Renewables Integration and the Clean Power Plan

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Synapse Energy Economics

- Founded in 1996 by CEO Bruce Biewald
- Leader for public interest and government clients in providing rigorous analysis of the electric power sector
- Staff of 30 includes experts in energy and environmental economics and environmental compliance
- We gratefully acknowledge the Environment, Economics, & Society Institute (EESI) for sponsoring this webinar

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CPP Assumes Significant Renewable Energy Potential

- In target-setting for the Clean Power Plan, EPA assumed a **quadrupling** of renewable energy production by 2030 from 2012 levels
  - 70% of that growth comes from wind
  - 25% comes from solar (mostly PV)
- **Does this pose a challenge for the grid?**

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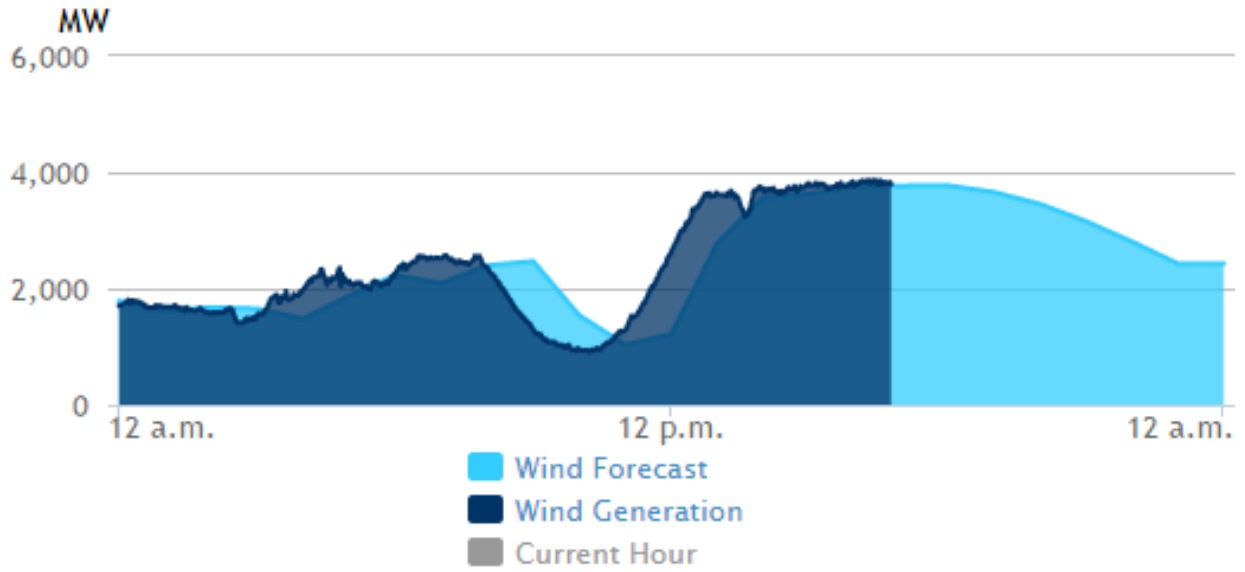
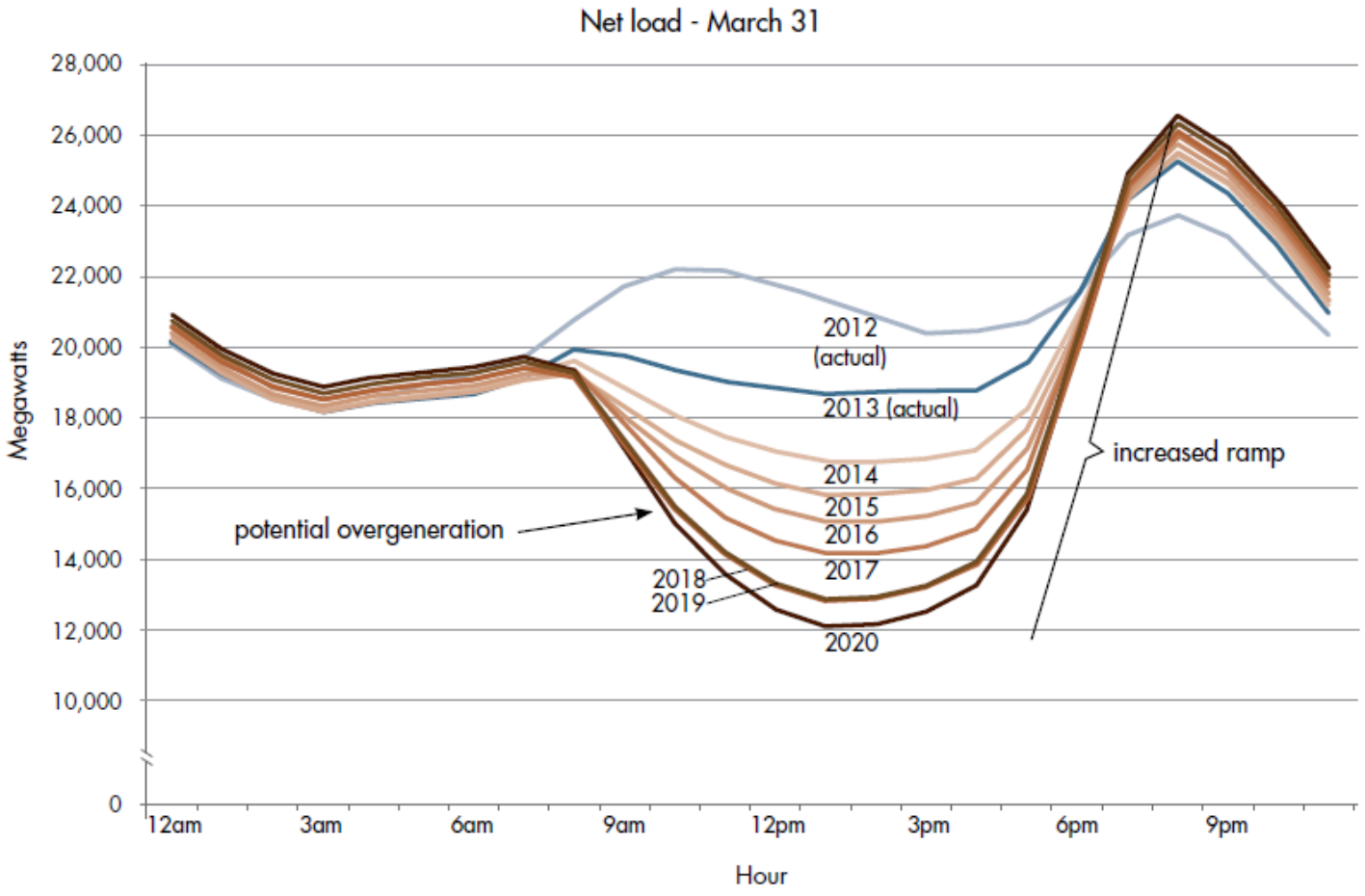
How is Renewable Energy Different?

- Wind and solar fluctuate throughout the day
  - Forecasts have improved significantly, but are still uncertain
  - Even with full certainty, new operational challenges

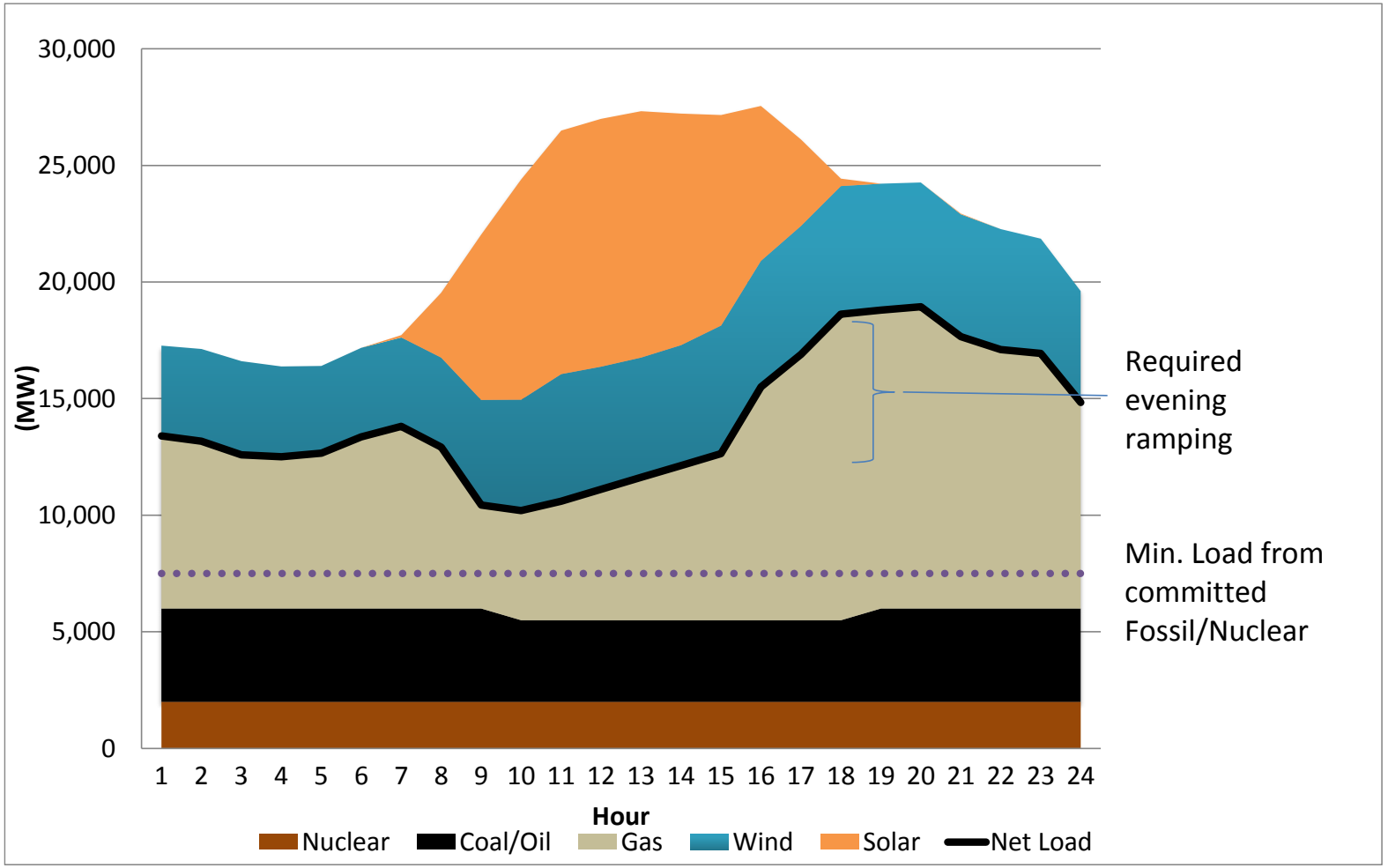
PJM Renewable Dashboard



California Spring Net Load



Representative Hourly System Dispatch



Minimum Loads and Operational Constraints

- Many plants have **minimum power outputs** between 40% and 60%, but some new plants can go even lower (20%?) and start up faster after being entirely offline
  - Thermal and mechanical constraints
- **Ramp availability**: how much capacity is available to come quickly online (or be turned down)
  - A function of capacity that is online—if plants are online at 75% of their max, they have more ramp potential than if at 100%
  - New plants can increase output more quickly—similar thermal and mechanical constraints

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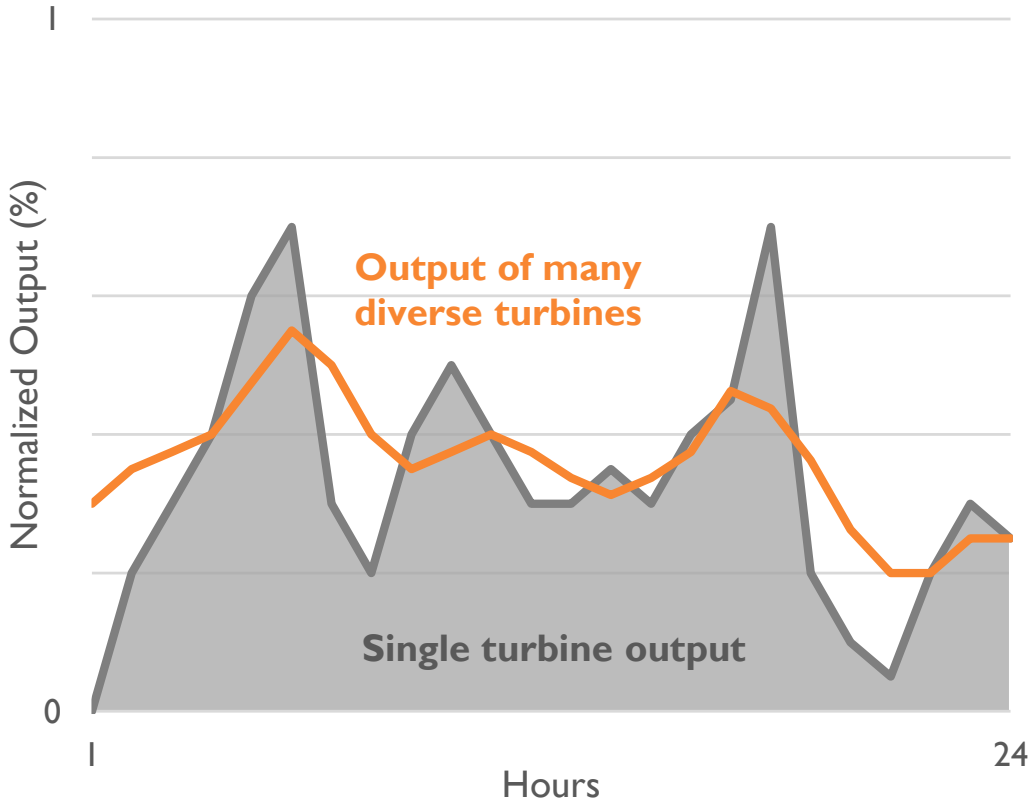
Measures to Incorporate More Renewables: Balancing Area Cooperation

- Increase exports or imports on a finer level of temporal resolution—much of this scheduling has historically been done at the day ahead with little flexibility
- "Coordinated Transaction Scheduling"

PJM September 2013 CTS Proposal

Measures to Incorporate More Renewables: Geographic Diversity of RE Resources

- Resources spread over a wider area dampen major swings due to changing weather patterns



Measures to Incorporate More Renewables: Other Measures

- At conventional thermal plants
  - Improved flexibility
- At control centers (or planning)
  - Better control of contracted resources
  - Incremental transmission investments
- At load
  - Demand response (and improving demand response products)
  - Time-of-use rates

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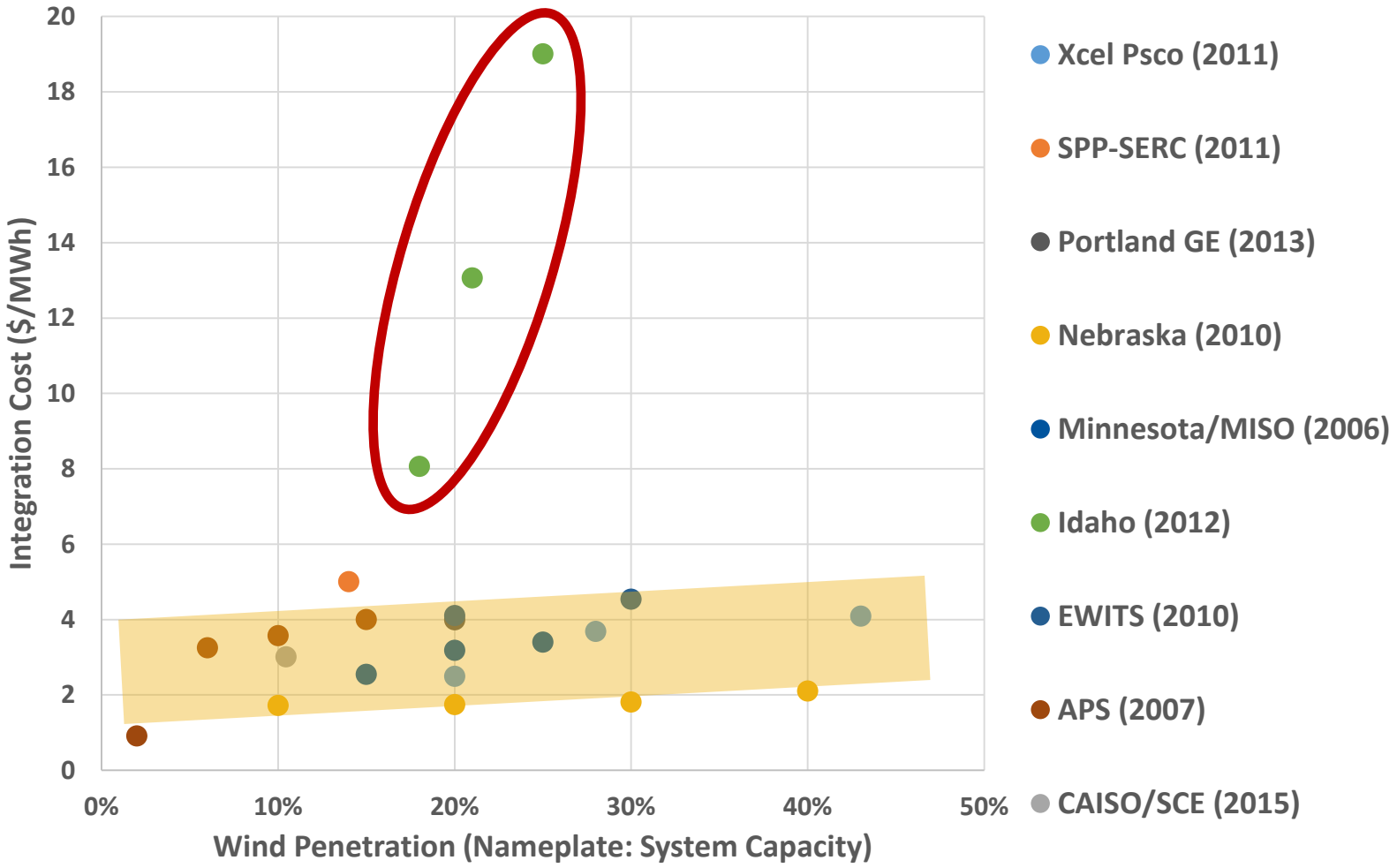
Integration Costs: Wind Results



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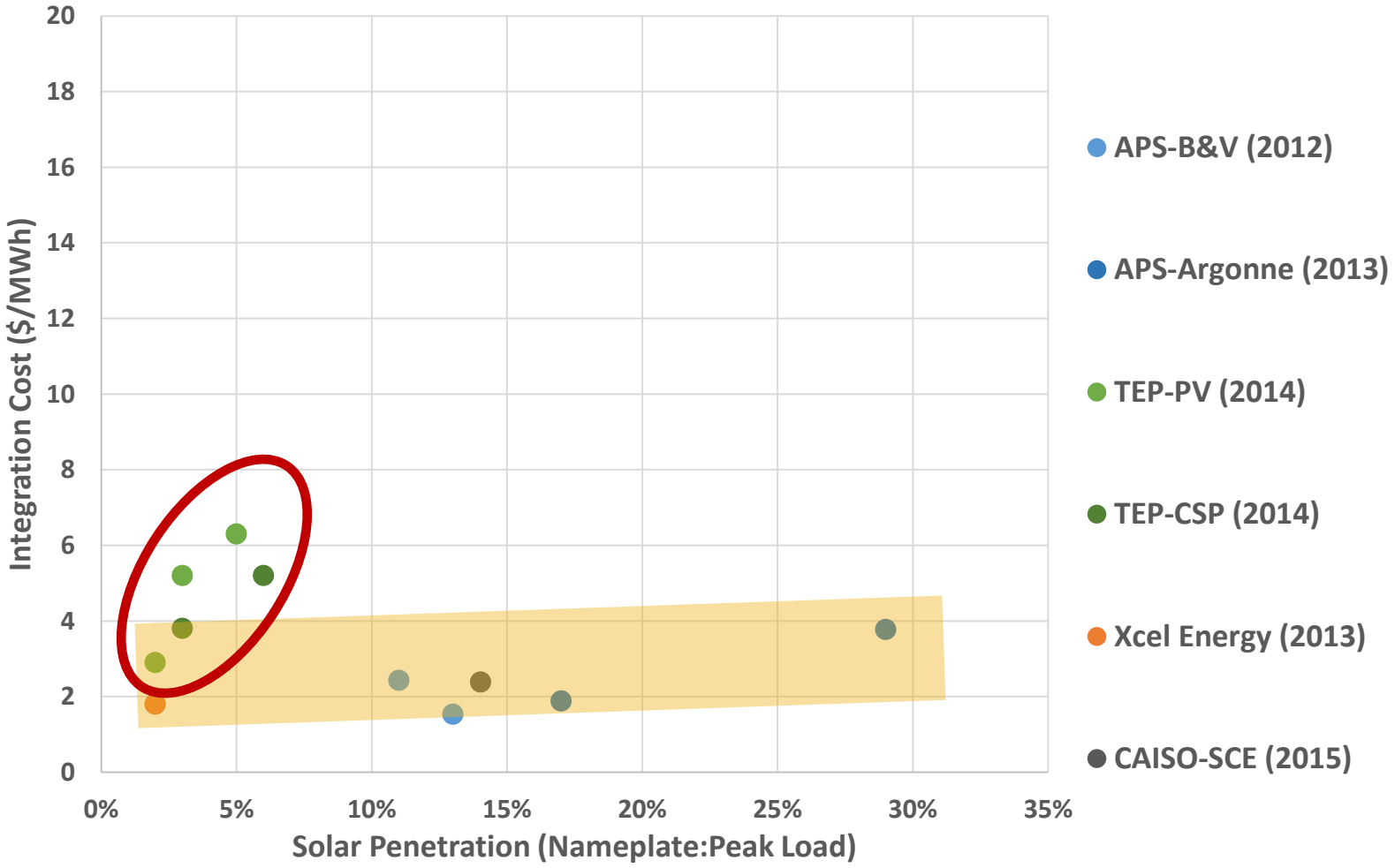
Integration Costs: Solar Results



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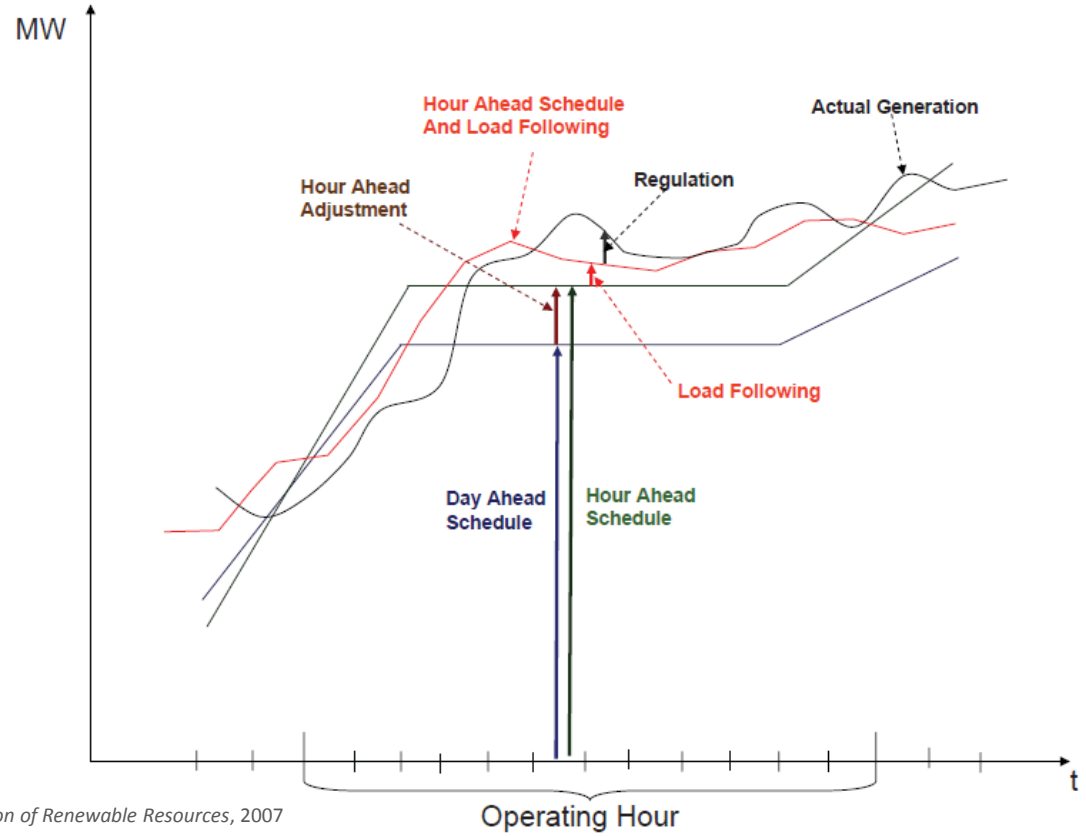
Integration Costs: *Which* Costs?

Wind and solar integration costs are costs incurred in *operational* timeframes that can be attributed to the variability and uncertainty introduced by wind and solar generation.



CAISO, *Integration of Renewable Resources*, 2007

Integration Costs: Costs Included

Wind and solar integration costs are costs incurred in *operational* timeframes that can be attributed to the variability and uncertainty introduced by wind and solar generation.

- Temporal variations
  - Regulation
  - Load Following
- Operating reserves
  - Spinning
  - Non-spinning
  - Supplemental
- Unit commitment
  - Startup and shutdown
  - Day-ahead fuel procurement
  - Difference in generating costs
- Transmission
  - Line loss variation
  - Hurdle rates

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Integration Costs: Costs Excluded

Wind and solar integration costs are costs incurred in *operational* timeframes that can be attributed to the variability and uncertainty introduced by wind and solar generation.

- Capital costs, incurred or avoided
  - Wind turbines
  - Combustion turbines
  - Fossil retrofits
  - Transmission
- Operating costs *not* the result of variability or uncertainty, incurred or avoided
  - Dispatch
  - Losses
  - Ancillary services

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Wind Integration Costs: Sensitivities

The $/MWh integration costs associated with wind and solar are sensitive to a number of inputs.

	APS 2007	CA 2010	EWITS 2010	ID 2012	MN 2006	MN 2014	NE 2010	NREL 2012	PacifiCorp 2014	PGE 2013	SCE 2013	SPP-SERC 2011	Xcel PSCo 2011
Penetration of intermittent resource	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓
Forecast error	✓	✓								✓			
CO_2 price forecast			✓										✓
Natural gas price forecast								✓		✓			✓
Other capacity resources						✓							✓
Transmission			✓	✓		✓	✓					✓	
Hydro		✓		✓		✓							
Reserve requirements					✓			✓	✓		✓	✓	

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Solar Integration Costs: Sensitivities

The $/MWh integration costs associated with wind and solar are sensitive to a number of inputs.

	APS 2012	Argonne 2013	NREL 2012	SCE 2013	Xcel PSCo 2013
Penetration of intermittent resource	✓	✓		✓	
Variability of intermittent resource	✓				
Forecast error		✓			
Natural gas price forecast	✓	✓	✓		✓
Other capacity resources		✓			
Reserve requirements		✓	✓	✓	

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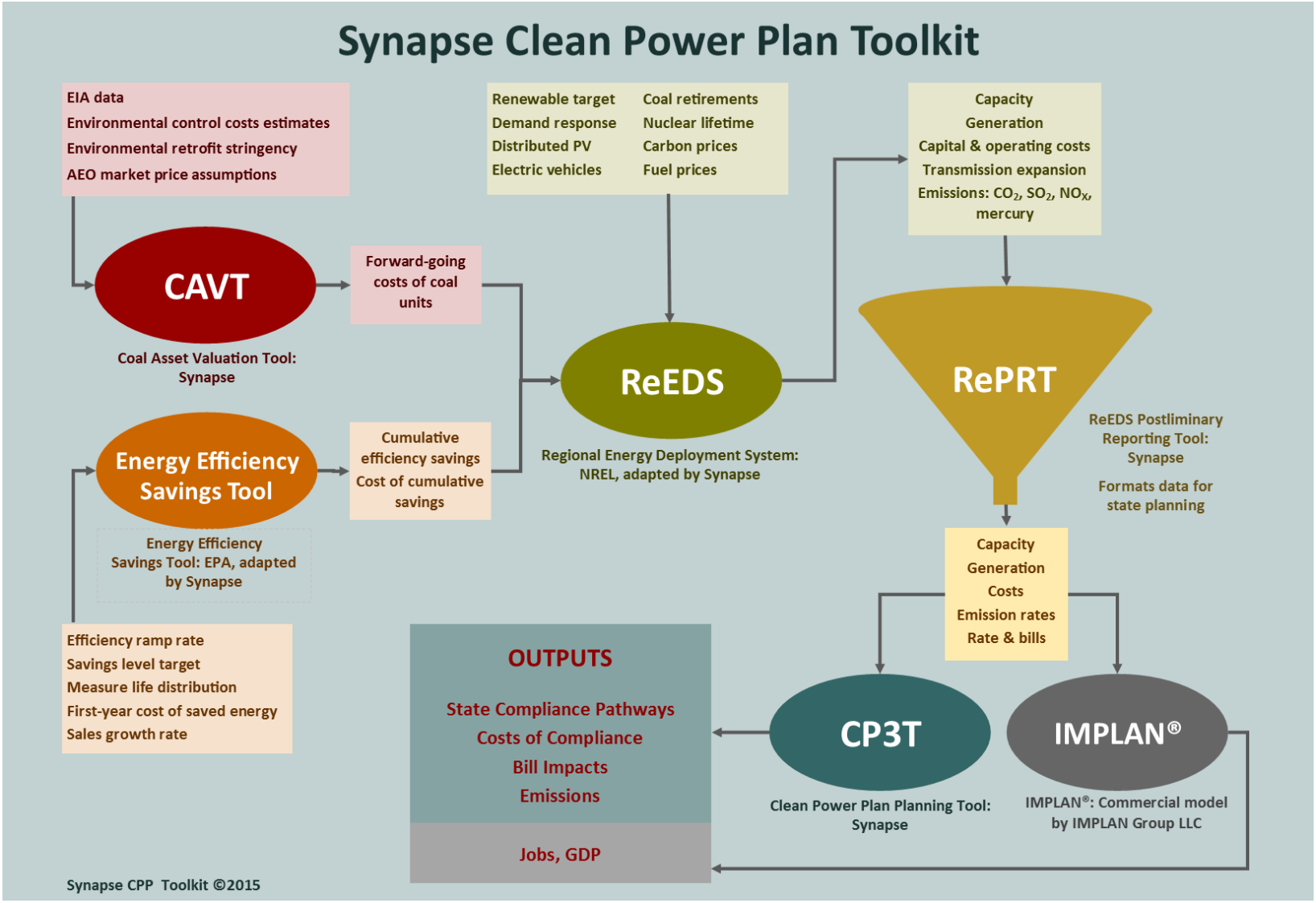
Synapse Clean Power Plan Toolkit



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Related Resources

Renewable Integration Report and Factsheet: http://synapse-energy.com/project/renewable-energy-integration-costs

Synapse Clean Power Plan Toolkit: http://synapse-energy.com/CleanPowerPlan

Past Clean Power Plan Webinars: http://synapse-energy.com/synapse-projects-and-webinars-related-clean-power-plan

Consumer Costs of Low-Emissions Futures Factsheets and Reports: http://synapse-energy.com/project/consumer-costs-low-emissions-futures

Clean Power Plan Reports and Outreach for National Association of State Utility Consumer Advocates: http://synapse-energy.com/project/clean-power-plan-reports-and-outreach-national-association-state-utility-consumer-advocates

Synapse Blog Posts on Clean Power Plan: http://synapse-energy.com/tags/clean-power-plan

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Stay Tuned!

Synapse is offering a series of webinars related to the final Clean Power Plan rule, updates to our compliance model, and impacts of the rule on consumer bills.

- **September 3:** "Brief #3: Modeling the Final Rule"
- **September 8 (tentative):** "Updates to Synapse's CP3T"

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