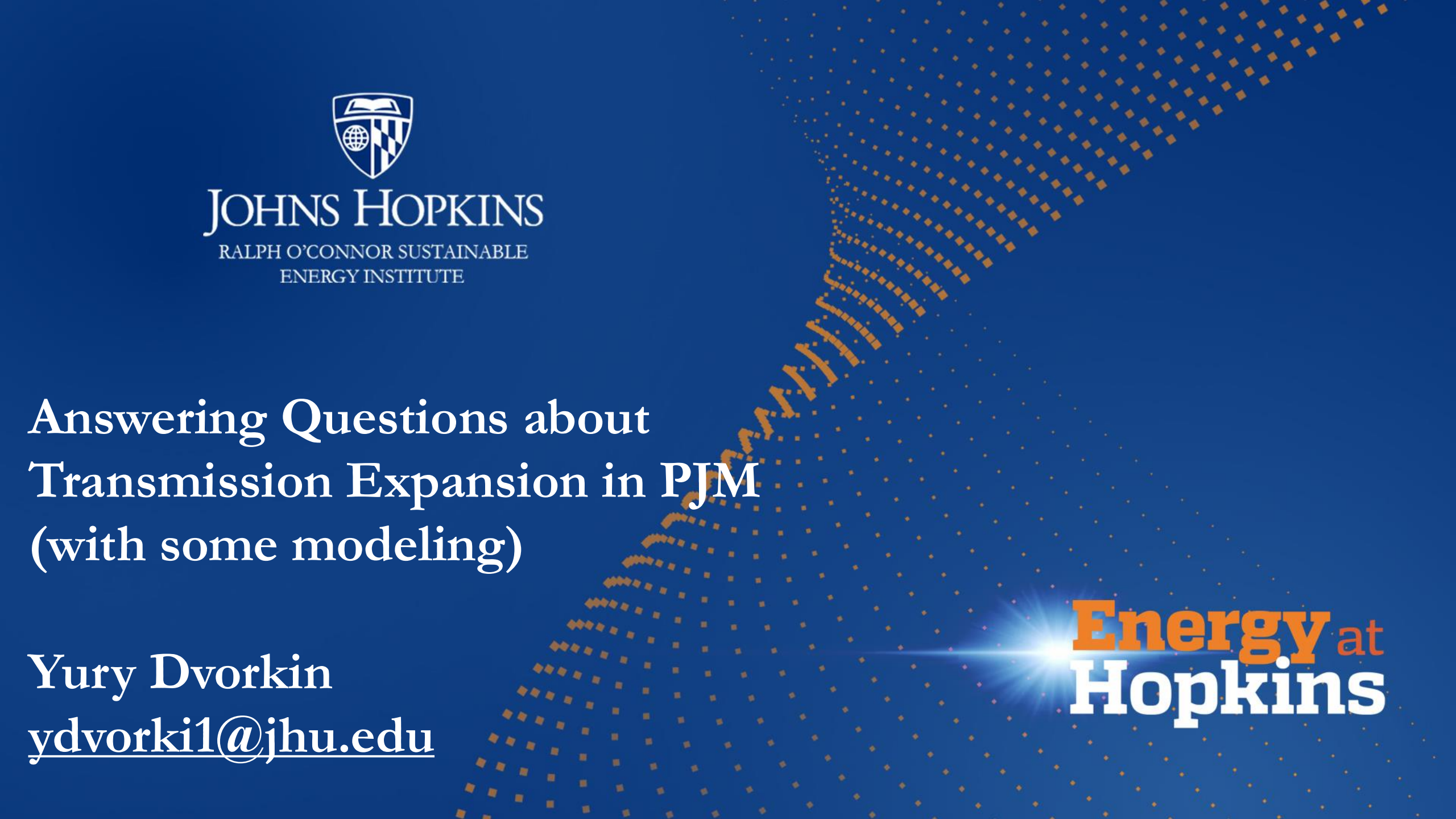


Answering Questions about Transmission Expansion in PJM (with some modeling)

Yury Dvorkin
ydvorki1@jhu.edu

Energy at Hopkins

DOE LIGHTS

TLDR: We're here to help PJM States with GETs; we're driven by States-need

Goal 1 – System Impact Assessment

- Evaluate ATT/GET to meet state transmission needs within the PJM footprint:
  - Cost reduction and ratepayer benefits
  - Deployment speed and implement ability
  - Avoided or minimized need for new greenfield rights-of-way
  - All ATT/GET technologies are game – but deployment speed is *key*.

Goal 2 – Framework Development & Application

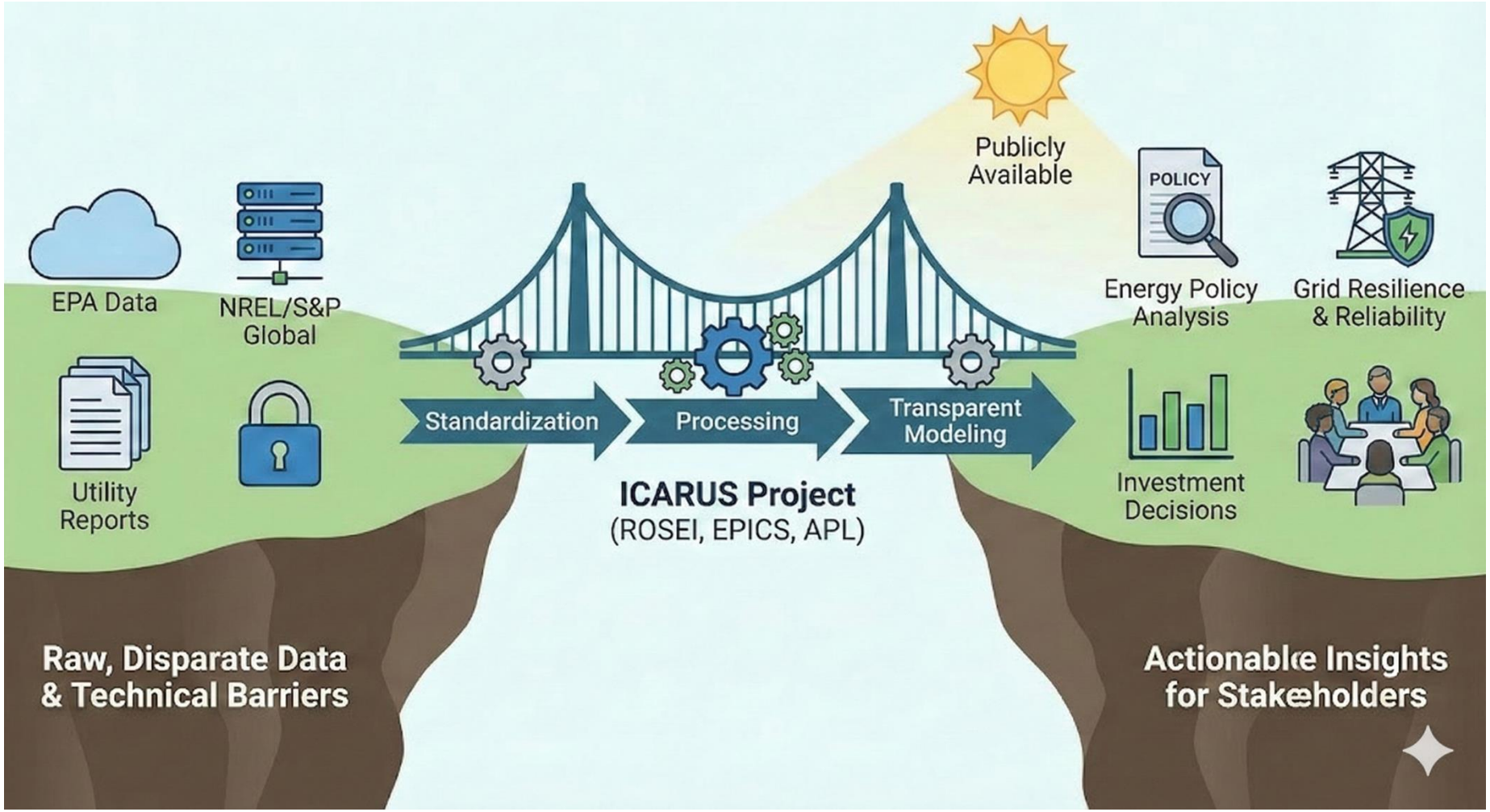
- Integrates ROW availability, production cost modeling, and least-regret analysis to identify **ATT/GET candidate projects** suitable for transmission planning processes.

Goal 3 – State-Driven Project Advancement

- Support interested states in pursuing ATT/GET projects through PJM venues
  - RTEP
  - FERC 1920

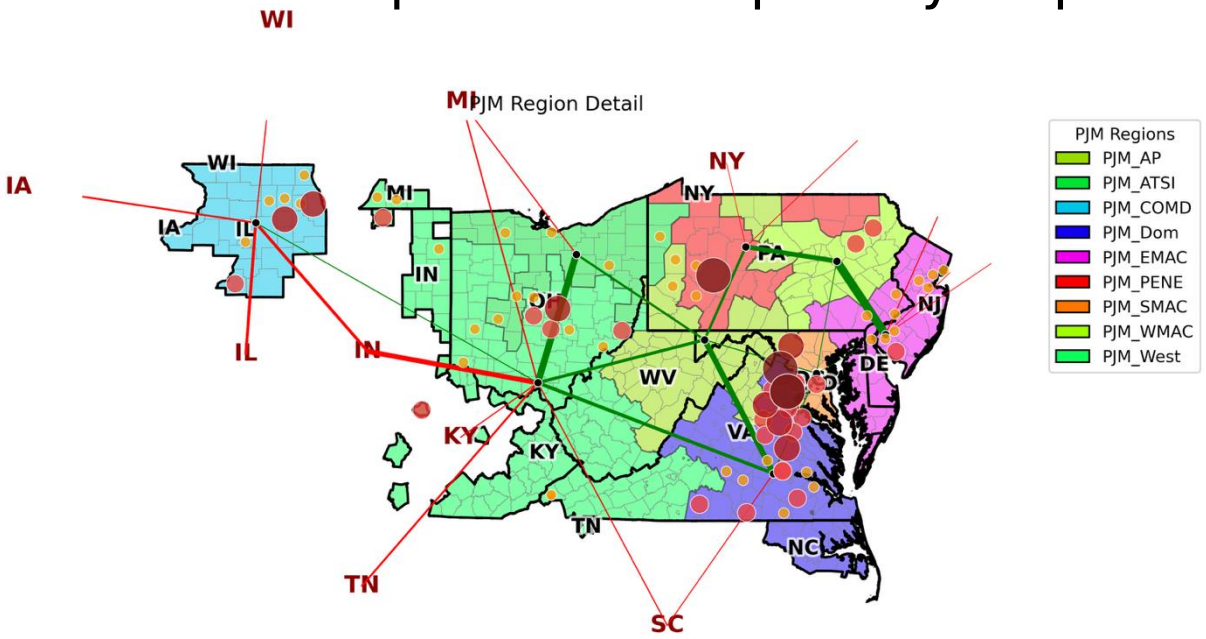
ICARUS: Modeling in the Energy Policy Loop

Goal: Bridging the modeling capabilities to run sophisticated energy policy analysis and the stakeholders that do not have data, models or expertise



ICARUS: PJM Data Democratization

Goal: Build operational capability for parallel PJM market and system analysis



Feature Area	Description	Target
Data Center Capacity	Incorporate state-, zonal- and regional-level projections for data center demand.	`Available as of Oct, 2025`, `Updated as of Nov, 2025`
Downscaled Atmospheric Data	Integrate other weather (year) data to model (extreme) weather impacts.	`Soon`
FERC Order 1920 Compliance	Model transmission expansion scenarios based on the new FERC rule.	`Soon`
State/Utility representation	Enhanced resolution spatially resolved upto PJM's 21 Zones and 9 IPM Regions for PJM, useful state/utility-level studies.	`Available as of Nov, 2025`
Nodal representation	Enhanced resolution to consider more detailed transmission network.	`Soon`

ICARUS: PJM Data Democratization

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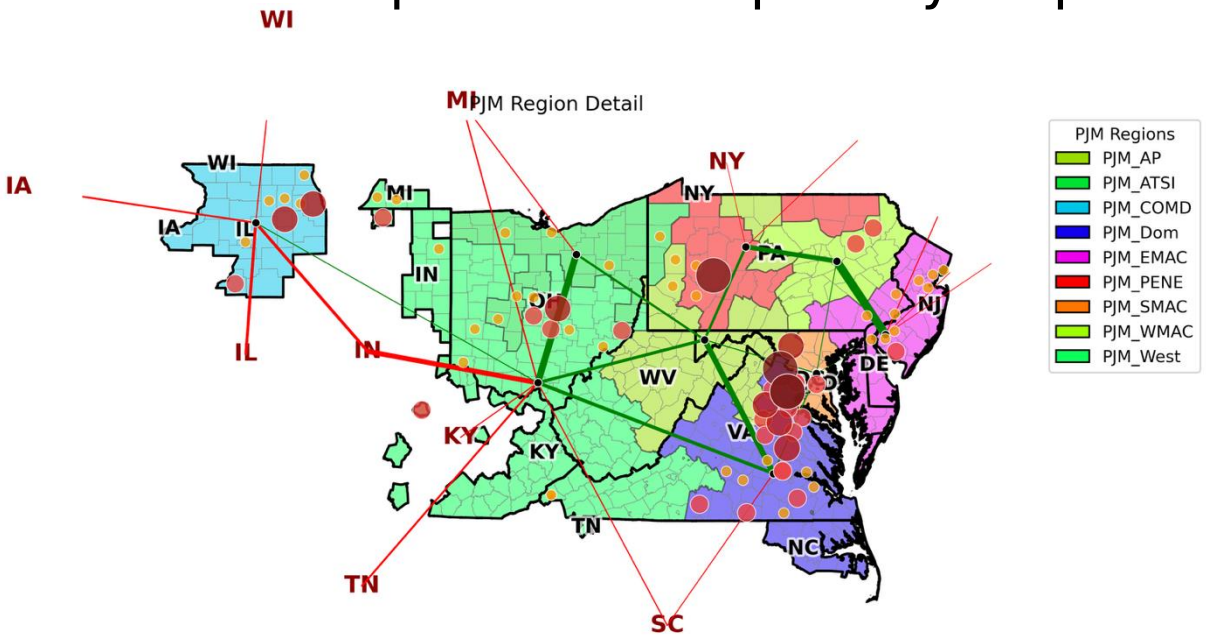

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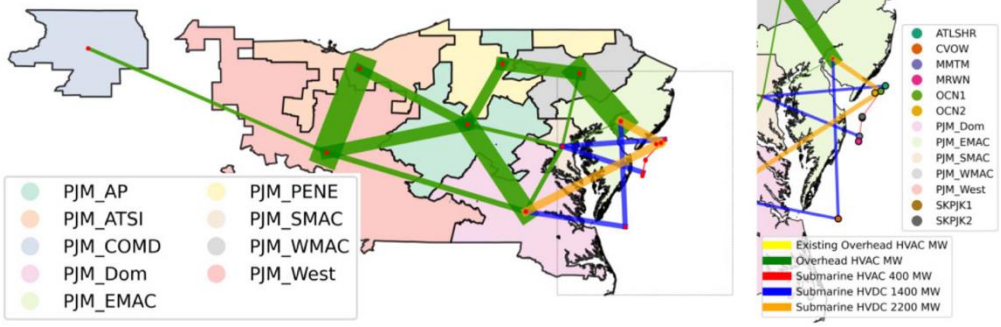


One-Click Downloads

For convenience, pre-processed datasets for common regions are available for direct download.

- **Download PJM Dataset (Base)**: 21 PJM zones over 9 IPM regions (with transfer limits)
- **PJM Dataset in GenX format**[†]
  - **Download GenX_PJM_9zones_Base**: 9 IPM regions (with transfer limits)
  - **Download GenX_PJM_9zones_DataCenters**: 9 IPM regions (with transfer limits)
- **Download PJM Data Center Dataset**: 21 PJM zones over 9 IPM regions (with transfer limits)

[†] These versions are simplified, hard-coded conversions of the **PJM Dataset (Base)** into the **GenX** format, following examples from the official GenX repository, where the corresponding **licenses and attribution requirements** are provided.

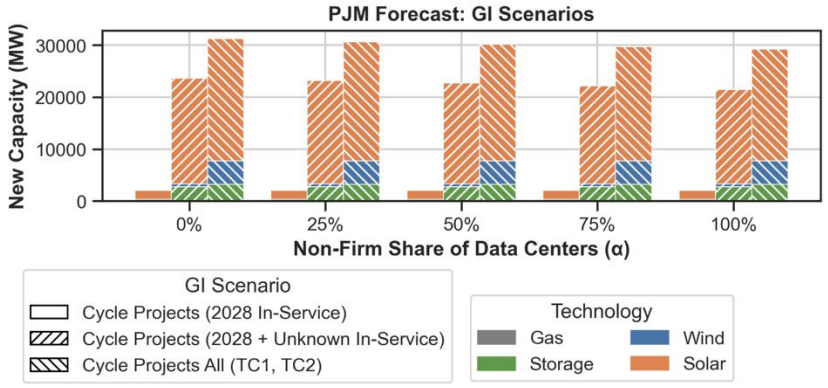
Example #1: How to Cope with Data Centers?

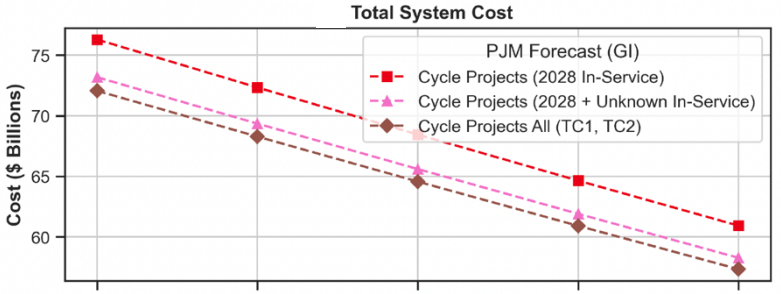
ANALYSIS & BRIEF — Johns Hopkins University · Ralph O'Connor Sustainable Energy Institute

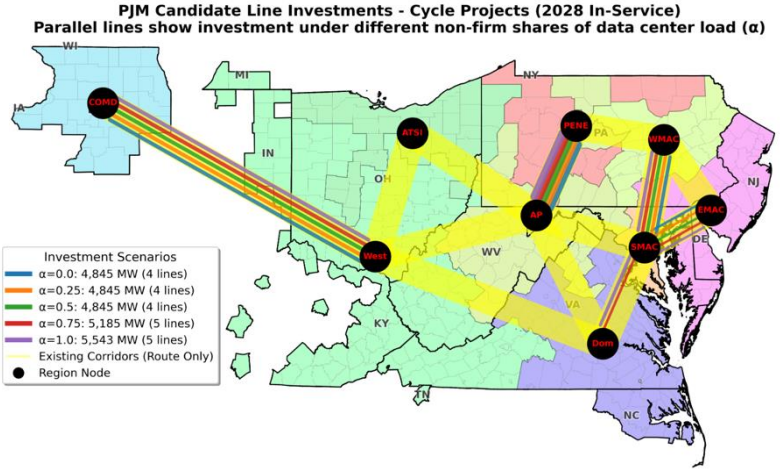
Data Center Flexibility and Grid Infrastructure Needs in PJM:

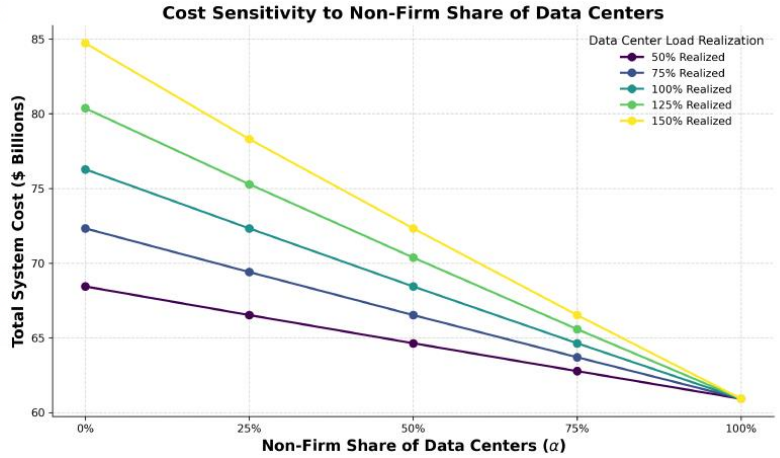
Data Center Flexibility Policies Can Substantially Reduce Energy Infrastructure Investments Necessary to Keep the PJM Grid Reliable.

For questions, please reach out to Dr. Yury Dvorkin (ydvorki1@jhu.edu) or Abraham Silverman, J.D. (asilve39@jhu.edu)
— March 2026



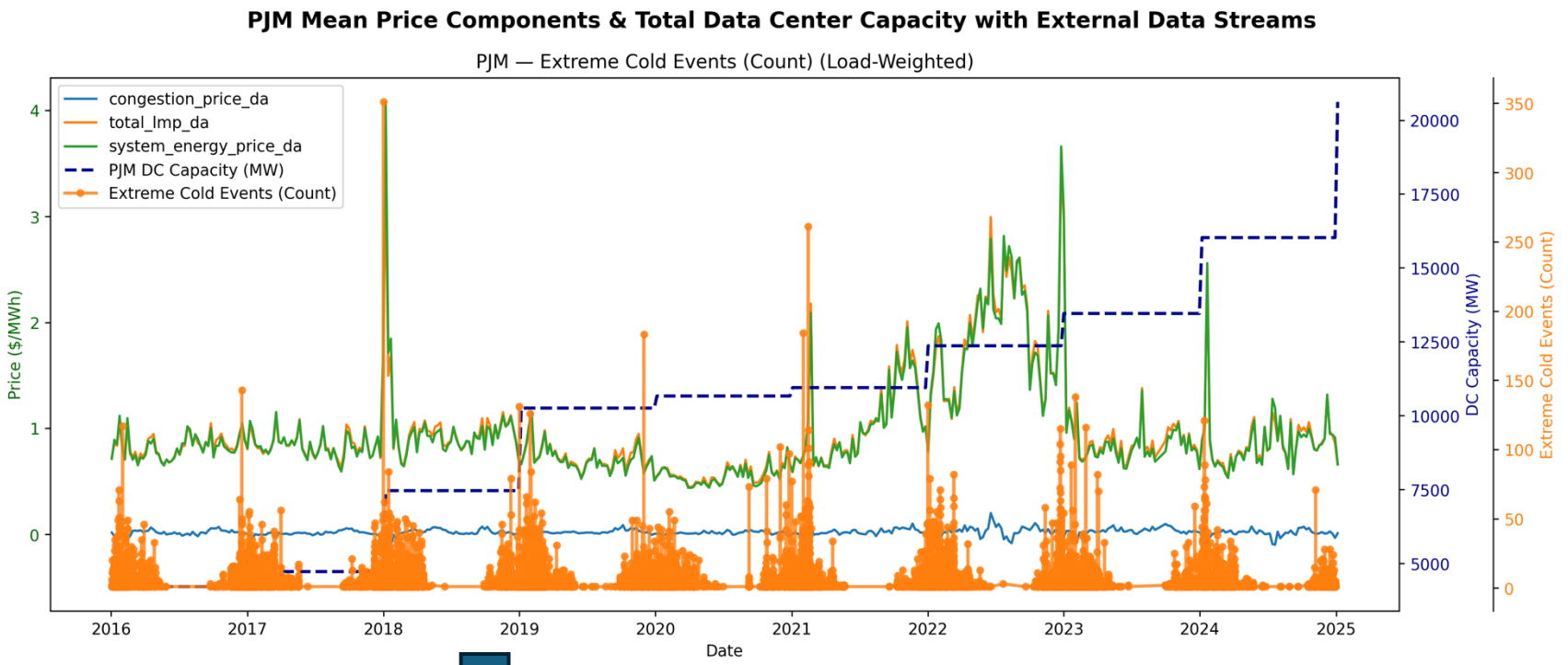






"$15B+/year in PJM savings from flexible data centers — about $200 per person, $1,000 per household".

Example #2: Causative Attribution of Price Increases to Data Centers



Your electricity rate

Competitive (mostly)

State-mandated programs (energy efficiency, environmental charges, universal services fund)

$$R_{\text{total}} = R_{\text{supply}} + R_{\text{transmission}} + R_{\text{distribution}} + R_{\text{public}} + R_{\text{taxes/fees}}$$

Cost of electricity supply (production + capacity)

Regulated

State and local taxes, franchise fees, and other MDPSC-approved adders.

"Wholesale electricity prices have one major driver: cold weather patterns, up to 35% of the residential rate…".

Example #3: Looking into the Future

#	Mechanism	Captures	Type
1	Annual energy budget	SLA / availability target	LP
2	Curtailment depth cap	Throttling, not blackout	LP
3	Load shifting (deferral)	AI training workloads	LP
4	Time-of-day restriction	Peak-only curtailment tariffs	LP
5	Tiered flexibility classes	Workload heterogeneity	LP
6	Max consecutive hours	Event-duration limits	MIP
7	Minimum recovery time	Event-frequency limits	MIP
8	Notification / ramp	Physical response constraints	LP

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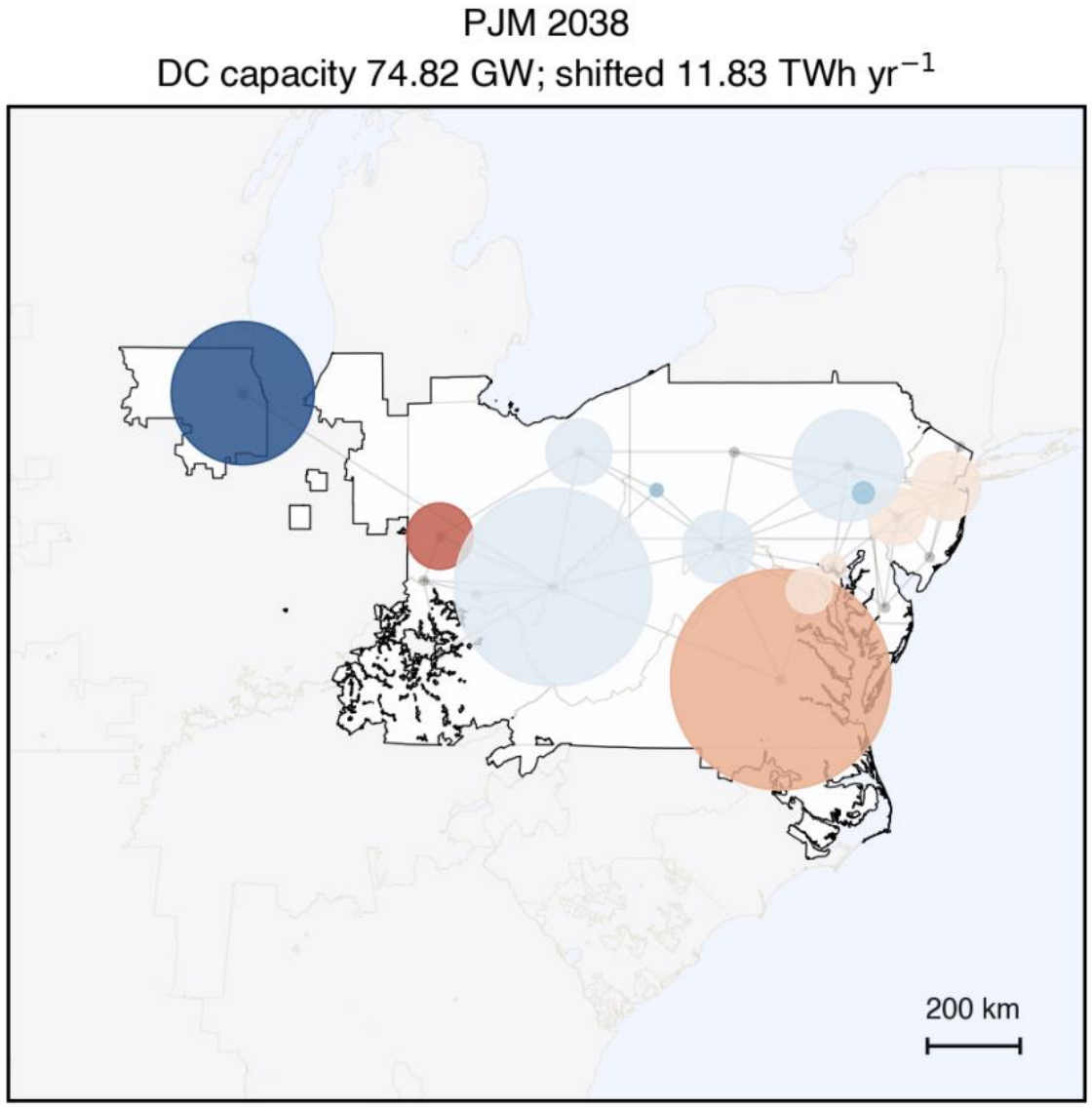
Different modes of flexibility lead to different planning and cost outcomes, which lead to different impacts on consumers

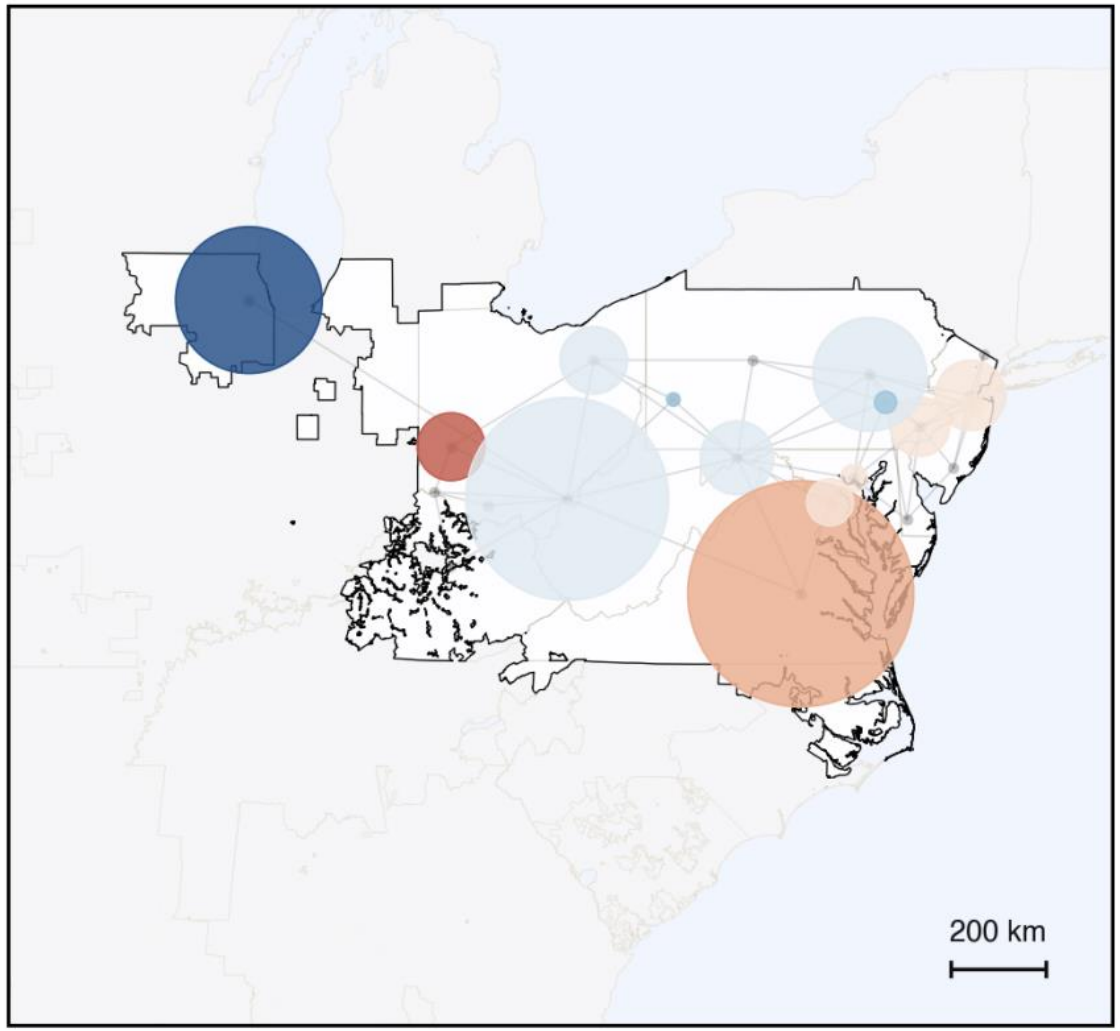
Example #3: Looking into the Future



Example #3: Looking into the Future

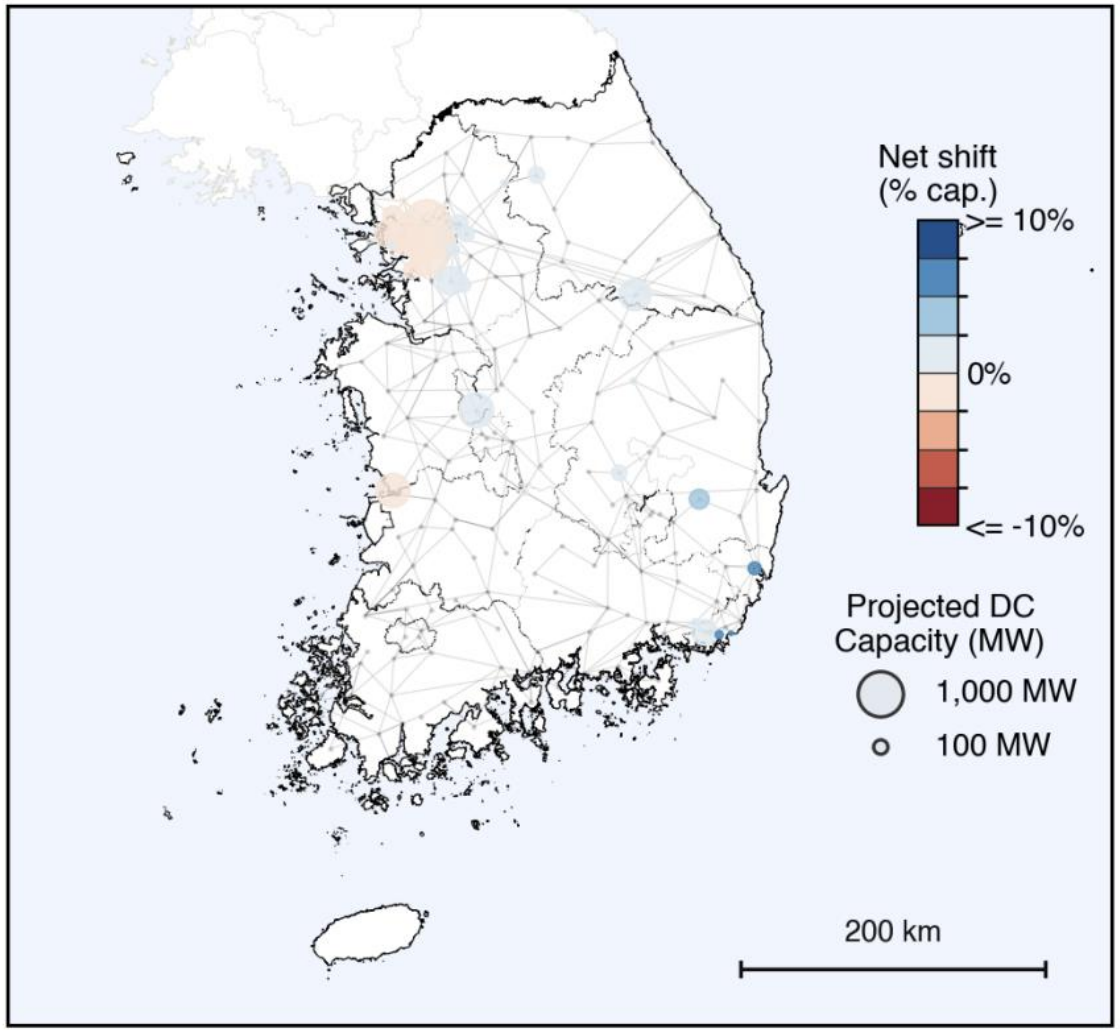
PJM 2038

DC capacity 74.82 GW; shifted 11.83 TWh yr^{-1}



Korea 2038

DC capacity 8.90 GW; shifted 0.25 TWh yr^{-1}



Example #3: Looking into the Future

	PJM (S2, 2038)				Korea (S2, 2038)			
Metric	Firm	Flex	Inter	Real.	Firm	Flex	Inter	Real.
Total cost ($B)	96.15	−25.49%	−49.70%	−19.43%	30.00	−5.20%	−21.30%	−3.31%
Investment ($B)	15.62	−37.51%	−60.44%	−53.10%	13.59	−7.90%	−17.27%	−5.41%
Operation ($B)	37.14	+3.91%	−51.47%	+5.83%	16.41	−4.39%	−24.63%	−2.34%
Non-Compliance ($B)	43.39	−46.59%	−44.32%	−29.23%	∼0	∼0	∼0	∼0
Deferred (TWh)	∼0	7.70	∼0	10.35	∼0	23.33	∼0	12.47
Spatial shift (TWh)	∼0	18.56	∼0	11.83	∼0	0.54	∼0	0.25
Interrupted (TWh)	∼0	∼0	655.40	6.55	∼0	∼0	77.69	0.78

- Flexibility cuts cost in both systems, but in PJM it is fundamentally driven by space shift
- The PJM binding constraint, not its size or growth rate, decides which mechanism creates value
- Flexibility policy and accreditation must be system-specific - there is no universal "demand-response" archetype.

Efficient, Reliable, Resilient and Clean Grid is Bigger than Modeling

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- **ROSEI** was established in 2021
- **EPICS**, **Earthshot** started in 2023
- **ARROW** started in 2024

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