



Reliability & Renewable Integration Study

May 4, 2021

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Reliability in PJM: Today and Tomorrow

Renewable Integration Study

Final Remarks

Why a Paper on Reliability?



- **To educate!** Reliability needs to be kept in the forefront during the significant change in the energy industry.
- Recognition that we will need to adapt our practices as well.
- It is a mutual interest among all policymakers and stakeholders.

Building Blocks of Reliability



Adequate Supply

Resources to reliably power the system and meet customer demand



Accurate Forecasting

Projection of future customer demand and system needs



Robust Transmission

Reliable delivery of power across the grid and to customers via local distribution companies



Reliable Operations

Monitoring and dispatch of the system by trained operators

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Industry Research/Outreach

Review industry experience: CAISO, MISO, NERC, ESIG, NREL, SPP, ERCOT.

Leverage PJM's work: GE (2012), MOPR, Offshore Wind Study, Carbon Pricing.



Analytics Markets/Operations

Understand the impact of renewables in the context of PJM.

Identify tipping points.

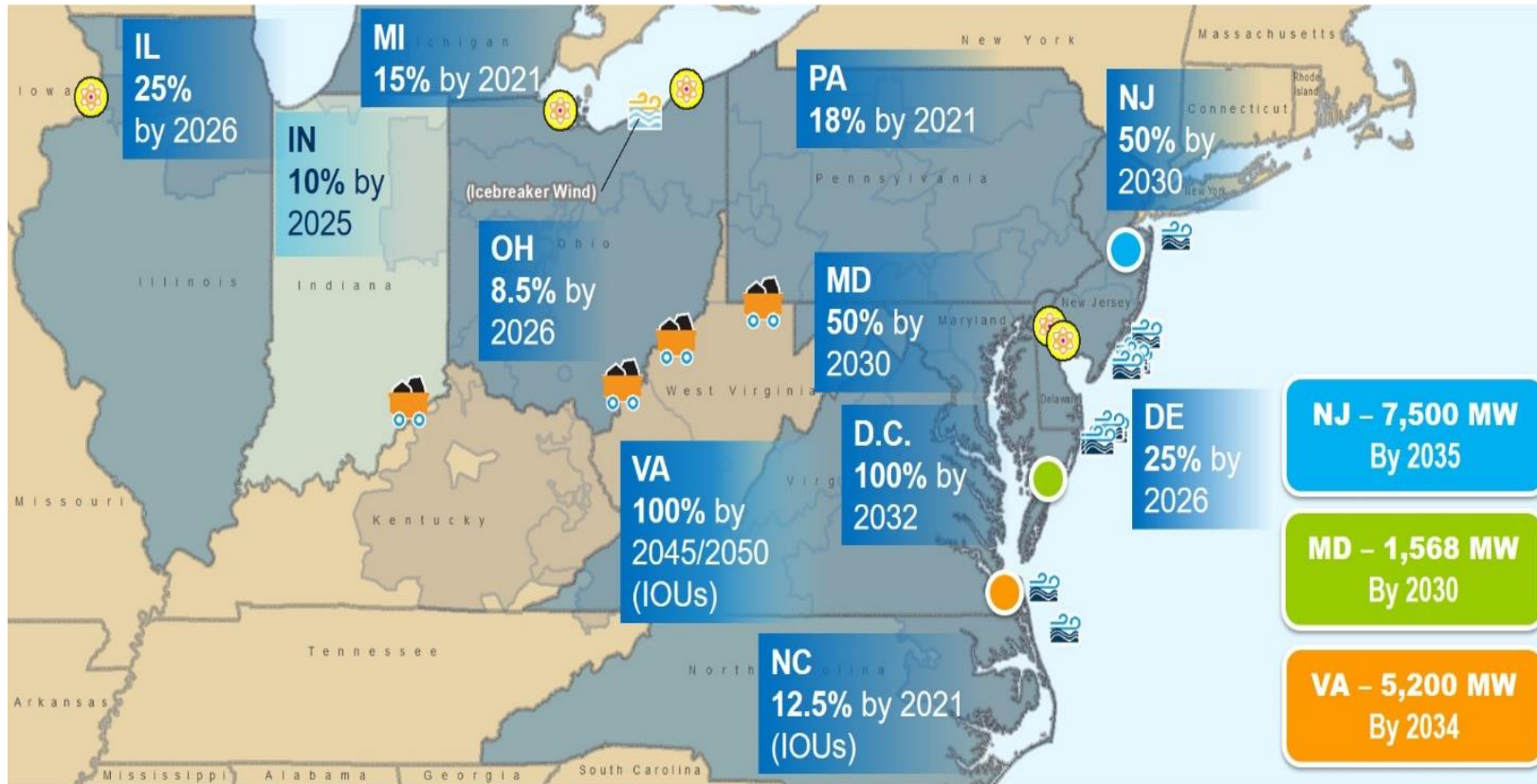


Takeaways

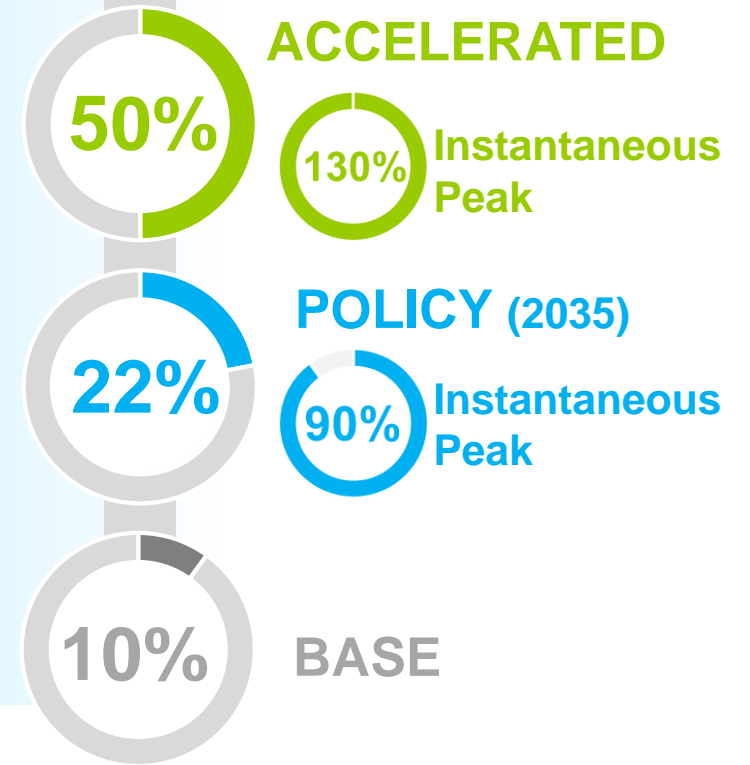
We do not propose solutions (it is not a position piece).

The intent is to inform and initiate discussion on changes that may be required given industry trends.

State Renewable Portfolio Standard



Renewable Scenarios (Annual Energy)



* State Portfolio Standard – April 2020

Modeling Assumptions (RIS 1.0)

Generation

- ✓ ELCC: wind/solar
- ✓ Retirements: declared, policy and “at-risk”
- ✓ Renewable hourly profiles based on geographical location (NREL)
- ✓ Storage **not** modeled
- ✓ Off-shore wind explicitly modeled

Transmission

- ✓ Interchange respects available transfer capability
- ✓ Methodology for transmission expansion
- ✓ Neighboring RTOs maintain status-quo

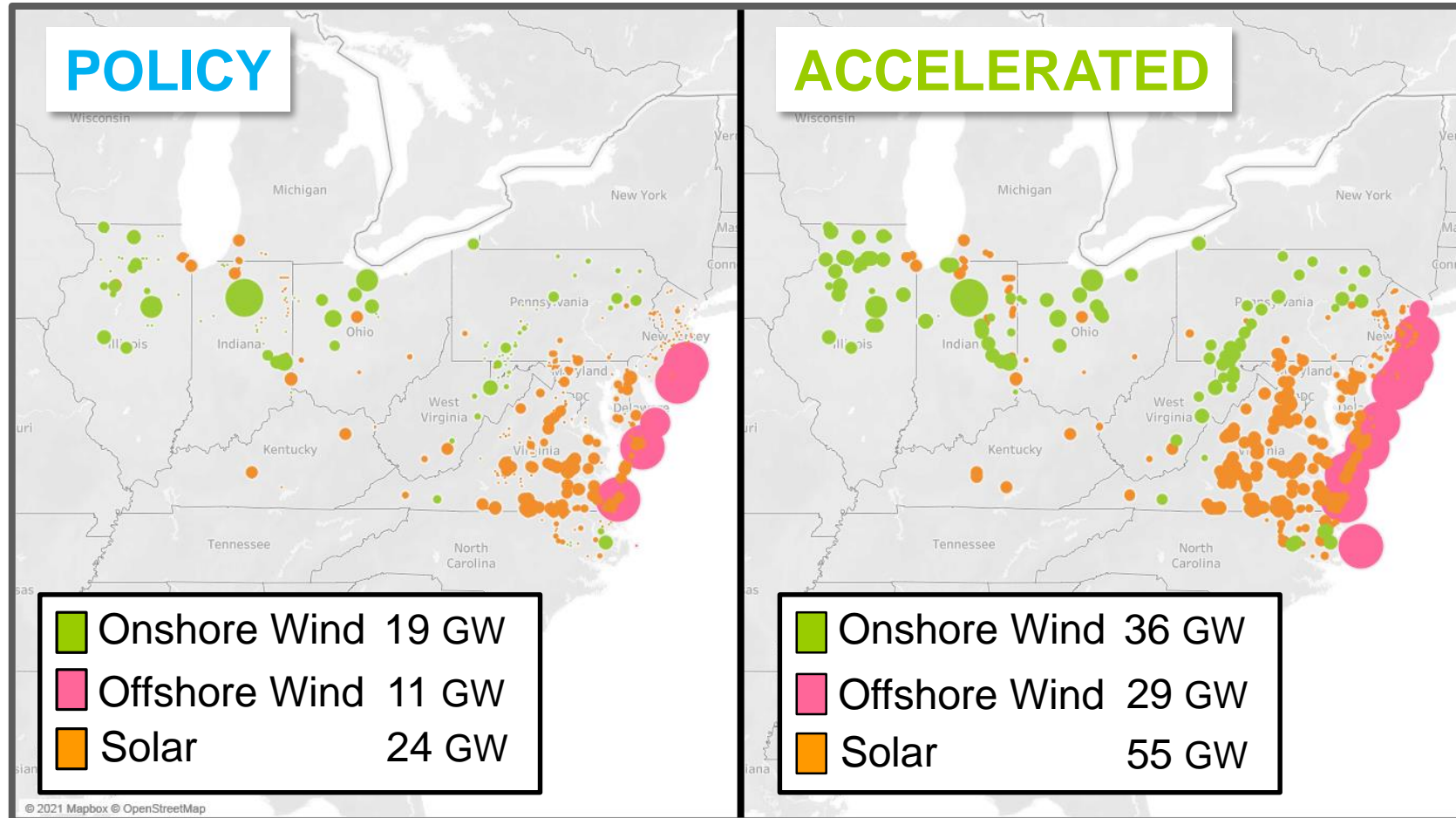
Load

- ✓ DR: ~7 GW
- ✓ Load forecast 2035: implicitly models energy efficiency, DER and electrification

Markets

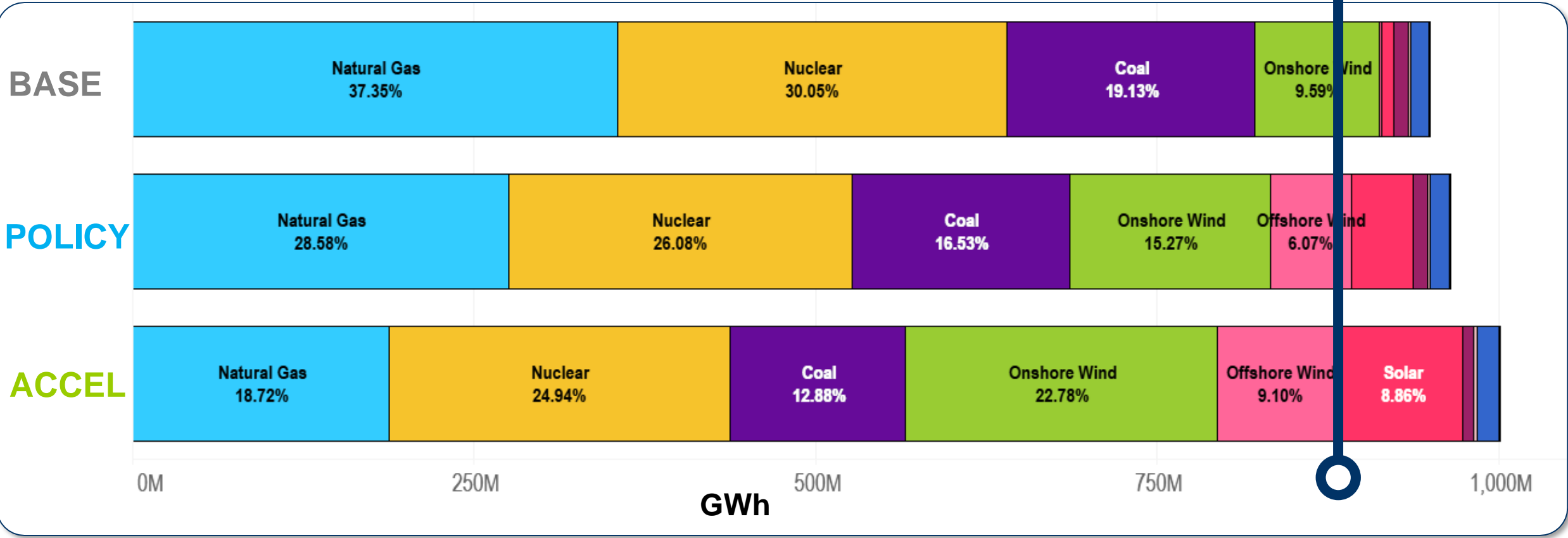
- ✓ As-is 2020: **not** modeling ORDC, fast start, renewables do not participate in reserves, etc.
- ✓ Projected fuel & commodity prices (IHS)
- ✓ RGGI carbon pricing in VA, PA, MD, DE, NJ

Renewable Generation Interconnection



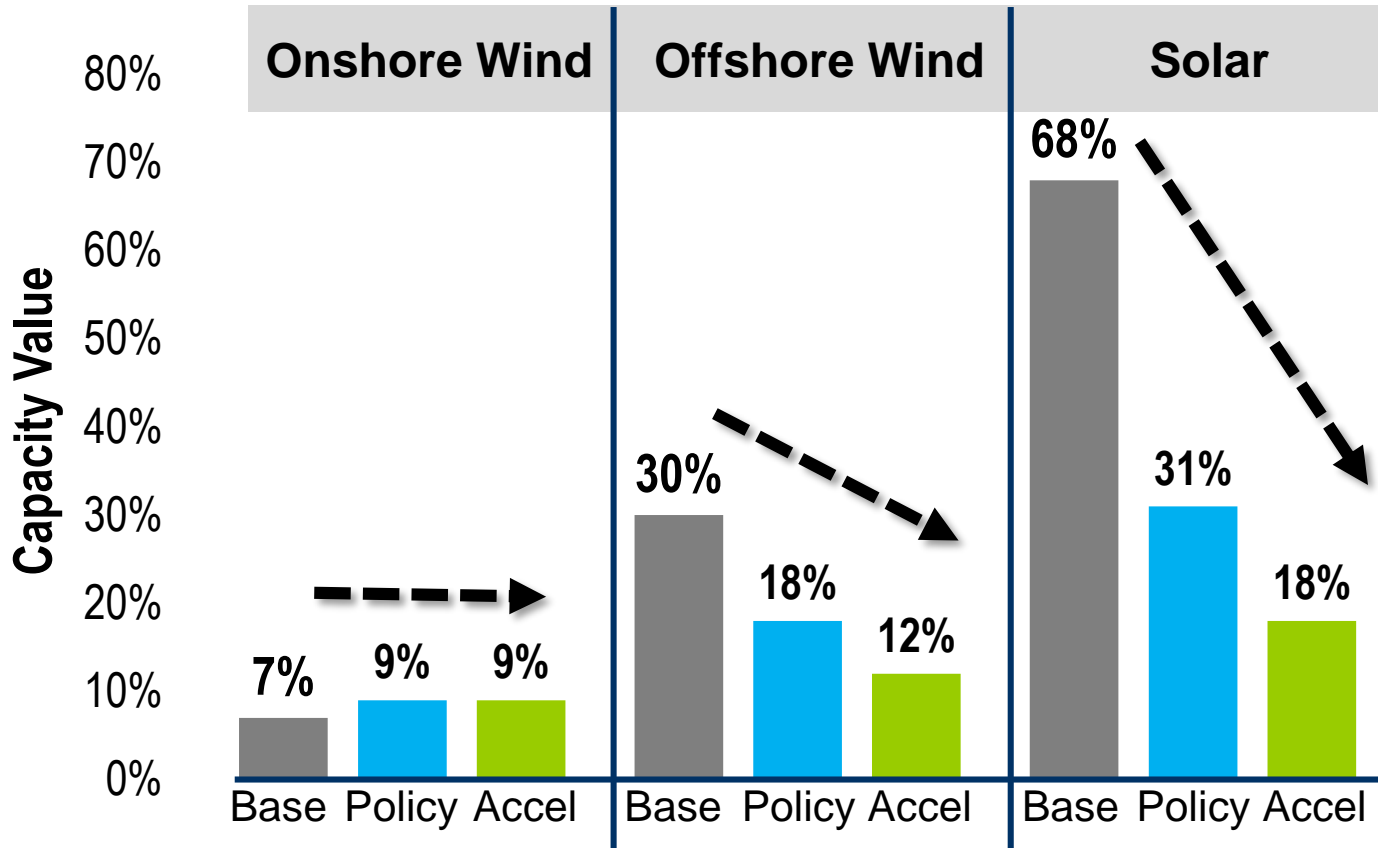
Dispatched Energy by Fuel Type

Average Demand

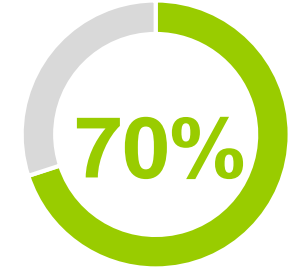


Effective Load Carrying Capability (ELCC)

ELCC



Load Shed
Events



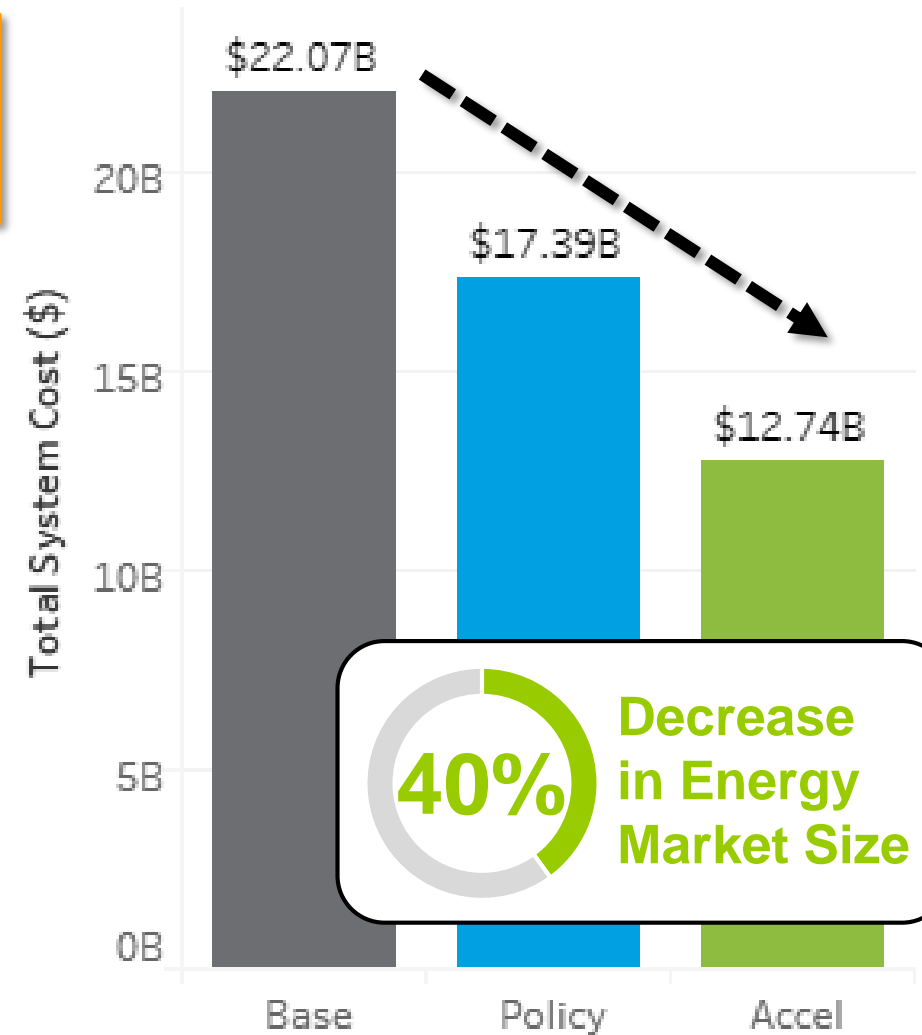
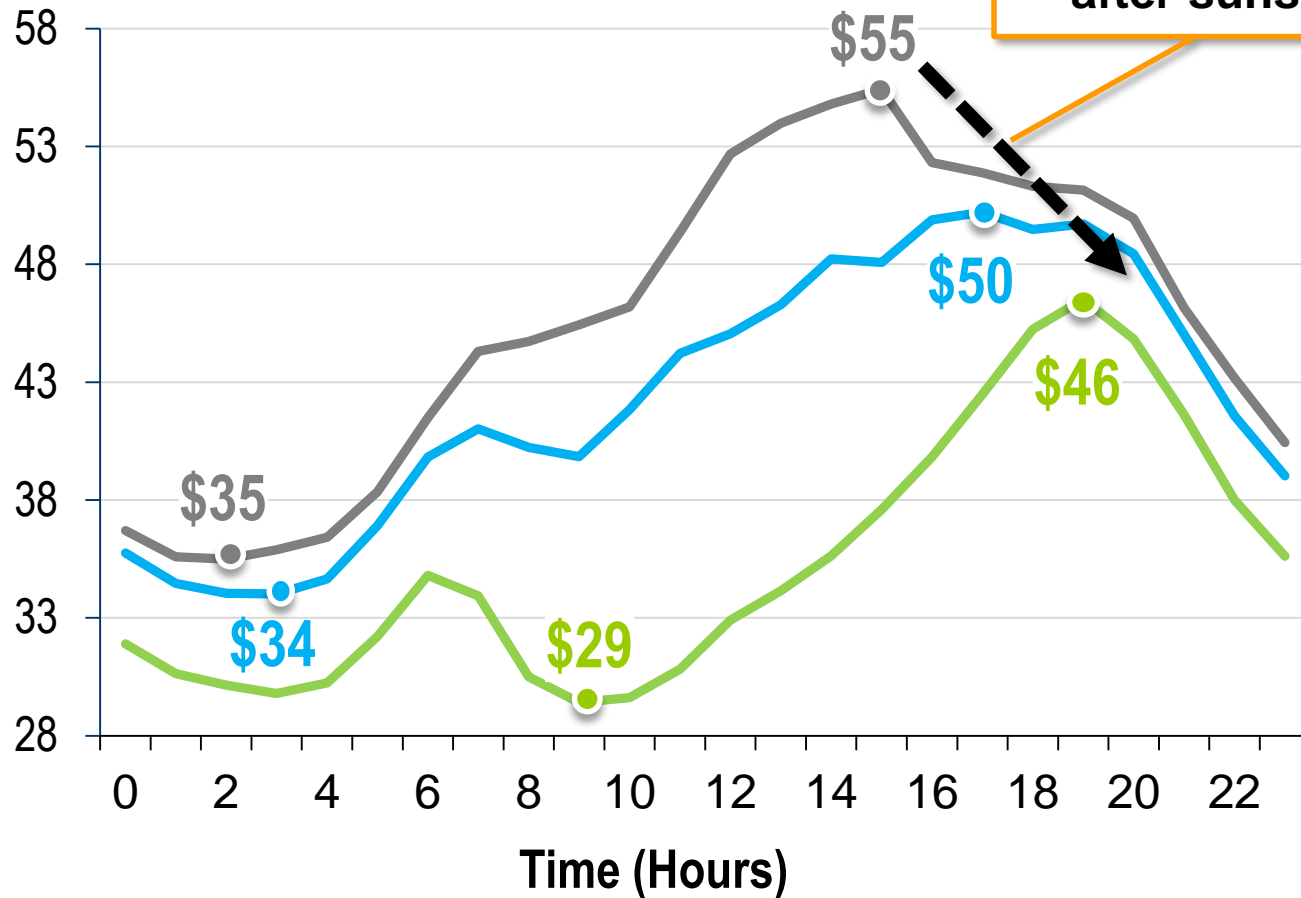
Installed Reserve
Margin (IRM)

What does this mean?

- ELCC appears to work.
- ELCC is all about UCAP. We need to transition out of the IRM (ICAP) vocabulary.

LMP & Size of Energy Market

Average Price (\$/MWh)



Generator Reliability Attributes

NERC/PJM Reliability Attributes

ESSENTIAL

Frequency

- System Inertia
- Primary Frequency Response

Voltage

- Reactive Capability

Ramping

- Effective Regulation
- Ramping Capability

Fuel Assurance

- Non-Fuel Limited
- On-Site Fuel Inventory

Flexibility

- Cycle
- Short Min. Run Time (< 2 hrs.)
- Startup/Notification Time < 30 Minutes

Other

- Black Start
- System Stability

Review Approach

Defining System Needs and Reliability

1

Industry Research and Outreach

2

Current State of the System

3

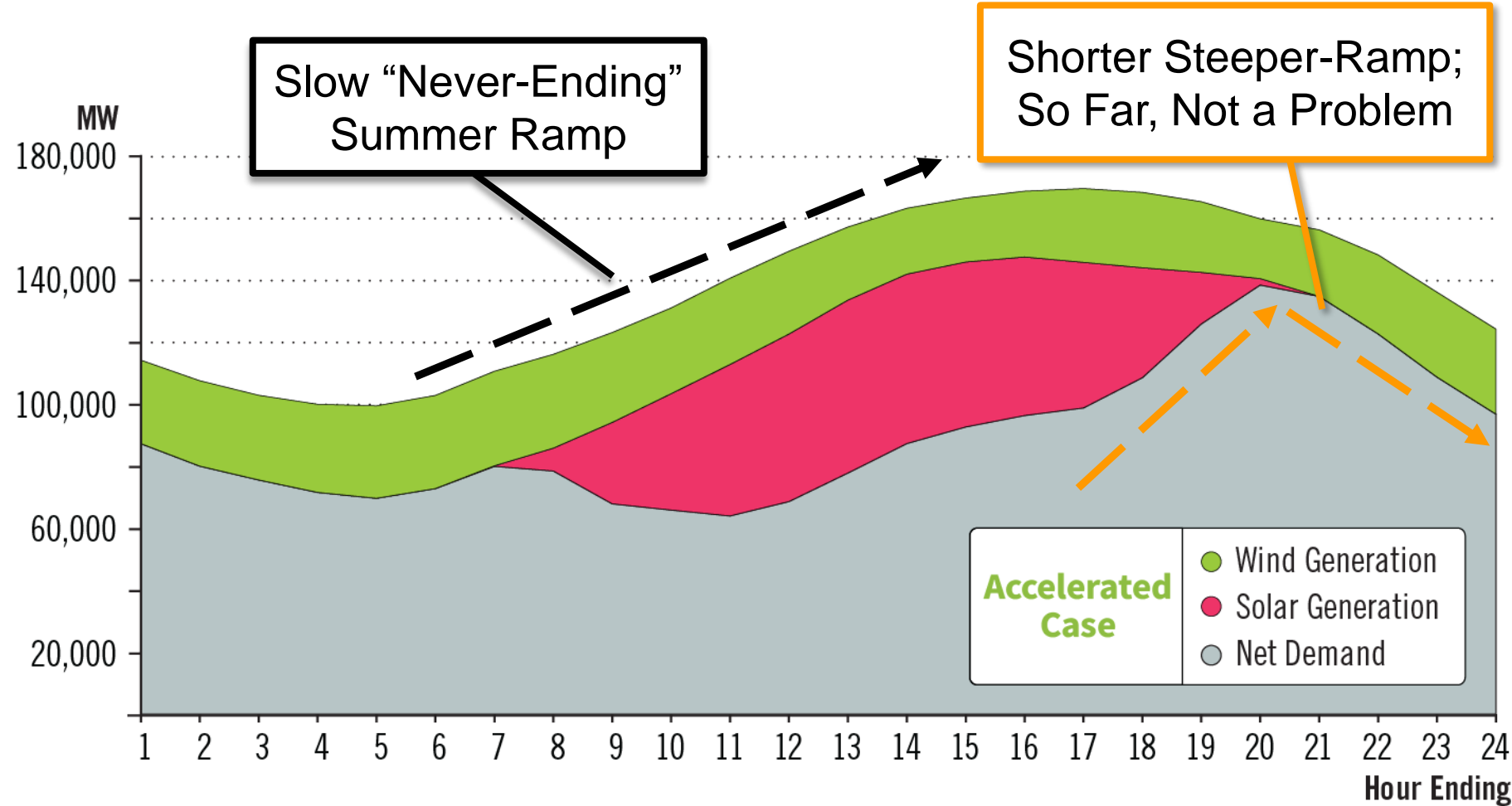
Future State of the System

4

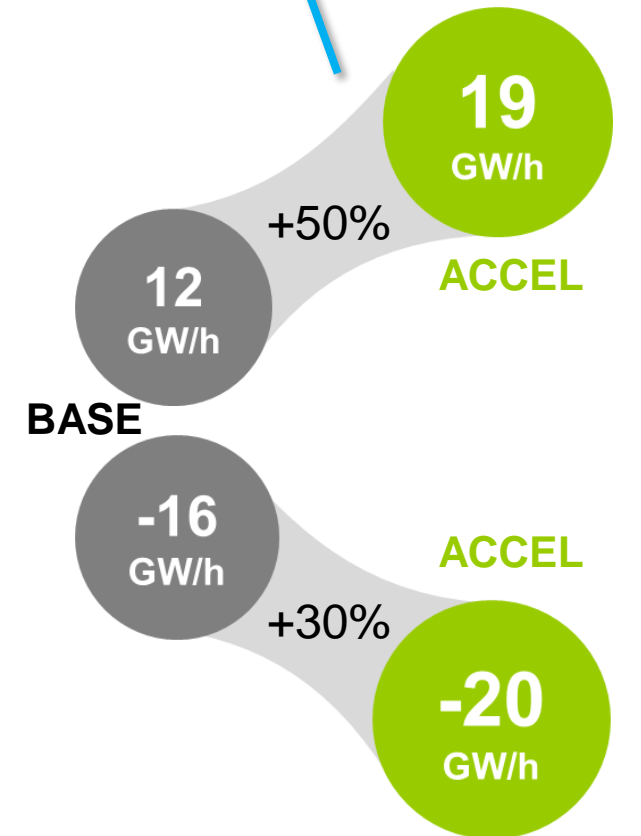
Key Takeaways & Recommendations

5

Ramping Requirements



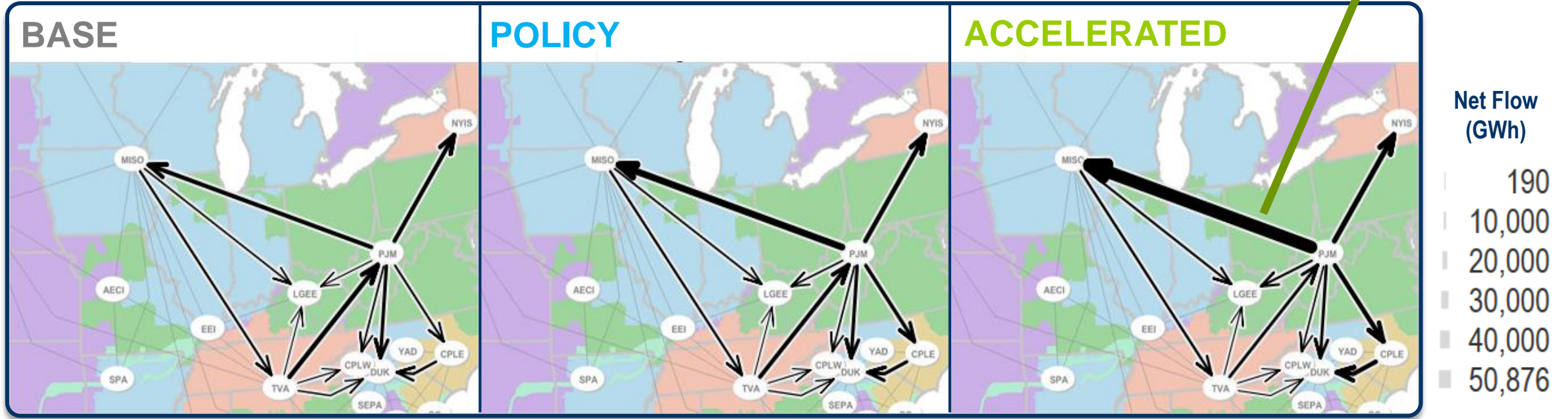
Ramping Requirements
Diversity Helps!



Interchange – Leveraging the Interconnection

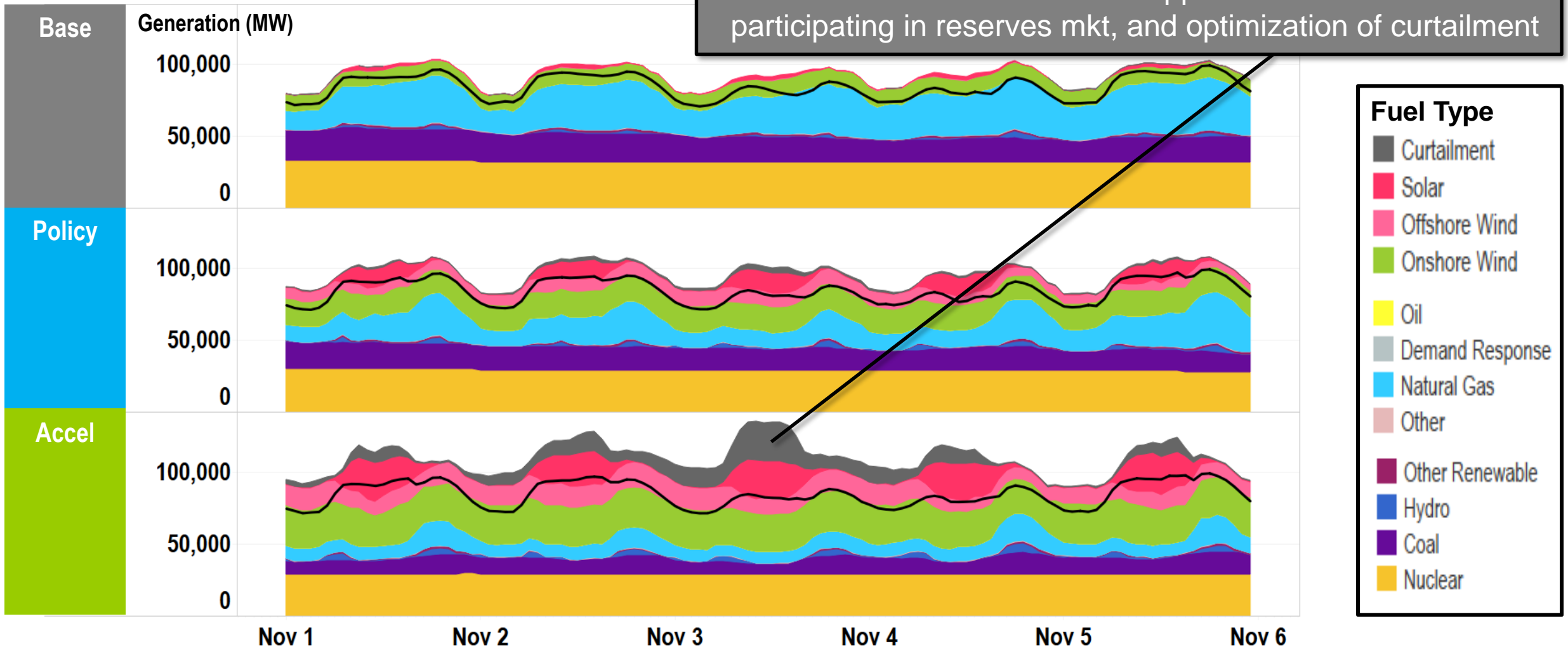
Net Exports Increased by 140%
-9 GW |—————| 20 GW

RTO Interchange



Renewable Curtailments

Massive Curtailment: Opportunities: renewables participating in reserves mkt, and optimization of curtailment



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Next Steps: Renewable Integration Study 2.0







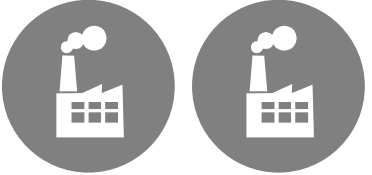


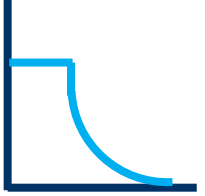
Energy Storage

Retirements

Load

Transmission

Reserves

	Energy Storage	Retirements	Load	Transmission	Reserves
RIS 1.0	Only Pump-Storage Batteries Not Modeled 	Policy, Declared & Economic Retirements 	Transmission Planning Load Forecast 	No Transmission Expansion 	Two-Step ORDC 
RIS 2.0 +12 combinations	Policy (Virginia 3 GW) & Economic 	Accelerated Retirement Sensitivity 	Accelerated Electrification 	Optimized Transmission Expansion 	Downward-Sloping ORDC 

Key Takeaways

Inform & Stimulate Thought-Provoking Questions



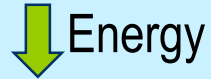
Anticipating
Market Evolution



IRM



Flexibility Needs



Energy



Capacity Factor



Maintaining Essential
Reliability Attributes



Leveraging the
Interconnection

