



Energy Transition in PJM: Emerging Characteristics of a Decarbonizing Grid

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Emanuel Bernabeu, Ph.D.

Sr. Director, Applied Innovation &
Analytics

Introduction – Refining the Assumptions of a *Living Study*

Key Findings & Focus Areas

Next Steps (Phase-3)



Facilitate
Decarbonization



Grid of
the Future



Innovation

THE ENABLING FOUNDATION



Maintain
Reliability



Stakeholder
Engagement and
Governance



Risk
Management



Workforce
Development



Efficiencies
of Scale



CULTURE

Monitor Developments



Industry Research/Outreach

- Leverage PJM's work: RIS 1.0, GE (2012), MOPR, Offshore Wind Study, Carbon Pricing.
- Review industry experience: CAISO, MISO, NERC, ESIG, NREL, SPP, ERCOT.



Analytics Markets/Operations

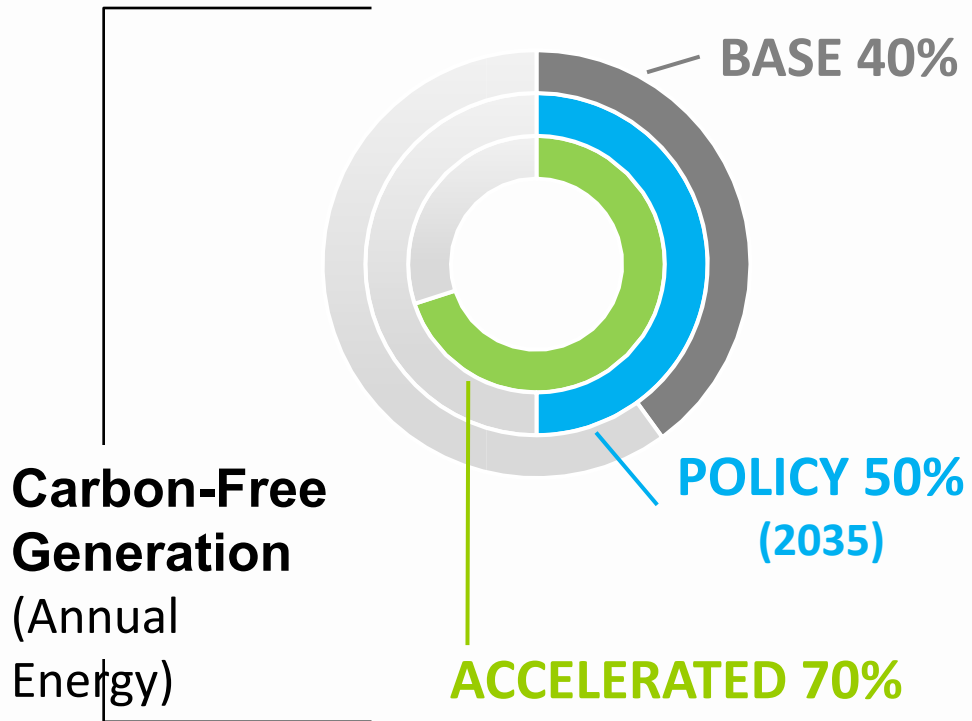
- Understand the impact of renewables in the context of PJM.
- Identify tipping points.



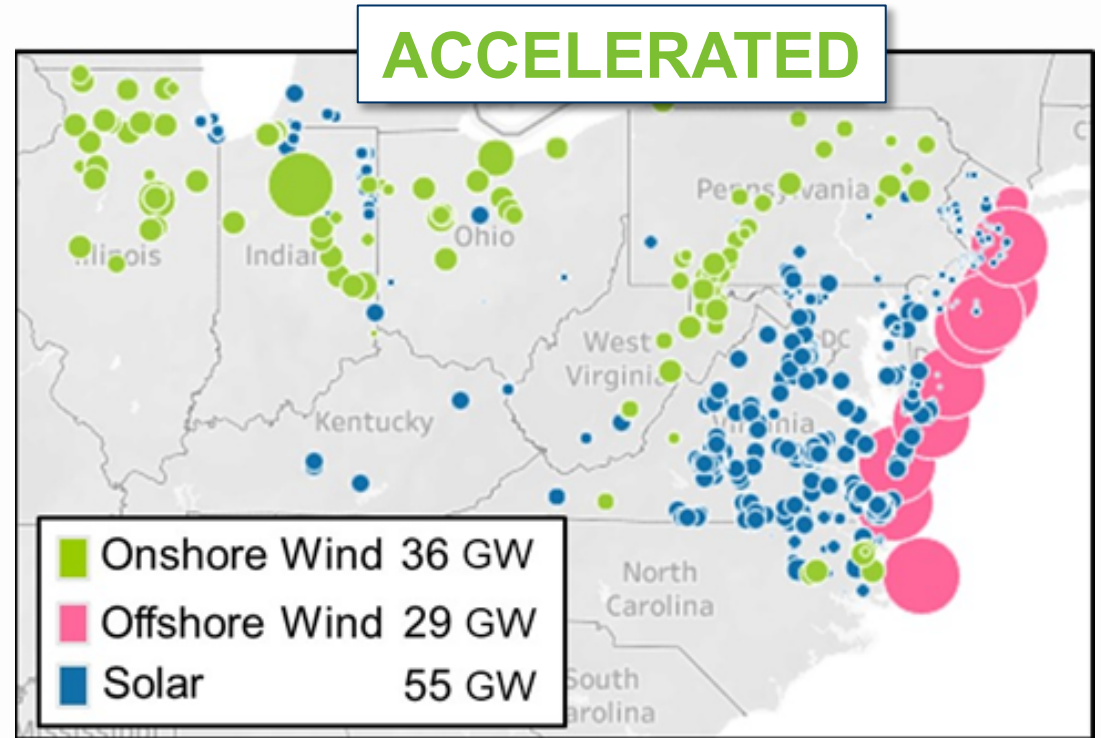
Takeaways

- We do not propose solutions (it is not a position piece).
- The intent is to inform and initiate discussion on changes that may be required given industry trends.

“Living study” to identify gaps and opportunities.



Note: Policies and Market rules “as-is” April 2020.



Maintained the same levels of renewable nameplate capacity.

Maintained the same level of Installed Capacity of Renewable Resources

Refined Study Assumptions (Phase-2)

Storage

6 GW =
Stand-Alone
31 GW =
Solar Hybrid



Solar

21 GW =
Stand-Alone
65 GW =
Solar Hybrid



Electrification

~19 GW = 17M EVs
14 GW = Heating



Interchange

Historical Levels
of Interchange



Reserves

Downward-
Sloping ORDC



Provided only to show ORDC curve impact – not to reflect a PJM intent to refile

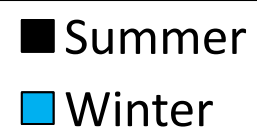
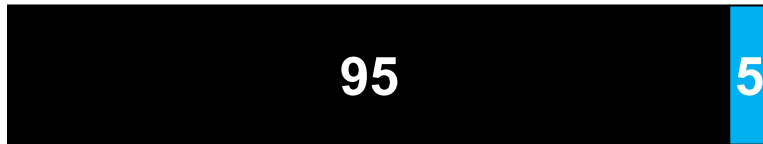
Focus Area No. 1



Electrification Shifts the Seasonal Resource Adequacy Risk to Winter.

Load-Loss Risk (%)

Accelerated



Accelerated +



KEY INDICATORS

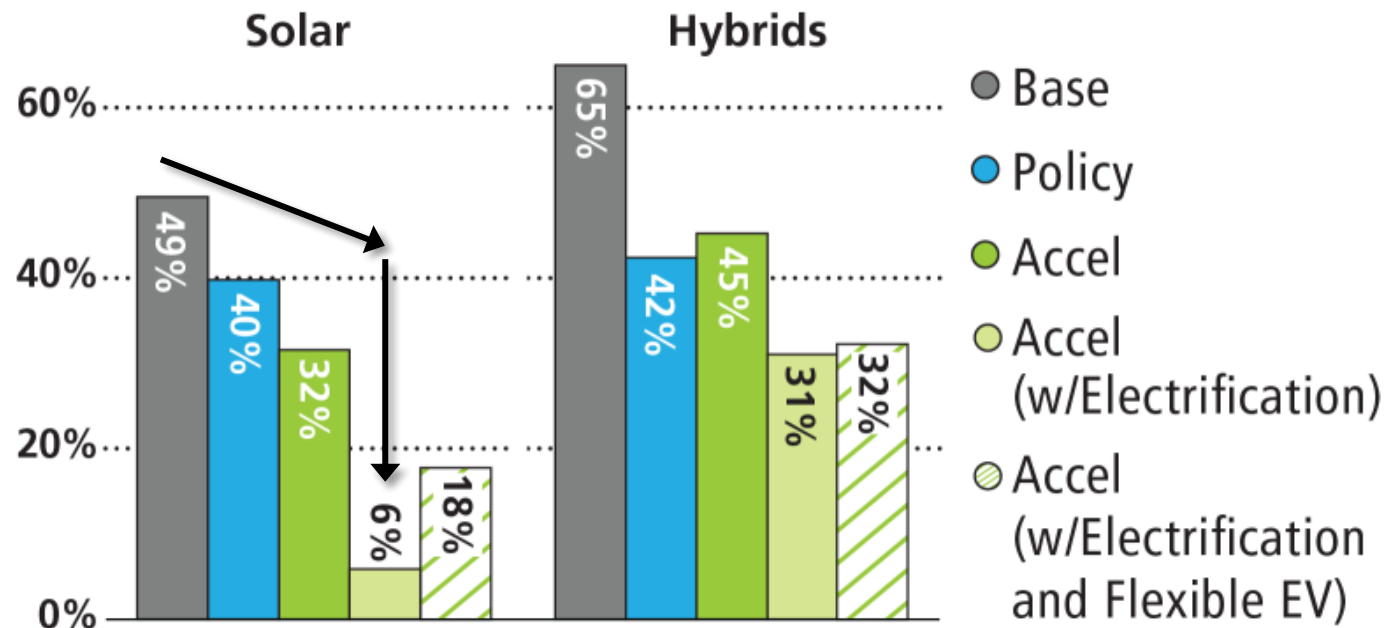
- Electrification Load Growth: Summer 7%, Winter 15%
- Winter net-load shape is flatter with a substantially wider peak demand
- 60% of the load-loss risk is concentrated during the last 4 hours of the day

Focus Area No. 2



Retail Rate Design & Energy Storage Become Increasingly Important With Electrification.

ELCC Accreditation



KEY INDICATORS

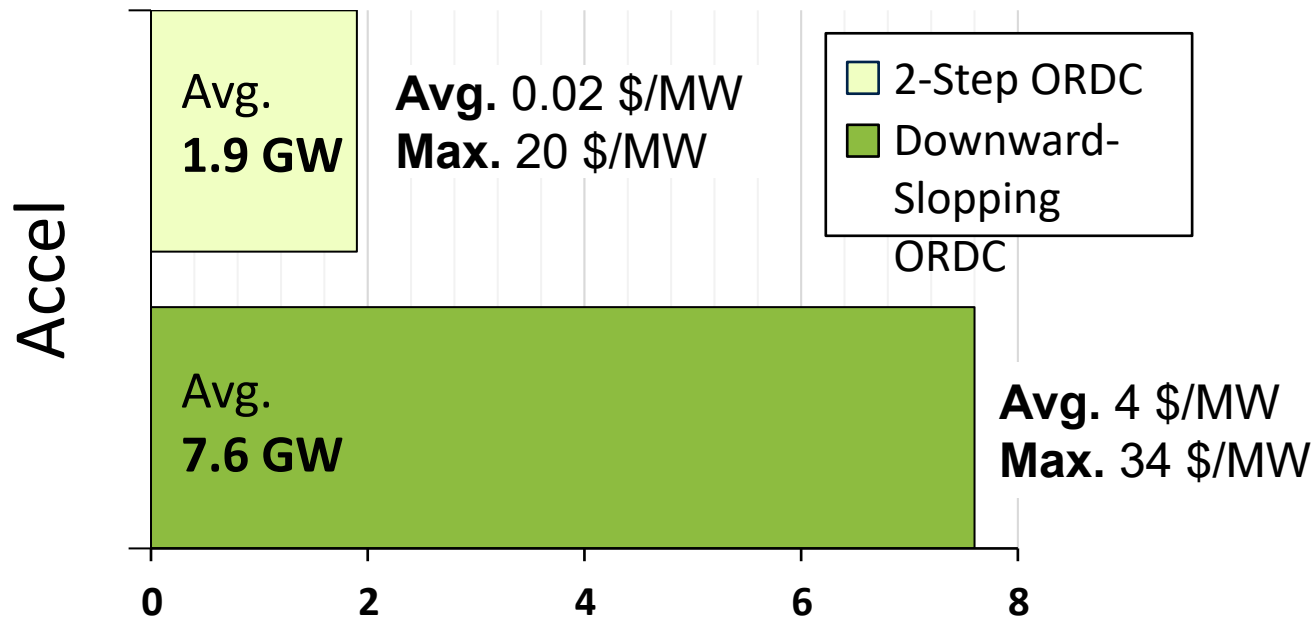
- Demand elasticity reduces the amount of capacity procured and triples the value of solar
- Solar-hybrid have a higher capacity value under all scenarios
- Retail rate design and storage do not have a simple additive effect



Focus Area No. 3

Market Reforms Are Needed To Mitigate Uncertainty and Incentivize Flexibility

Average Annual Synchronized Reserves (GW)



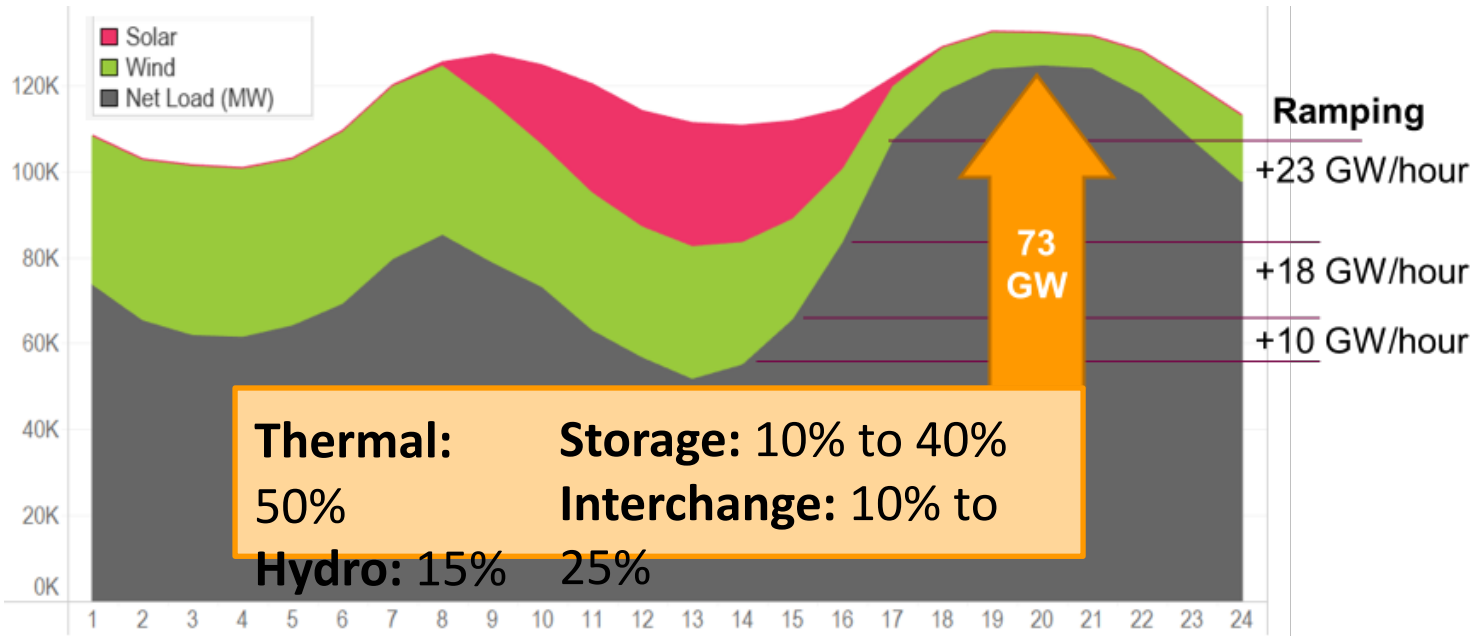
KEY INDICATORS

- 2-step: procured a third of the reserves needed and provided no incentives for flexibility (0.02 \$/MW)
- Up to 80% of synch-reserved provided by storage
- PJM does not intend to rehash the ORDC proposal

Focus Area No. 4



The Integration of Renewable Resources Increases the Need for Balancing Resources To Meet Forecasted Ramping Requirements & Increases the Operational Flexibility Needs in Winter.



* Peak ramping in Winter

KEY INDICATORS

- Ramping: 50% Load, 50% Renewables
- 90th percentile > 10 GW/hour
- Peak ramping > 20 GW/hour
- Winter season has the highest ramps (adverse alignment with load)



Focus Area No. 5

Energy Storage (4-hours) Enhances Operational Flexibility, but Seasonal Capacity and Energy Constraints Require Transmission Expansion, Long-Term Storage, and other Emerging Technology.

4-Hour Storage
6 GW Stand Alone
31 GW Solar Hybrid




Long-Term/Seasonal Storage



Emerging Technology



Regional Transmission Expansion

Short-Term Operational Flexibility

Long-Term Operational Flexibility

Essential Reliability Services

Capacity & Seasonal Energy Constraints

KEY INDICATORS

- Storage provides up to 80% synch-reserves and 30% of ramping requirements
- Congestion increased by 60%
- Renewable curtailment 16% (in RIS 1.0 it was 10%)

Refining Study Assumptions (Phase-3)

Policy Update

State/federal policy update of Base, Policy, and Accelerated scenarios



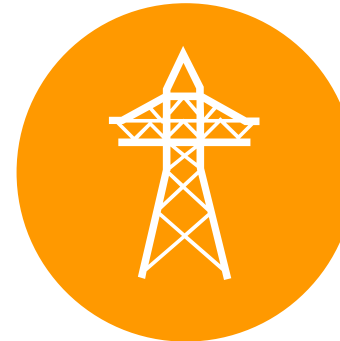
Retirement Sensitivity

Accelerated retirement of thermal resources



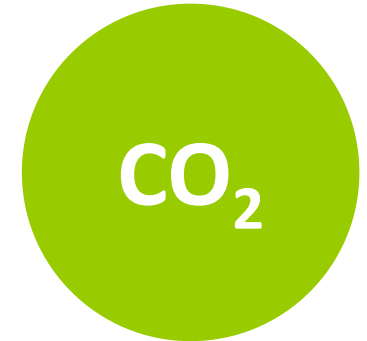
Interchange

Renewables buildout in the Eastern Interconnection; sensitivity on transfer capability



100% Carbon-Free Scenario

Resource Adequacy (ELCC)



Appendix



Correctly Calculating Capacity Contribution of Generators Is Essential



Flexibility Becomes Increasingly Important With Growing Uncertainty



Market Reforms Are Needed To Mitigate Uncertainty and Incentivize Flexibility



Regional Markets Facilitate a Reliable and Cost-Effective Energy Transition



Reliability Standards Must Evolve



Electrification Shifts the Seasonal Resource Adequacy Risk to Winter



Retail Rate Design & Energy Storage Become Increasingly Important With Electrification



Market Reforms Are Needed To Mitigate Uncertainty and Incentivize Flexibility



The Integration of Renewable Resources Increases the Need for Balancing Resources To Meet Forecasted Ramping Requirements & Increases the Operational Flexibility Needs in Winter



Energy Storage (4-hours) Enhances Operational Flexibility, but Seasonal Capacity and Energy Constraints Require Transmission Expansion, Long-Term Storage, and Other Emerging Technology