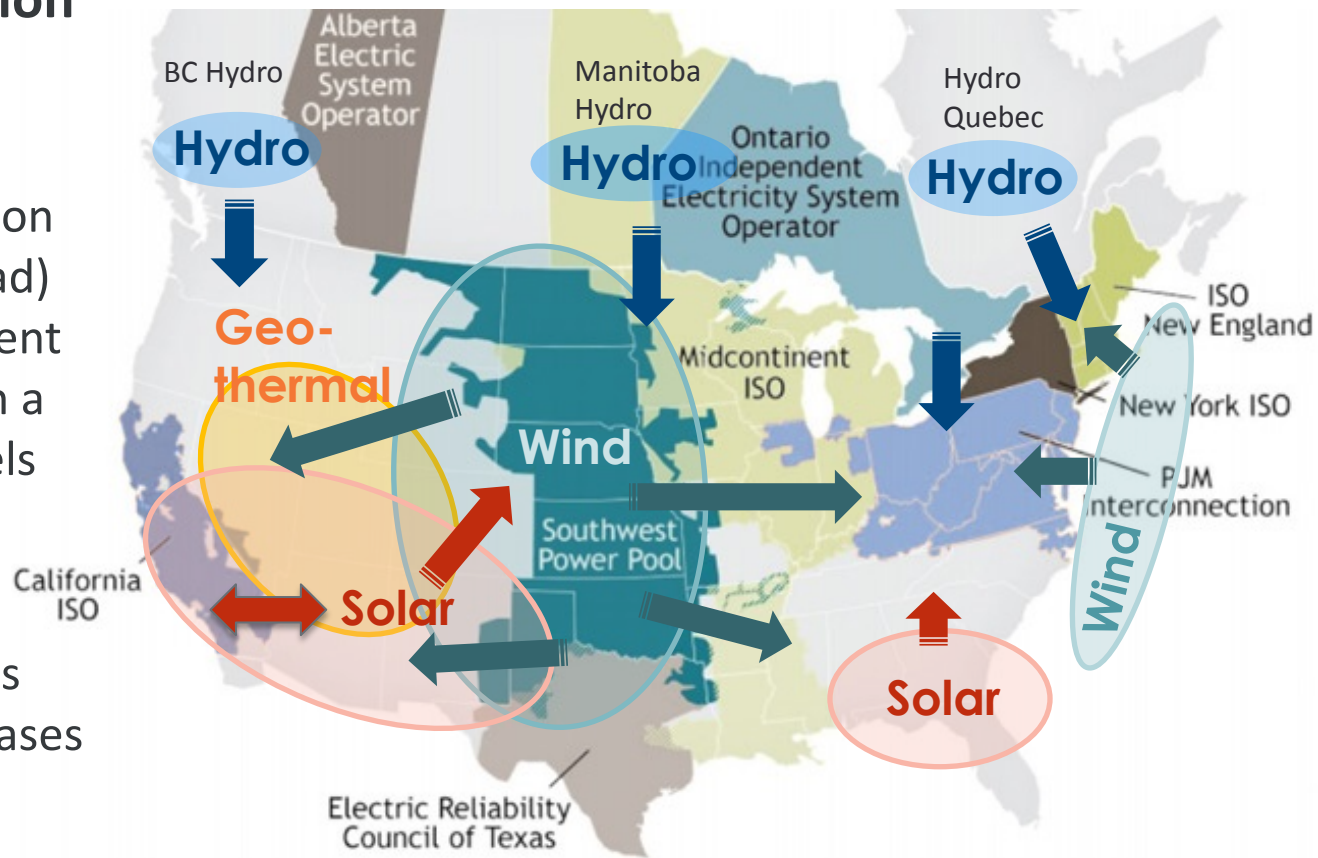
SB 350 Study: Simulated Dispatch for May 29, 2030



Diversifying Low-Cost Renewable Generation

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:

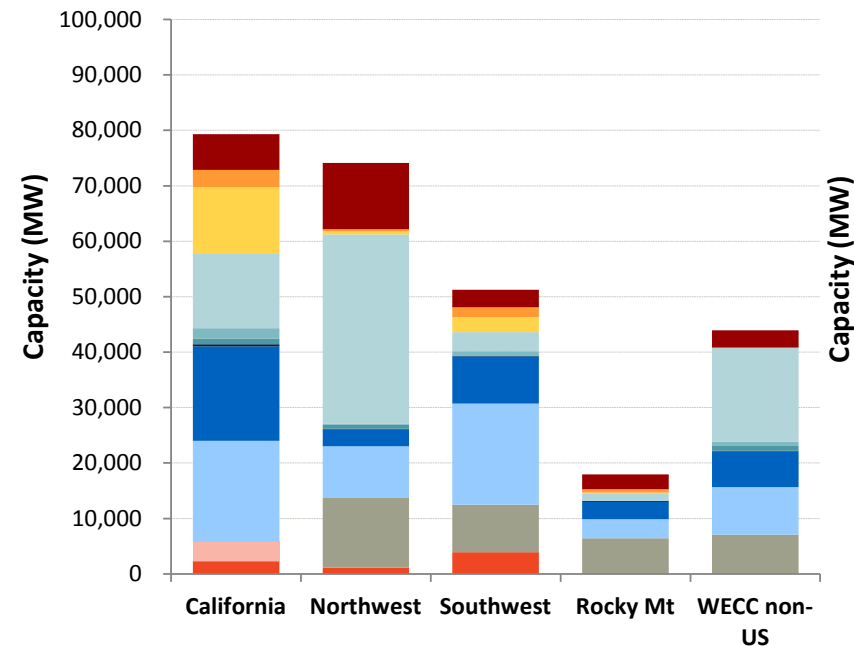
Resource Additions to Meet CA's 50% RPS

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

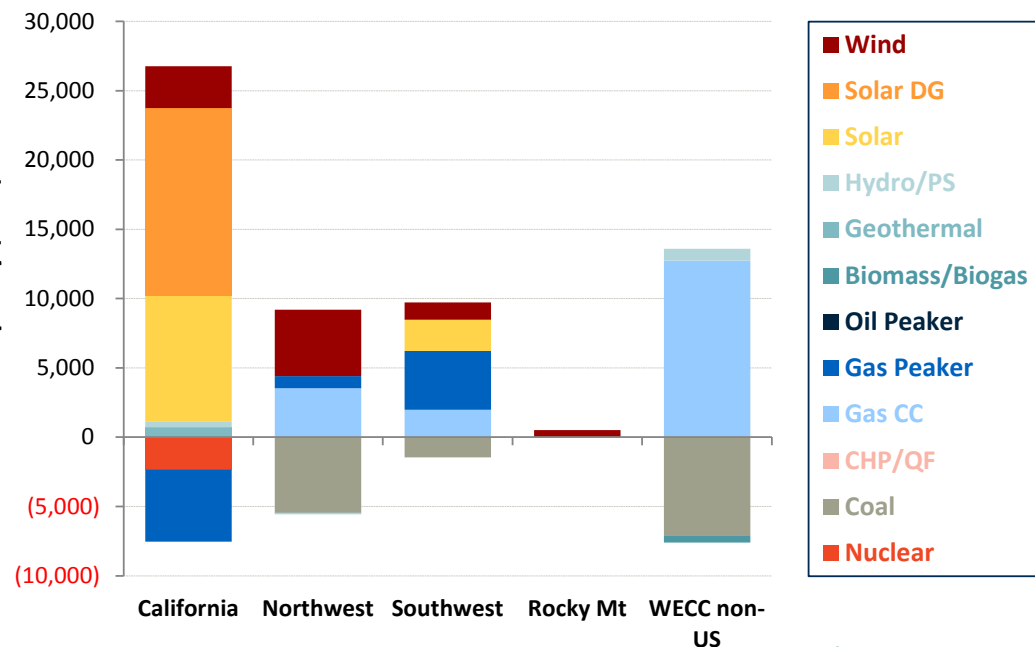
- A significant amount of solar generation will be built in or close to California, unless the rules allow for more out-of-state resources to qualify

2020 WECC Resource Mix

(33% RPS in California,
mostly already contracted)



2020–2030 Additions Under Current Practice Scenario 1 (CAISO Standalone)

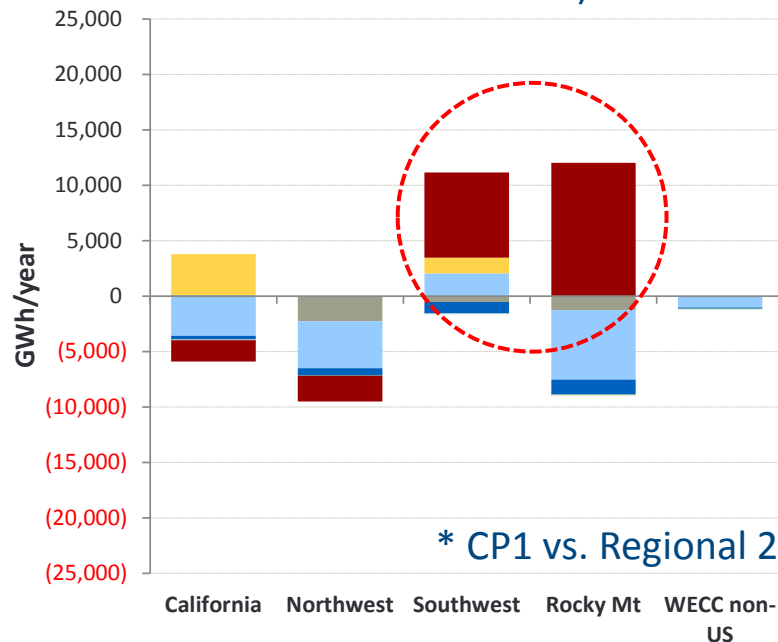


Impact of Regional Market on CA Procurement

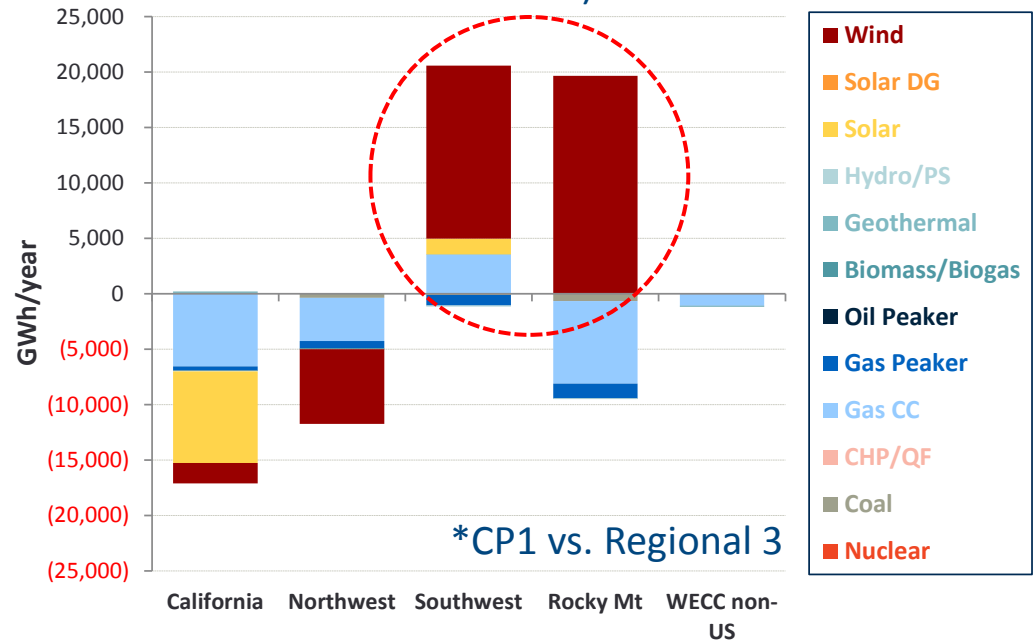
If California became a part of a large western regional market, the optimal renewable resource procurement could shift to lower-cost generation

- 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)



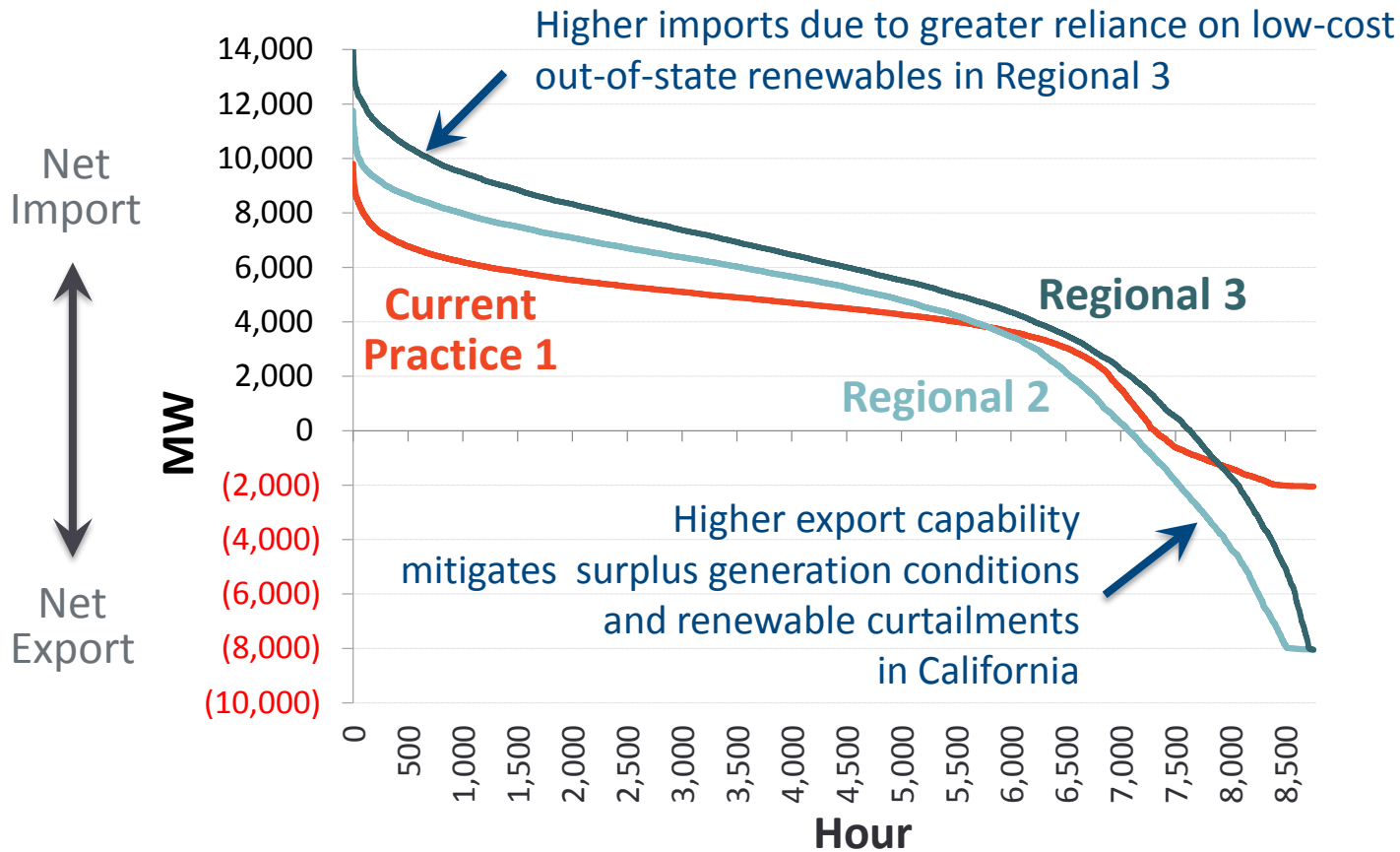
2030 Regional Market Impact
(with Regionally-Focused Procurement)



SB 350 Study:

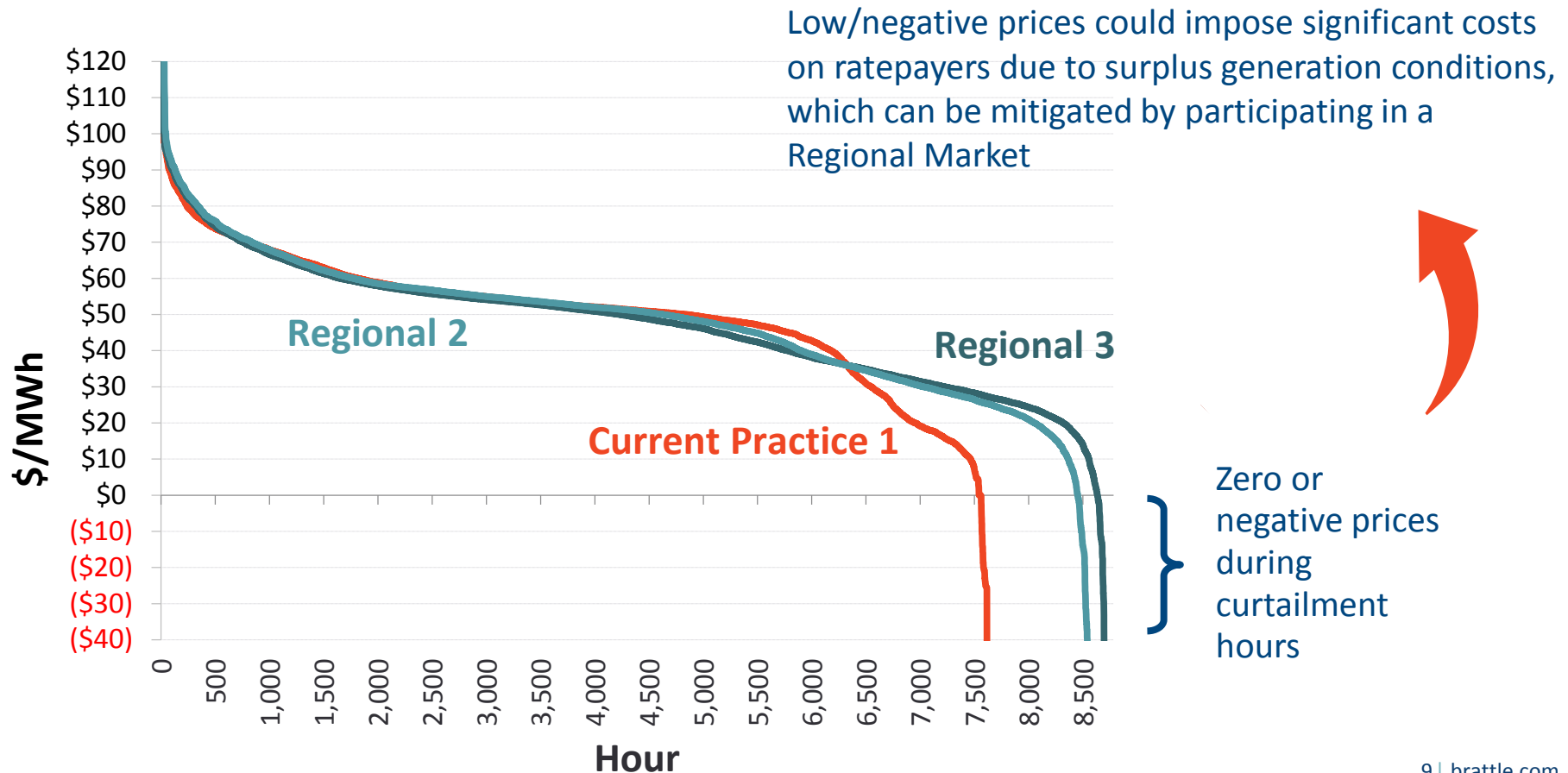
CAISO 2030 Imports and Exports

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



CAISO 2030 Wholesale Energy Prices

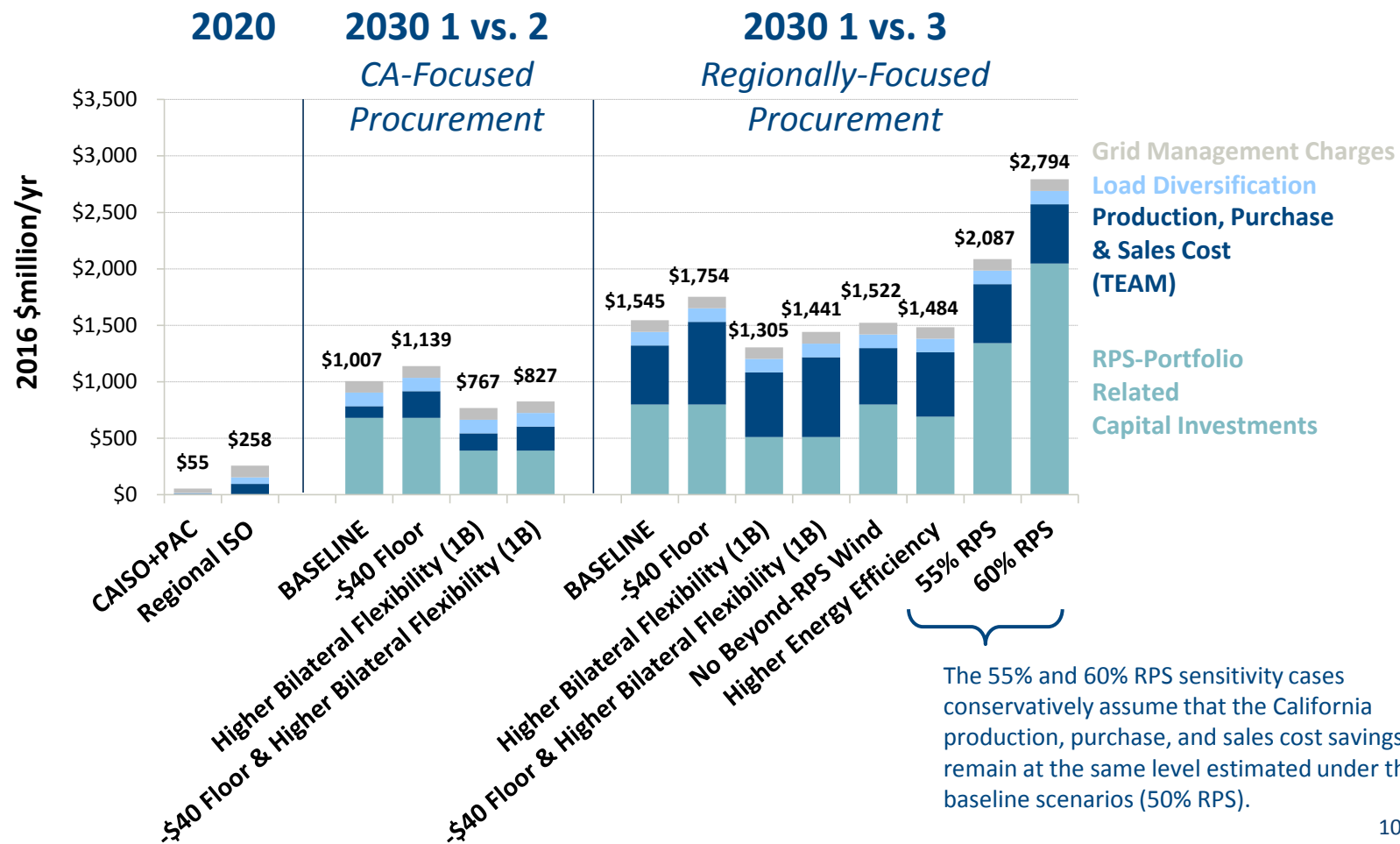
Regional market operations would: (1) significantly reduce the number of curtailment hours and (2) increase prices and revenues obtained by CA LSEs during surplus generation hours



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

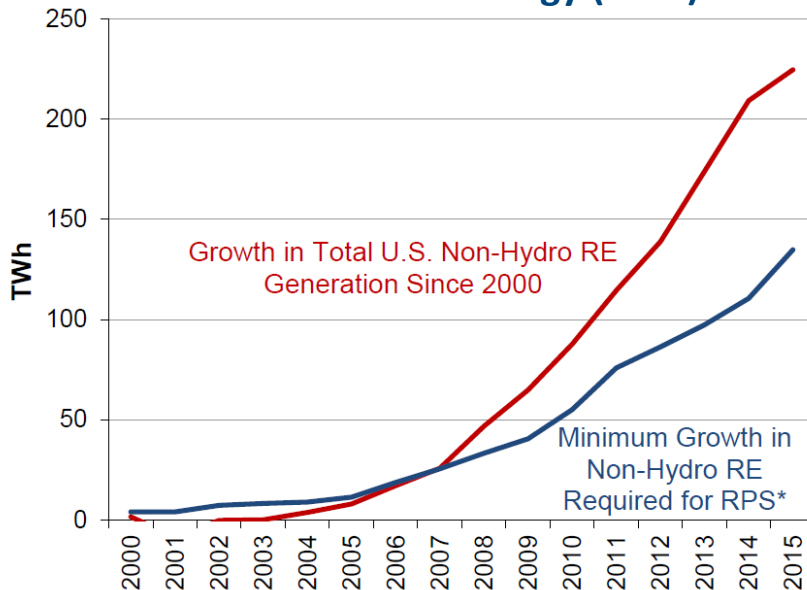


Trends in Renewable Additions

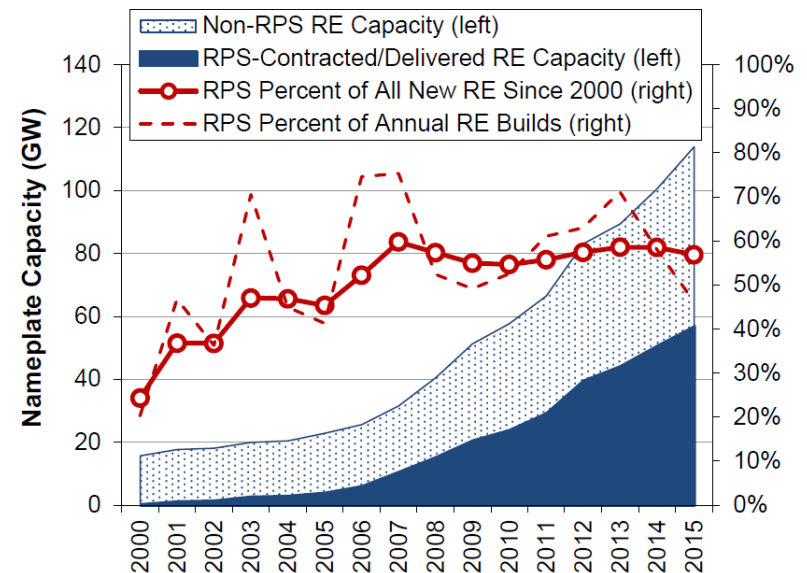
Investment in renewable generation significantly exceeds state RPS mandates in some regions, providing large environmental benefits

- 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

2000–2015 Growth in U.S. Non-Hydro Renewable Energy (TWh)



Total U.S. Non-Hydro Renewable Capacity (GW)

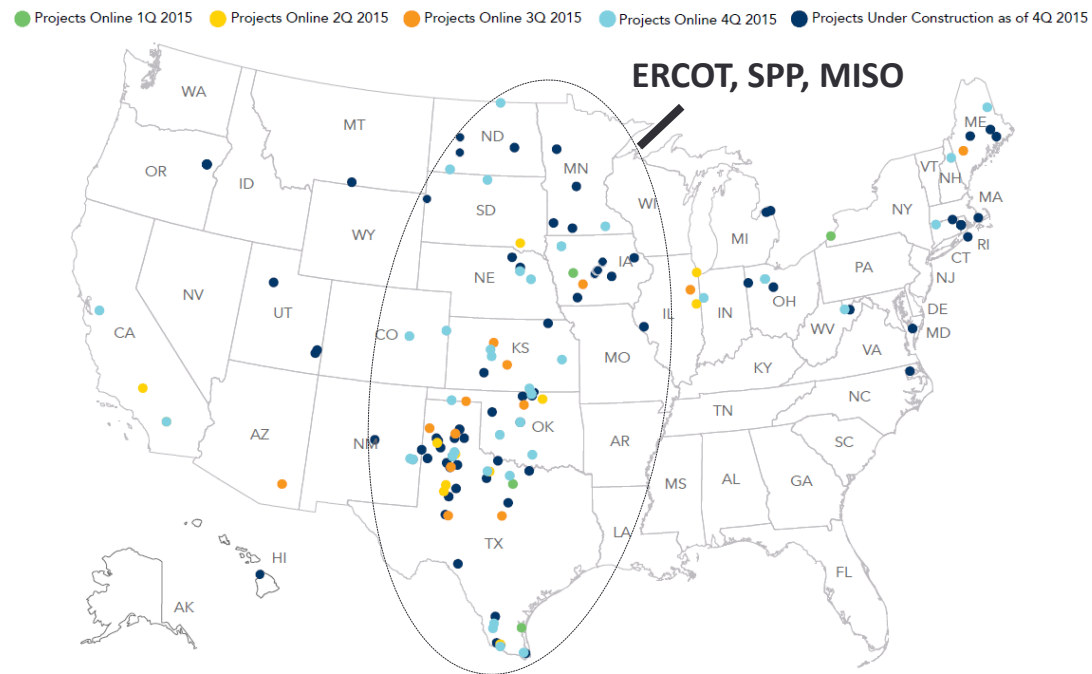


2015 Wind Additions Mostly in RTO/ISO Markets

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)

Wind Generation Projects Online & Under Construction in 2015



Source: AWEA, "U.S. Wind Industry Fourth Quarter 2015 Market Report," American Wind Energy Association, January 27, 2016.

Factors by which RTO/ISO Markets Facilitate Renewable Development

Factor	Description
Improved Market Design	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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

Speaker Bio and Contact Information



ONUR AYDIN

Senior Associate | Cambridge, MA

Onur.Aydin@brattle.com

+1.617.864.7900 office

+1.617.234.5611 direct

Note:

The views expressed in this presentation are strictly those of the presenter and do not necessarily state or reflect the views of The Brattle Group, Inc.

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

PREPARED FOR



PREPARED BY

THE **Brattle** GROUP



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