Energy Transition in PJM: Flexibility for the Future

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Background

Phase 1 & 2

2021 **2022**

- Energy and ancillary services
- Essential reliability attributes
- Electrification and impacts on Effective Load Carrying Capability (ELCC)

Phase 3

2023

Resource mix "balance sheet" as defined by:

- Generation retirements
- Demand growth
- New generation

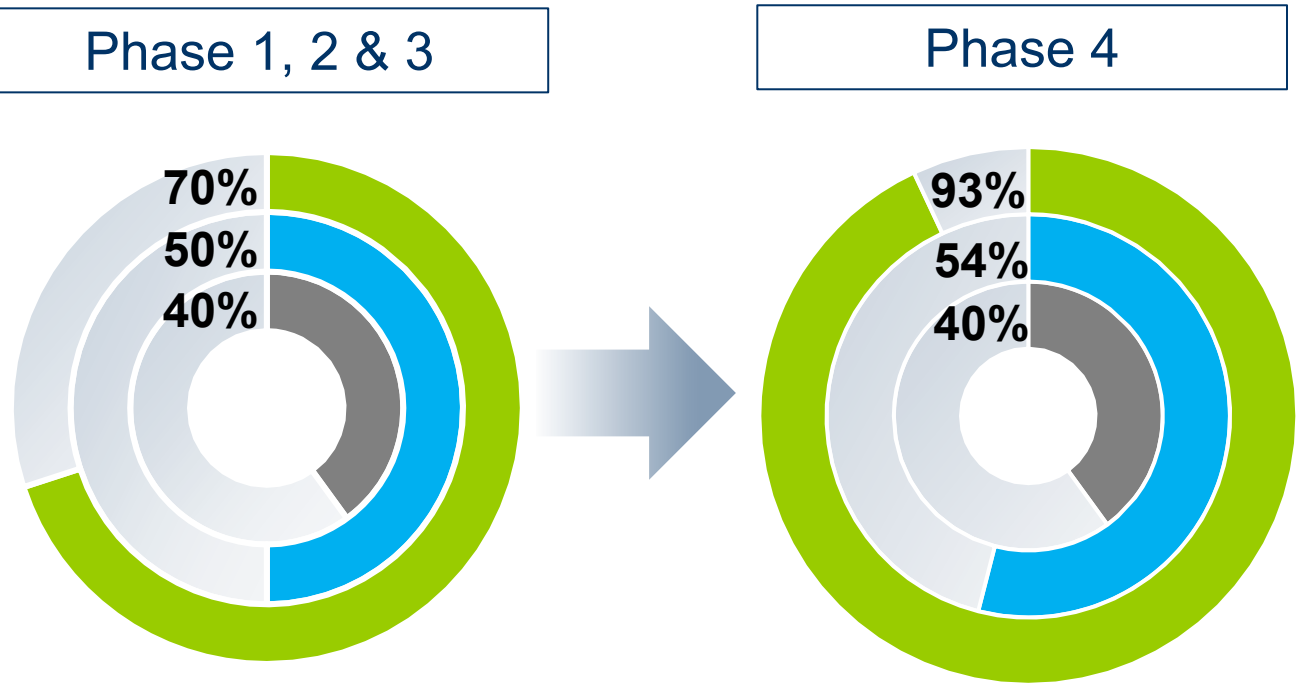
Phase 4

2024

- Retirements and new entry to achieve 93% carbon-free generation
- Complementarity between renewable resources in PJM and the Eastern Interconnection
- Interregional impacts and seasonality effects

Updating Scenarios

Energy Served by Carbon-Free* Resources



- **Base:** Benchmark for today's system
- **Policy:** Evaluate system impacts of existing state and federal policies implemented by 2035.
- **Accelerated:** Stress system with a high-end levels of generator retirements and new renewable and storage resources.

* Carbon-free generation includes wind, solar, solar-storage hybrid, hydro and nuclear.

Refining Assumptions

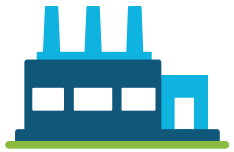
Accelerated Scenario

Retirements
up to 70 GW

38 GW Gas

27 GW Coal

5 GW Oil



Replacements
up to 300 GW

117 GW Wind

77 GW Solar

55 GW Solar Hybrid

27 GW Batteries

30 GW BTM Solar

Demand Growth

19 GW EVs

14 GW Heating

10 GW Data Centers

Neighbors' Renewables
up to 400 GW

90 GW Carolinas

195 GW MISO

48 GW NYISO

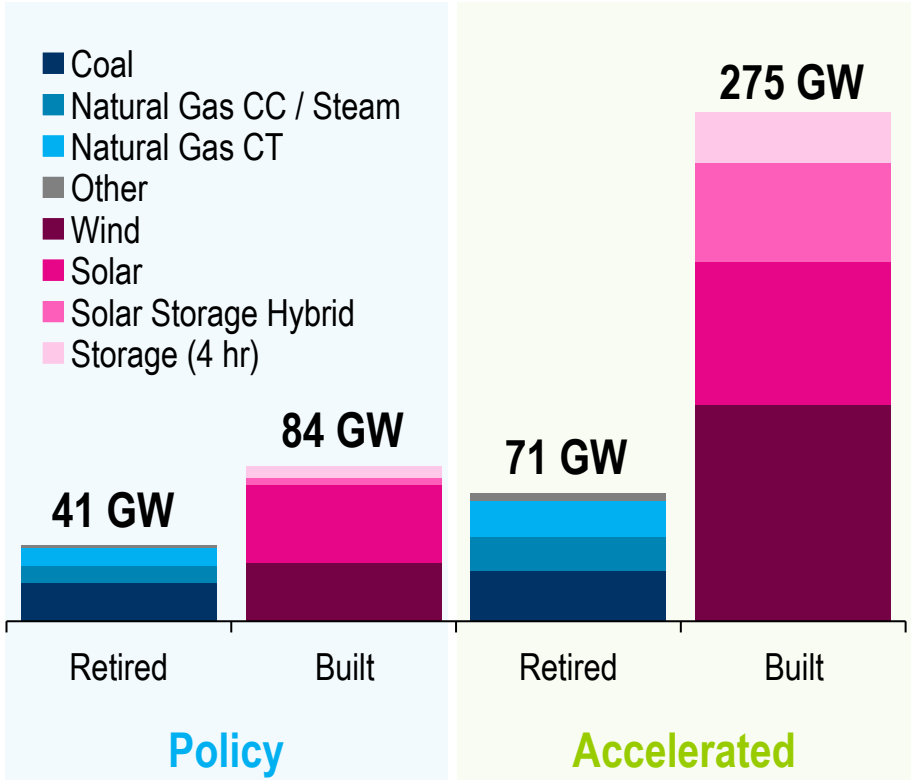
62 GW TVA/LGE/KU

Interchange allowed up to tie limits.

Reserves Today's Two-Step ORDC & Resource Participation

Focus Area No. 1

Accelerating the Pace of New Entry Is Critical To Maintaining Reliability



- Less than **doubling** the amount of retirements **quadruples** the amount of new entry needed. Replacing thermal generation with renewable resources gets significantly more difficult.
- Despite **275 GW of renewables and storage** in the Accelerated scenario, **79 GW of flexible, thermal resources still needed** to maintain resource adequacy at one-in-10 LOLE.
- Demand growth is unprecedented and dynamic, adding to the complexity of ensuring new entry keeps pace with retirements and demand growth.

Focus Area No. 2

Interregional Transfer Capability Is Increasingly Important

Transfer Capability

- Healthy transfer capability margins in Policy scenario
- Interface limits are reached more often in Accelerated scenario.

Interchange Plays a Major Role for the Grid

- Periods in which PJM goes from exporting to importing +10 GW
- Interchange provided essential reliability services, supplying 15% of the ramping needs.

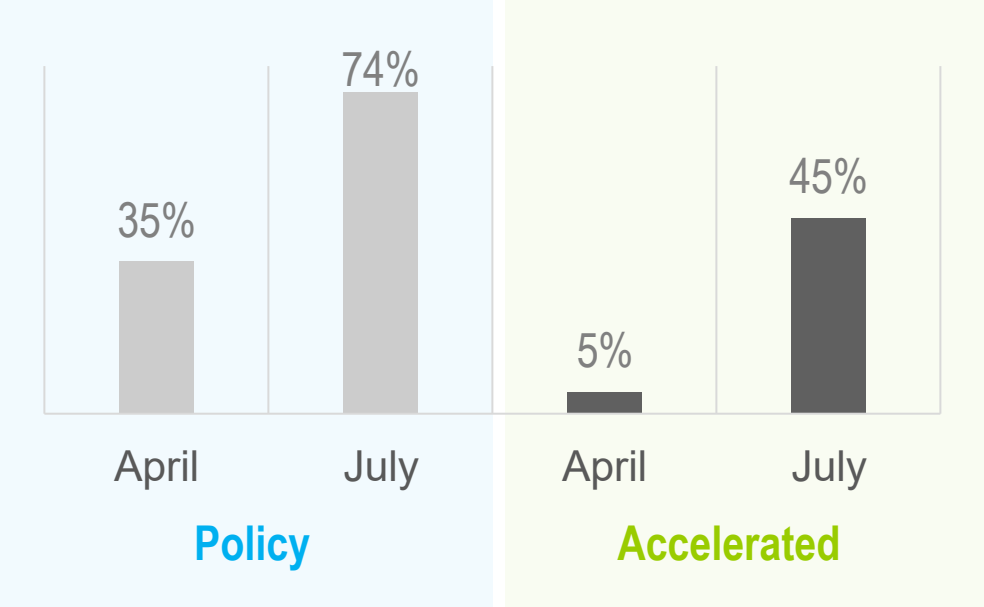
Need To Manage New Uncertainty & New Extremes

- Coincidental low wind in PJM and MISO (9% of the year) limits the ability to manage uncertainty with interregional transfers.
- Enhanced interregional coordination is needed to ensure reliability.

Focus Area No. 3

Multiday, Dispatchable Resources Are Needed

Combined Cycle Capacity Factors



The plot shows pronounced seasonal effects of the capacity factor of combined cycle power plants.

- Renewable generation instantaneously represents as high as 118% of the load and as little as 3% of the load. The total system ramping needs are met by energy storage (43%), thermal resources (32%), interchange (15%) and hydro (7%).
- Seasonal effects polarize the need for thermal resources. Large amount of storage assumed built and utilized heavily.
- If the gas fleet of today remains as is, or declines, but additional storage does not get built, immense pressure will be placed on existing natural gas to supply the balancing and ramping needs for the system.

Moving Forward

PJM must evolve to address the complexity of the energy transition as increasing levels of intermittent resources create significant variability and uncertainty.

Continuing to track mismatches among:

- Resource retirements
- Load growth
- Pace of new generation entry
- Transmission build-out

Enhancing interregional coordination to better manage existing interregional capability that will be needed with the increasing volatility and uncertainty that is anticipated

Continually evaluating evolving system needs for essential reliability services and developing market mechanisms to require and incentivize them

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Energy Transition in PJM:
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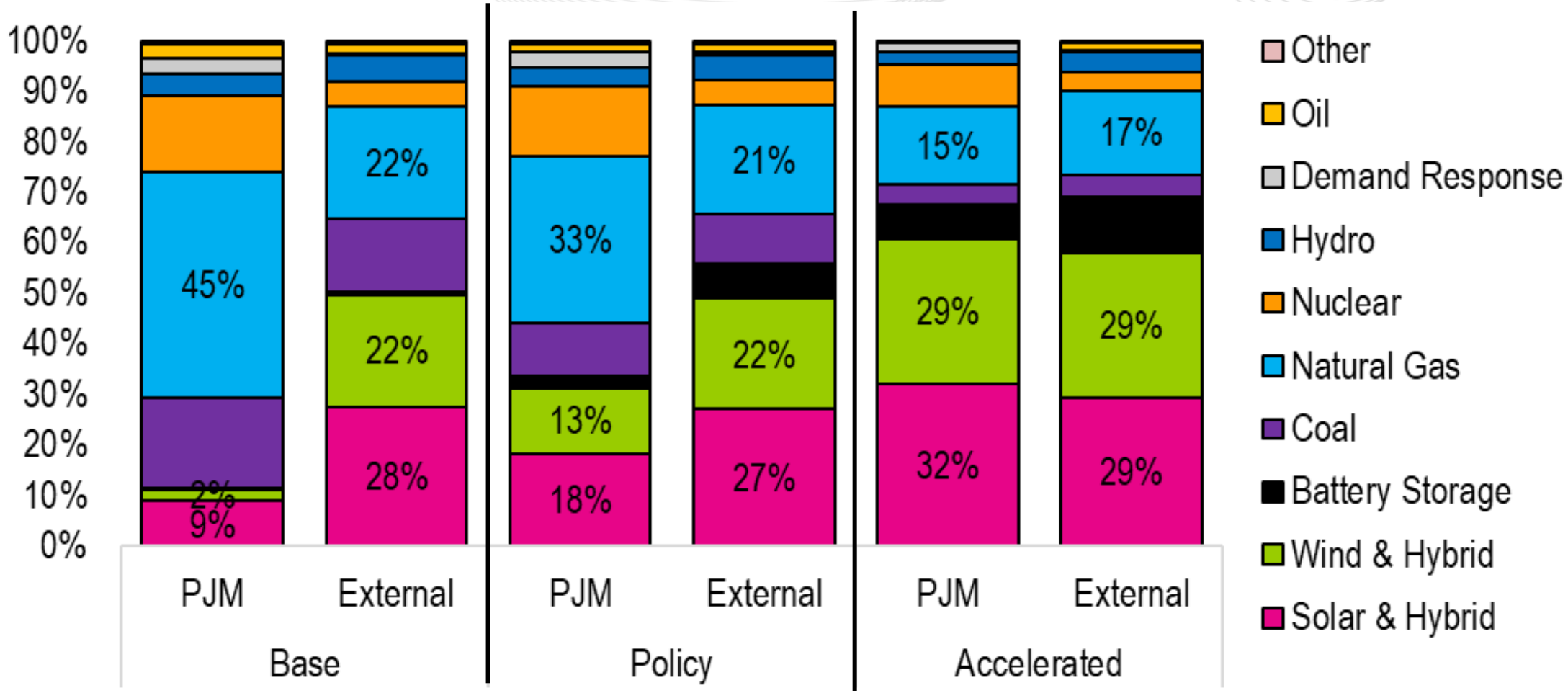
Appendix

Scenario Summary

	Base	Policy	Accelerated
Purpose	Provide benchmark for today's system, aligned with 2022 RTEP case.	Evaluate system impacts of state and federal policies implemented by 2035.	Evaluate system impacts of an accelerated pace of resource expansion, retirement and electrification.
Supply	8% renewable 40% carbon-free	22% renewable 54% carbon-free	61% renewable 93% carbon-free
Retirements	Announced deactivations	41 GW of anticipated coal, natural gas and oil retirements due to state and federal policies by 2035	71 GW total; retirements beyond Policy scenario to keep system at minimum reserve margin (1-in-10 LOLE) while adding large amounts of renewables and storage
Demand	2022 PJM load forecast for 2035 9 GW BTM solar 900 thousand electric vehicles	2022 PJM load forecast for 2035 19 GW BTM solar 7.6 million electric vehicles	2022 long-term load forecast for the year 2035 with accelerated electrification 30 GW BTM solar 17 million electric vehicles

Percent of Installed Capacity in PJM & Neighbors



Transfer Capability