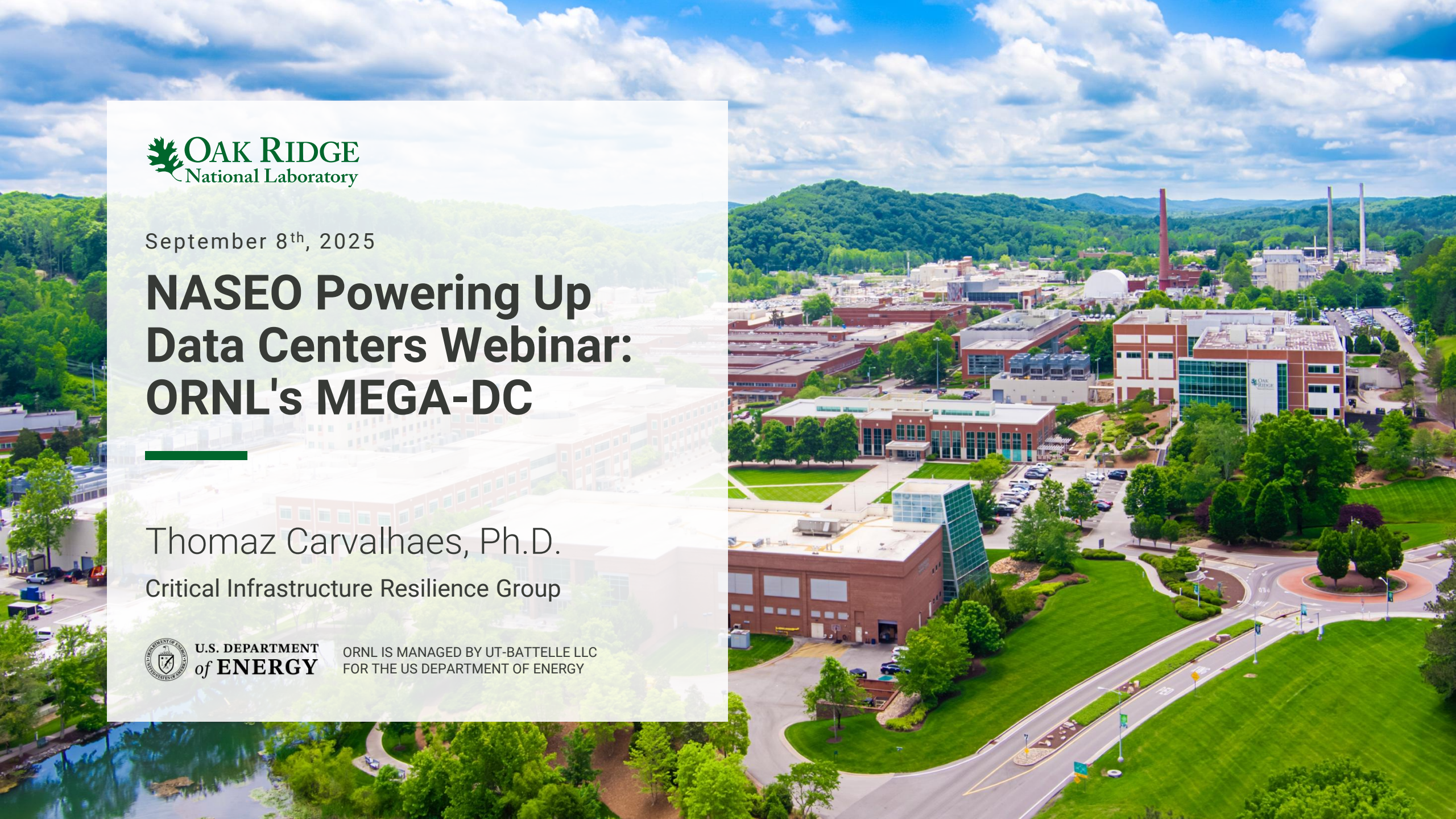


OAK RIDGE National Laboratory

September 8th, 2025

NASEO Powering Up Data Centers Webinar: ORNL's MEGA-DC

Thomaz Carvalhaes, Ph.D.

Critical Infrastructure Resilience Group

U.S. DEPARTMENT of ENERGY

ORNL IS MANAGED BY UT-BATTELLE LLC
FOR THE US DEPARTMENT OF ENERGY

Agenda

- Introduction to CIR
- MEGA-DC Overview
- Q&A

(U)

CUI//SP-CEII/SP-PROPIN/SP-PRVCY

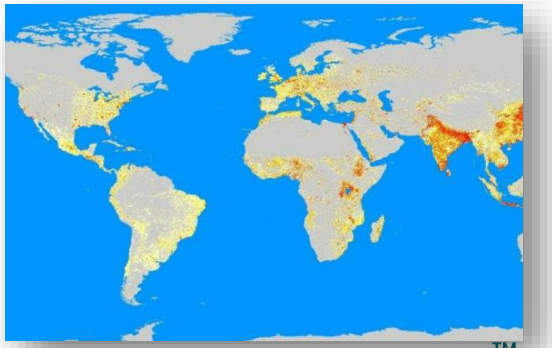
National Security Sciences Directorate Global Impact

National Security Sciences Directorate

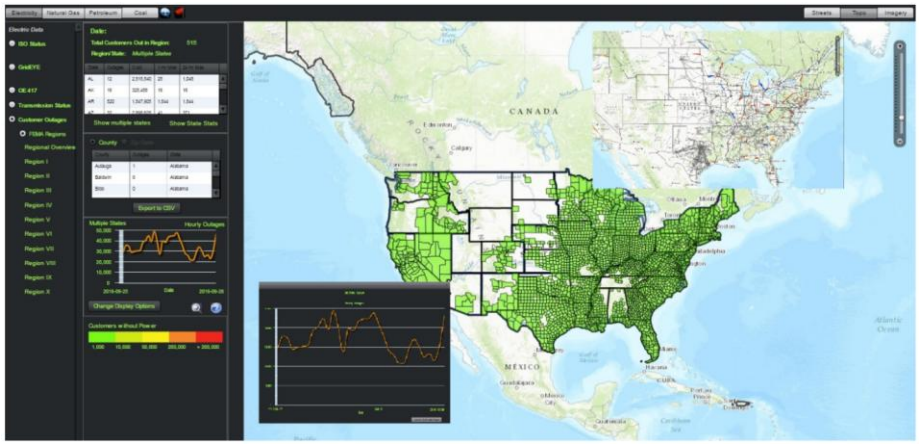
Geospatial Science & Human Security Division

Human Dynamics Section

Critical Infrastructure Resilience Group



LandScan™

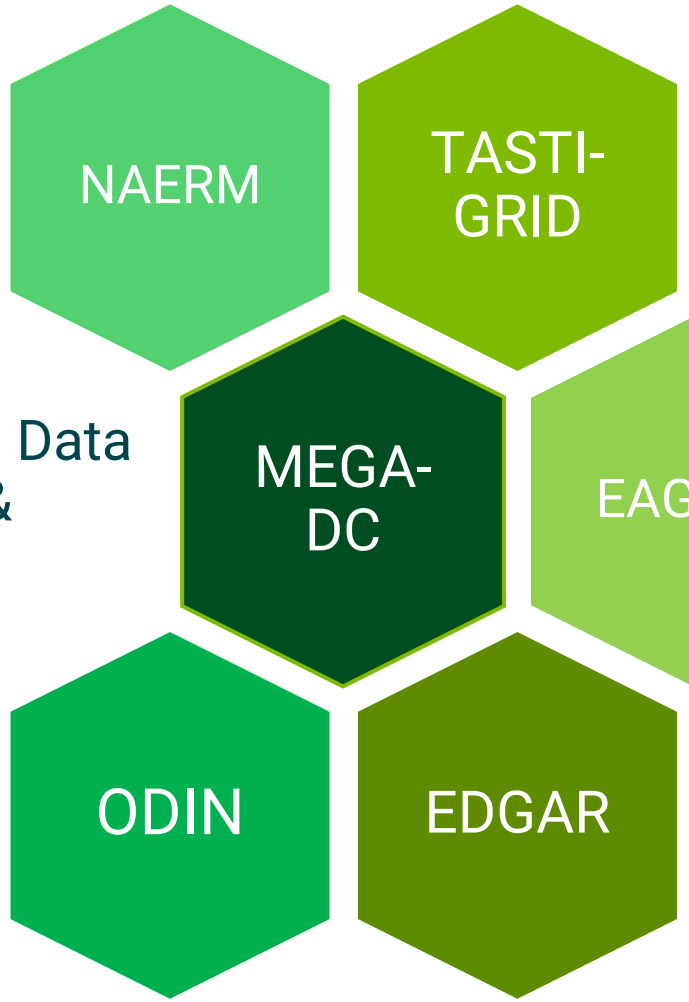


EAGLE-I

GSHSD Capabilities

- *High-Performance Geocomputation*
- *Human Dynamics Modeling and Simulation*
- ***Critical Infrastructure Resilience***
- *Remote Sensing and Autonomous Systems*
- *GeoAI for Mapping and Monitoring*

Intertwined Resilience Projects

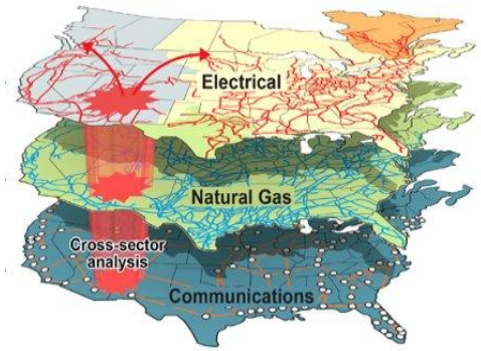


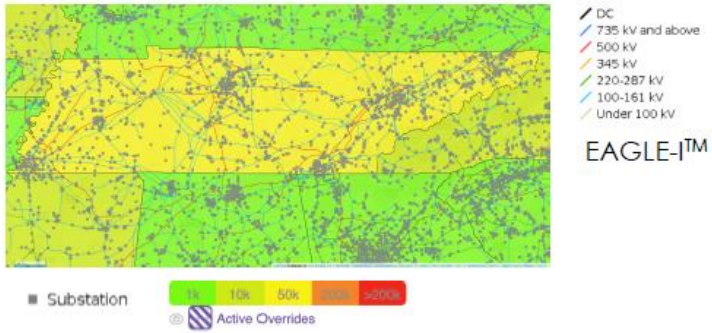
Technical Assistance to States & Tribes

Modeling Data Centers & Power

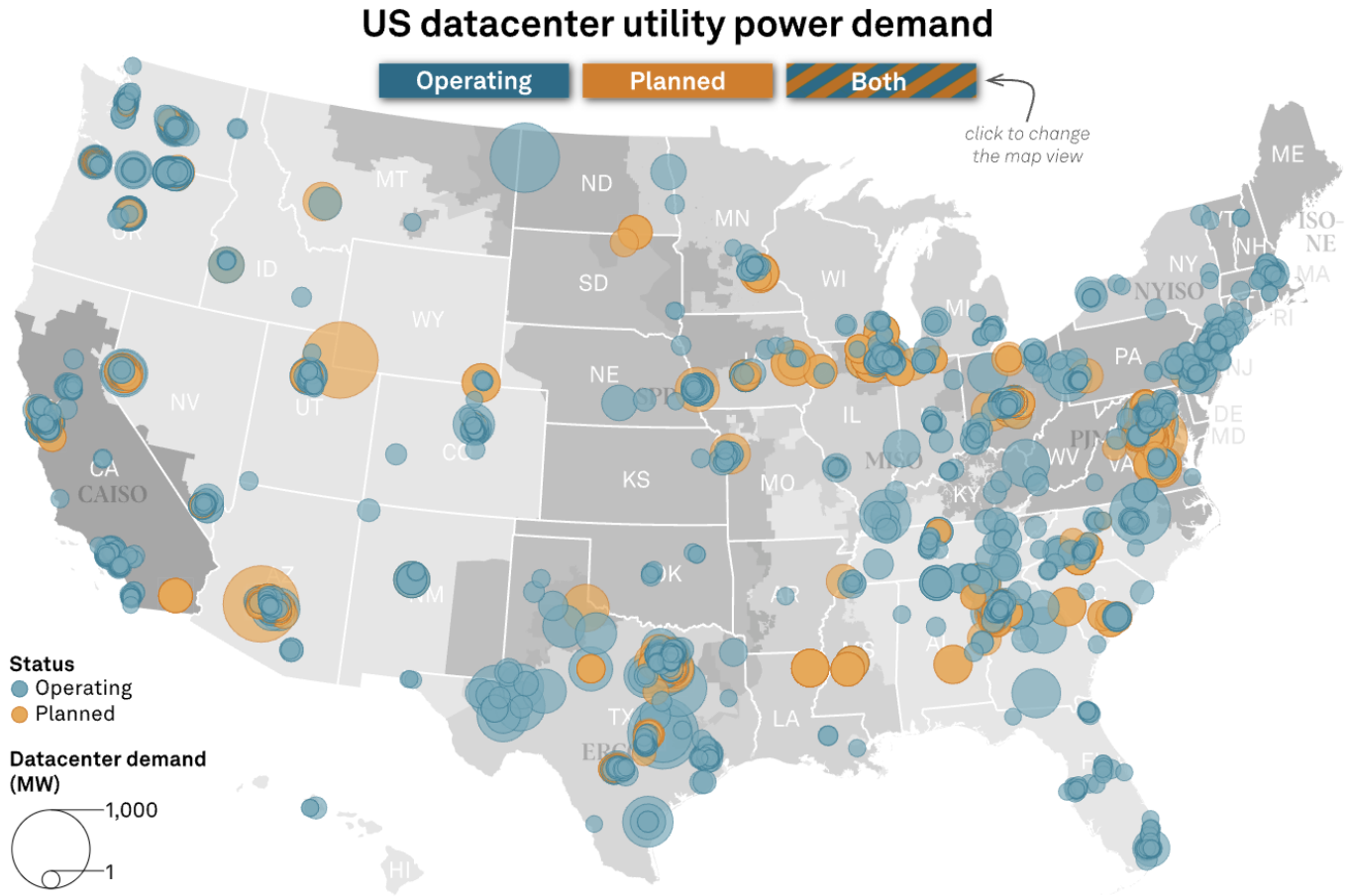
Outage Data Initiative Nationwide

Resilience-as-a-service





Latest S&P Global Update July 2025

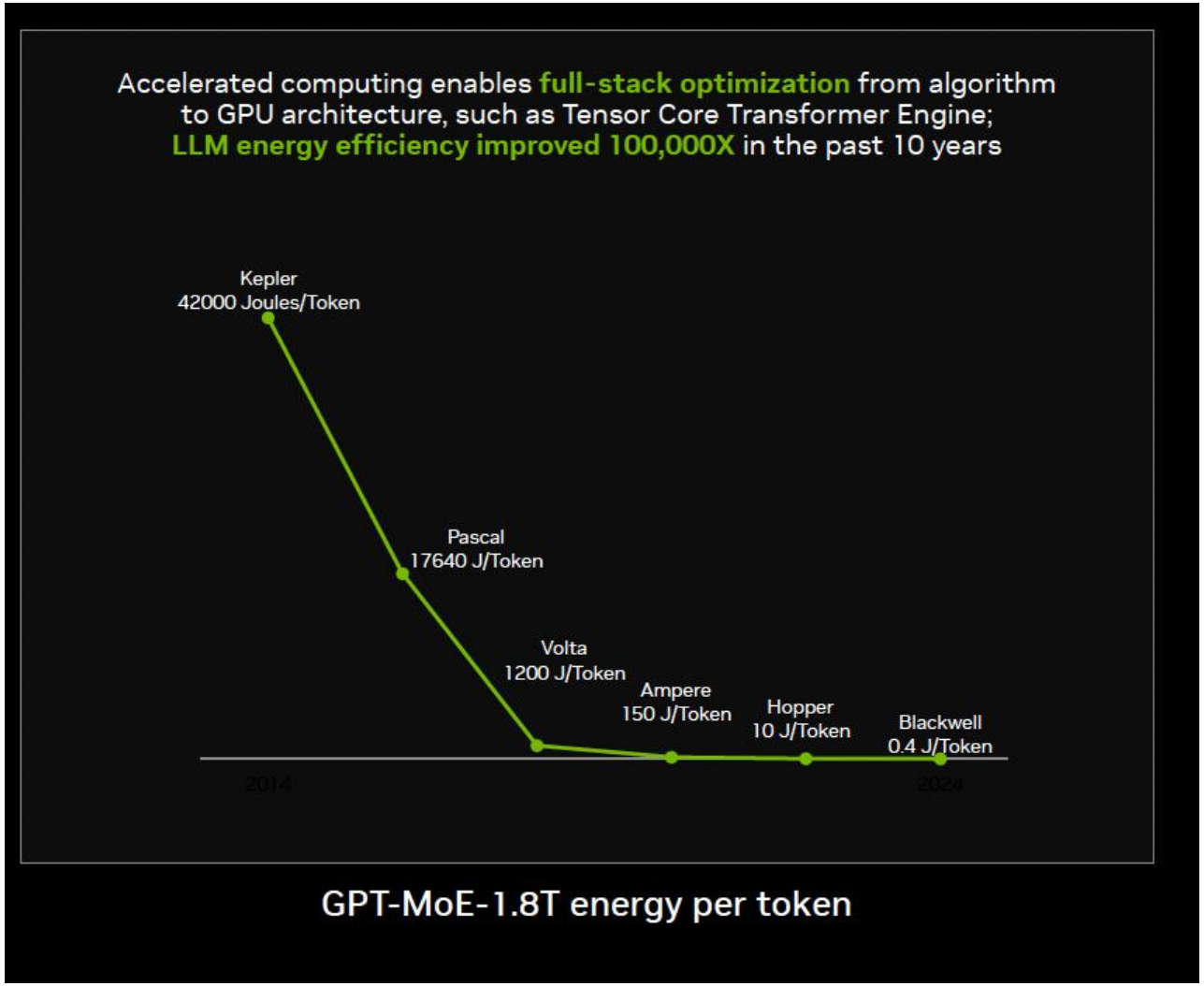


Data compiled June 23, 2025.
Includes operating and estimated datacenter campus demand with at least 1 MW of utility power demand; excludes datacenters with no available utility power demand figures. Includes city-centric geographic locations.
Excludes enterprise-owned datacenters with the exception of Meta, Google, Microsoft, Amazon and Apple.
Source: S&P Global Market Intelligence 451 Research; Q1 2025 Datacenter Knowledge Base.

https://www.spglobal.com/market-intelligence/en/news-insights/articles/2025/7/us-datacenter-power-draw-to-double-by-2028-states-tackle-cost-supply-concerns-91382267?mkt_tok=NTY1LUJETy0xMDAAAAGcGcTJjRQwRf_zf648zMnlQw-3iglAmbXQFhQhbdGvYUArkaKeAWr2np9sTjB1IDx2kHInX_nxcieIMe7mang5vjcvxIhSdRhzYlUy4tTkPuis5BijDA

Thinking deeper about load growth root causes…

- Huge Quarter for NVIDIA
- Energy Affordability concerns now a mainstream worry around data center load growth
- Pacifico energy makes the first move-major BTM 5GW hyperscaler announcement with ERCOT (https://www.pacificoenergy.com/post/pacifico-energy-announces-gw-ranch-project-bringing-5-gigawatts-of-reliable-off-grid-power-for-ai-i)
- Is the market overheated and heading to a correction at some point? https://www.cnbc.com/2025/08/18/openai-sam-altman-warns-ai-market-is-in-a-bubble.html



Empowering decision-makers to anticipate and guide decision making through actionable insights.

Executive Summary- MEGA-DC

Our team's core capabilities include:

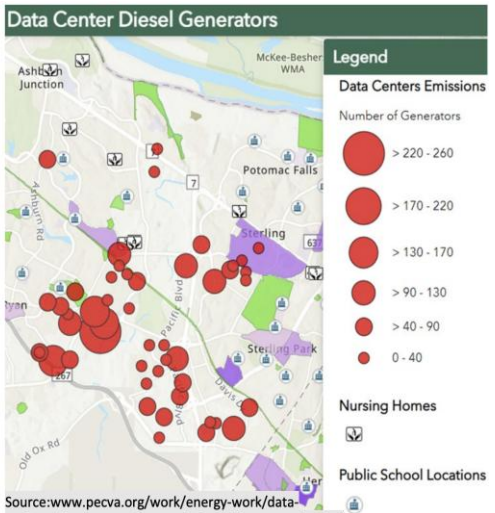
- **Geospatial conflation & modeling**
- **Land-use policy, rural & tribal governance**
- **Urban planning**
- **Data Center feasibility and siting**
- **Energy affordability analysis & modeling**
- **Data Center Digital Twin- Grid cognisance and grid orchestration enablement of data centers**
- **Load forecasting for states- energy surplus/reserve modeling**
- **Transmission capacity modeling with large loads**

Added benefit of extensive knowledge of states's policy landscape, and complex social, tech, environmental, economic, and political drivers of change.

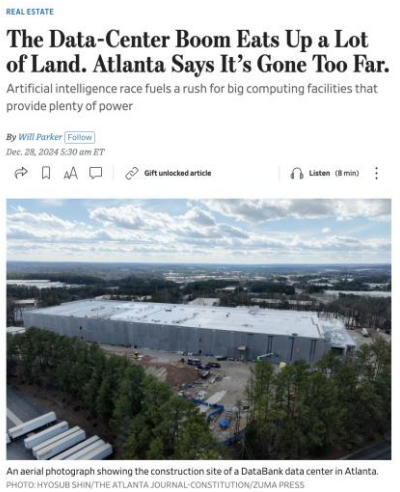
This comprehensive insight will enhance our efforts in State and create meaningful collaboration.

What's the threat?

- 24% of Dominion Energy's electric sales
- delayed retirement of three coal facilities
- new gas facilities proposed by utilities and behind-the-meter at data center sites
- over 4,000 diesel generators permitted as backup power in northern Virginia
- Loudoun Water disclosed that potable water consumption by data centers has now surpassed reclaimed water usage
- Loudoun Water disclosed a 250% increase in potable water consumption from data centers in the last 4 years



Source:www.pecva.org/work/energy-work/data-centers-diesel-generators-and-air-quality-pec-web-map/


REAL ESTATE

The Data-Center Boom Eats Up a Lot of Land. Atlanta Says It's Gone Too Far.

Artificial intelligence race fuels a rush for big computing facilities that provide plenty of power

By Will Parker Follow
Dec. 28, 2024 5:30 am ET

Gift unlocked article | Listen (8 min)

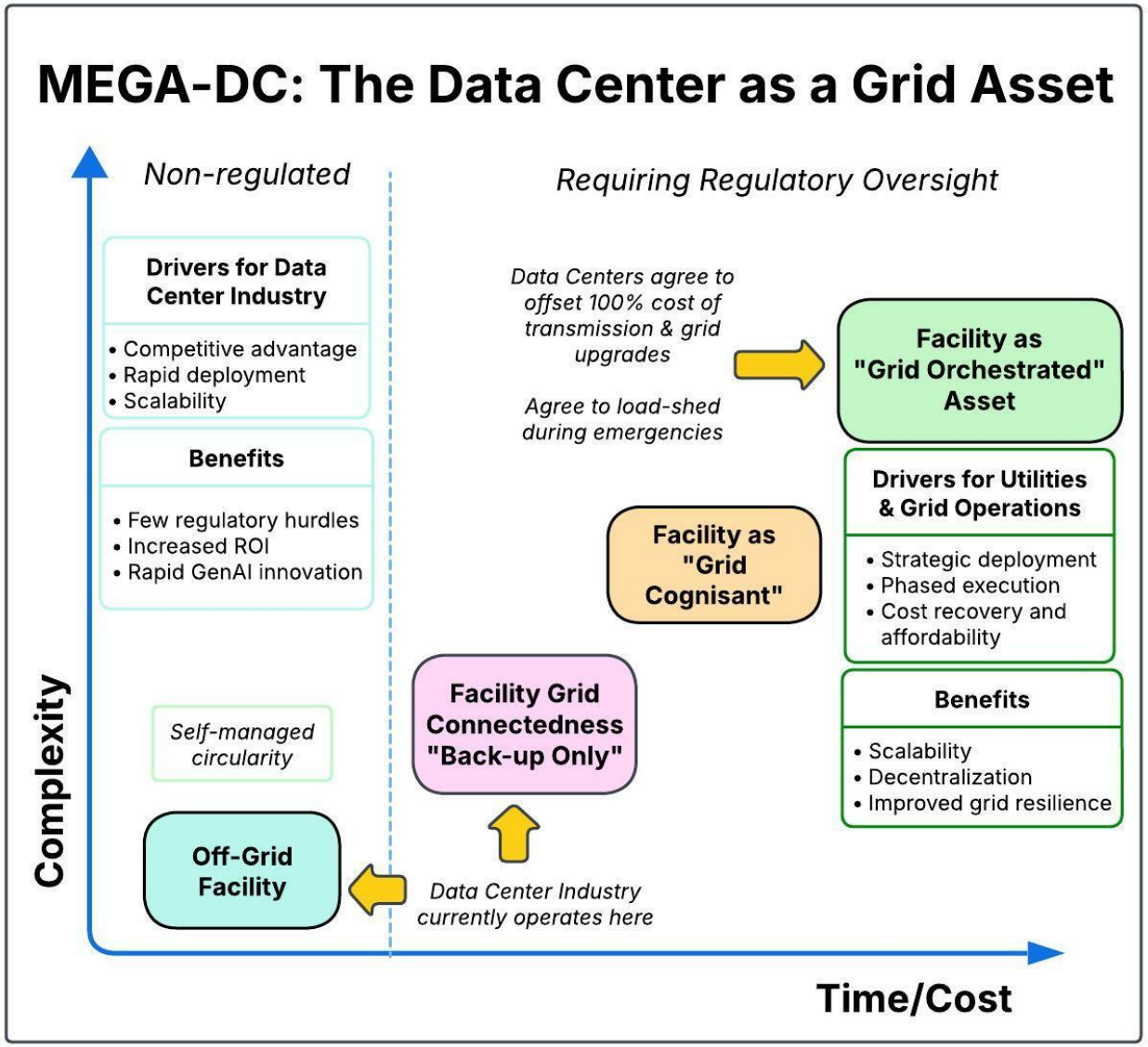
An aerial photograph showing the construction site of a DataBank data center in Atlanta.
PHOTO: HYOSUB SHIN/THE ATLANTA JOURNAL-CONSTITUTION/ZUMA PRESS

https://www.wsj.com/real-estate/data-center-land-use-atlanta-georgia-bd6a2f93

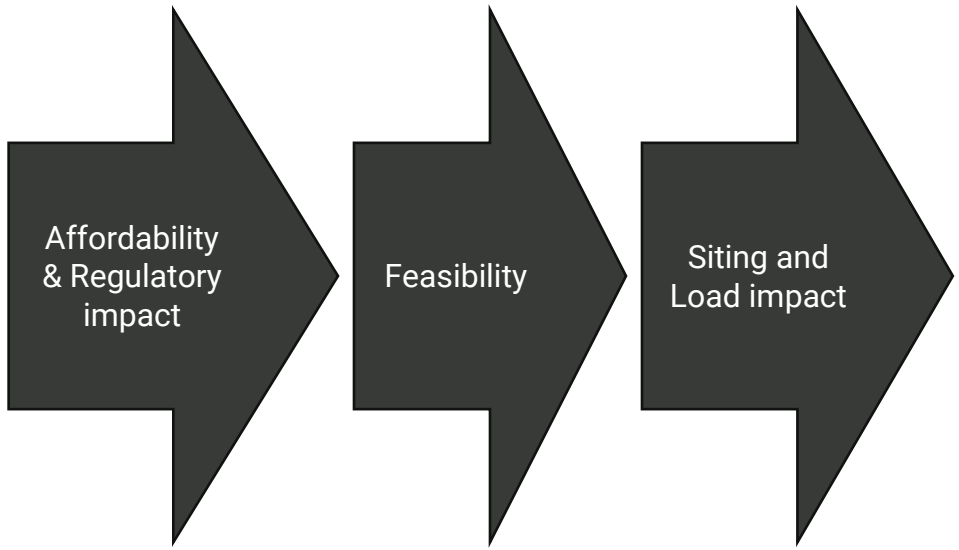
Are we ready for >1GW behind the meter commercial Data Centers?

Data Centers as a Grid-connected Asset

- **Most data centers today** operate as passive grid loads: MEGA-DC models the shift toward coordinated, grid-supportive infrastructure.
- **Backup-only and off-grid models** limit transparency and shift upgrade costs to ratepayers.
- **Grid-cognizant sites** coordinate with utilities but lack full flexibility or cost-sharing.
- **Grid-orchestrated data centers** support demand response, offset grid upgrade costs, and improve system resilience.
- **MEGA-DC helps states identify and prioritize sites** that move toward this high-value integration.



What is the MEGA-DC team working on?



Tasks 1 & 2	**Platform capabilities in development**	• Modeling attributes like: electricity, gas, water, real estate, prices, data center existing site load and new site feasibility, grid reliability & resilience, etc. • **Affordability modeling** - state level analysis across the utilities, narrow to county level across all counties. Modeling an Affordability Index for new data center feasibility
Task 3	**Digital Twin work initiated**	• Individual Data Center load intensity and aggregation • Aggregate Data Center(s) Feasibility study by state/county • Enable intelligent feasibility and siting decision based on affordability and other tradeoffs at a parcel level • Leveraging the AI task disaggregation work at ORNL to **create grid cognizant and orchestrated data centers** • Understand upstream generation/transmission cost impacts and need for new builds • Advise states on regulatory insights
Tasks 4 - 6	**Transmission and Distribution Energy Load Growth Modeling**	• Distribution side load aggregation and hosted load capacities • Transmission side energy reserves modeling

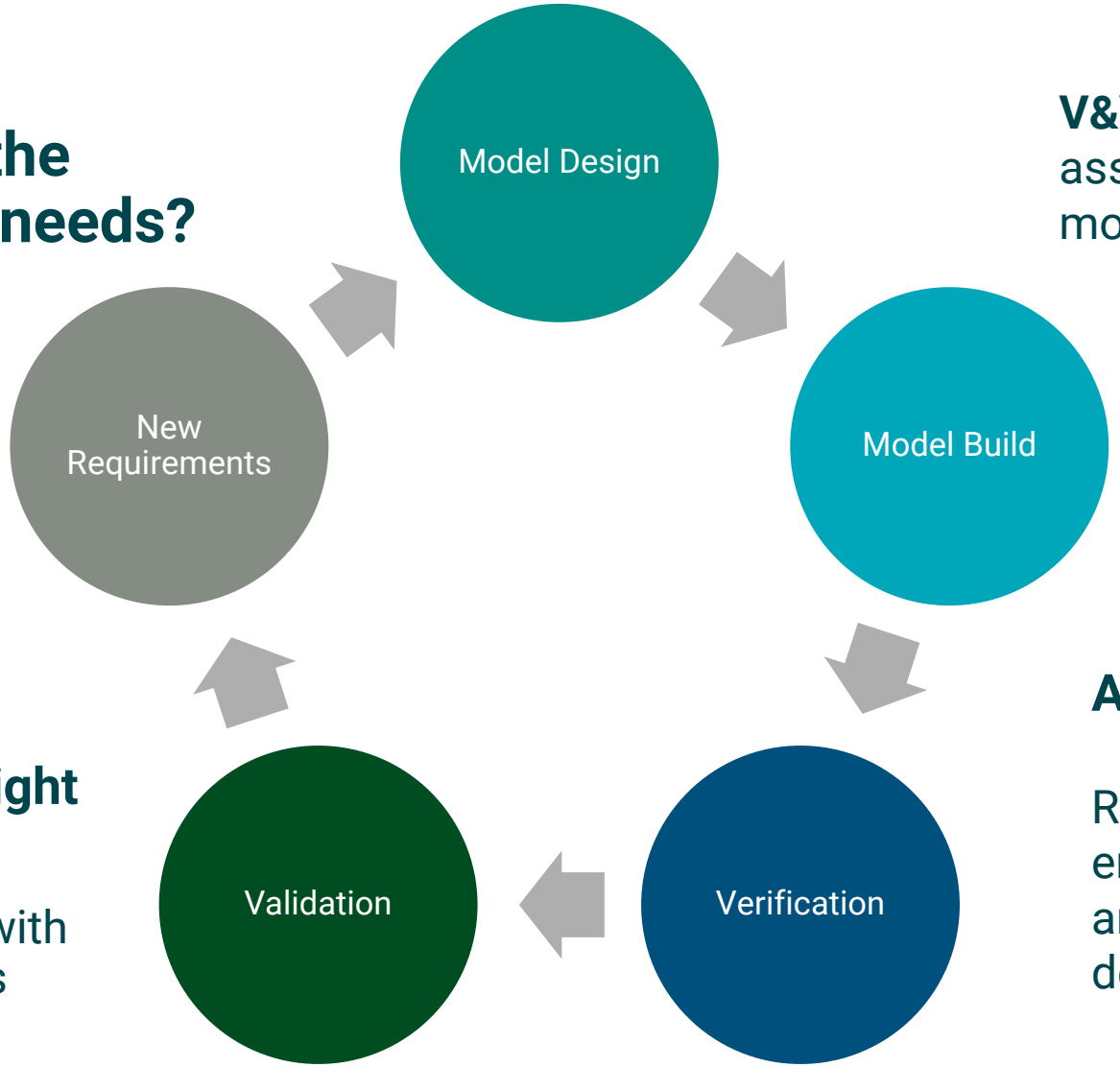
Enable strategic tradeoff analysis between energy affordability and incentives that trigger proliferation of data centers

Tasks 1-2: Data Center Dimensions

Dimensions	Criteria
Land Availability & Workforce	Buildable Land
	Environmental Hazards
	Workforce & Laborshed
Infrastructure Robustness	Power Availability + Reliability
	Connectivity & Network Infra.
	Fuel Supply for Back-up Gen.
	Water Accessibility
Regulatory Burden	Regulatory Environment
	Econometrics & Pricing

Task 2: Verification and Validation as an iterative process

What are the customer needs?



V&V Products: Documentation of V&V assessment in spreadsheets, code, model description document

Are we building the system right?

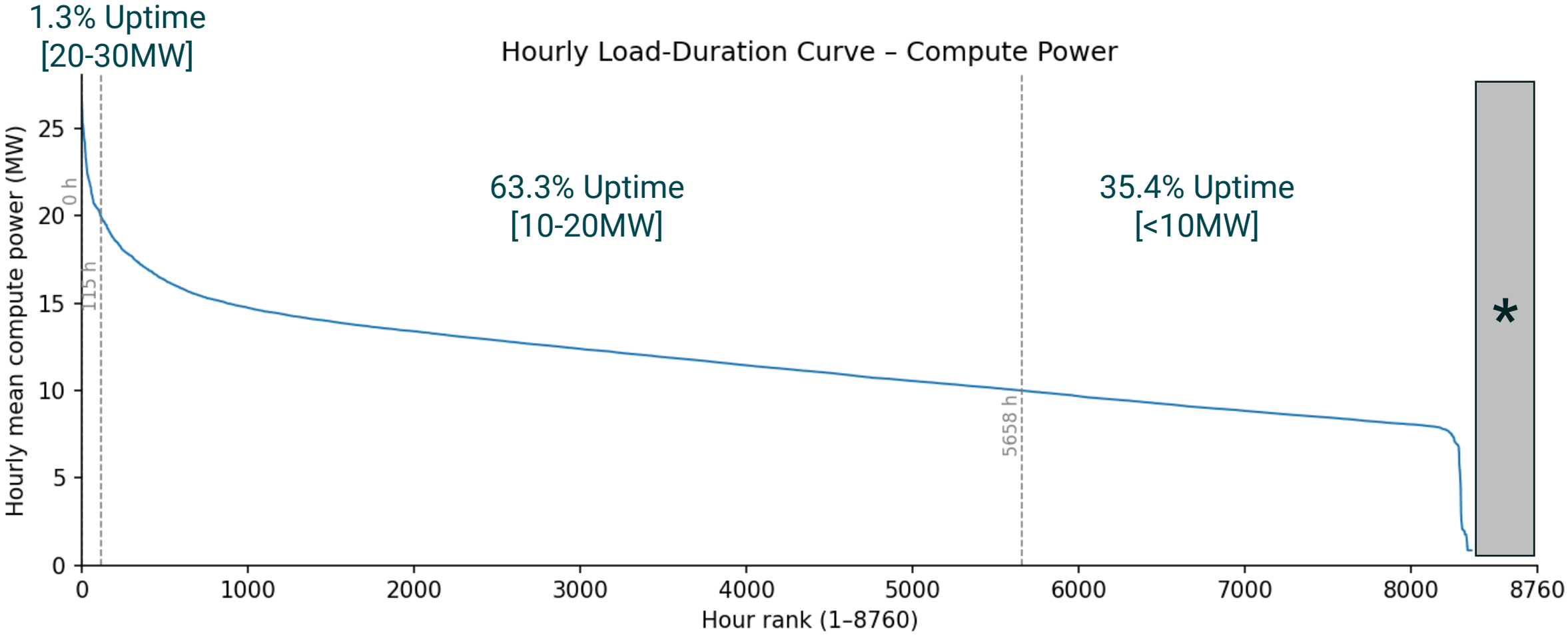
Review all datasets and code to ensure the data inputs are correct and the code is doing what we designed

Are we building the right system?

Confirm model results with alternative data sources and expert review

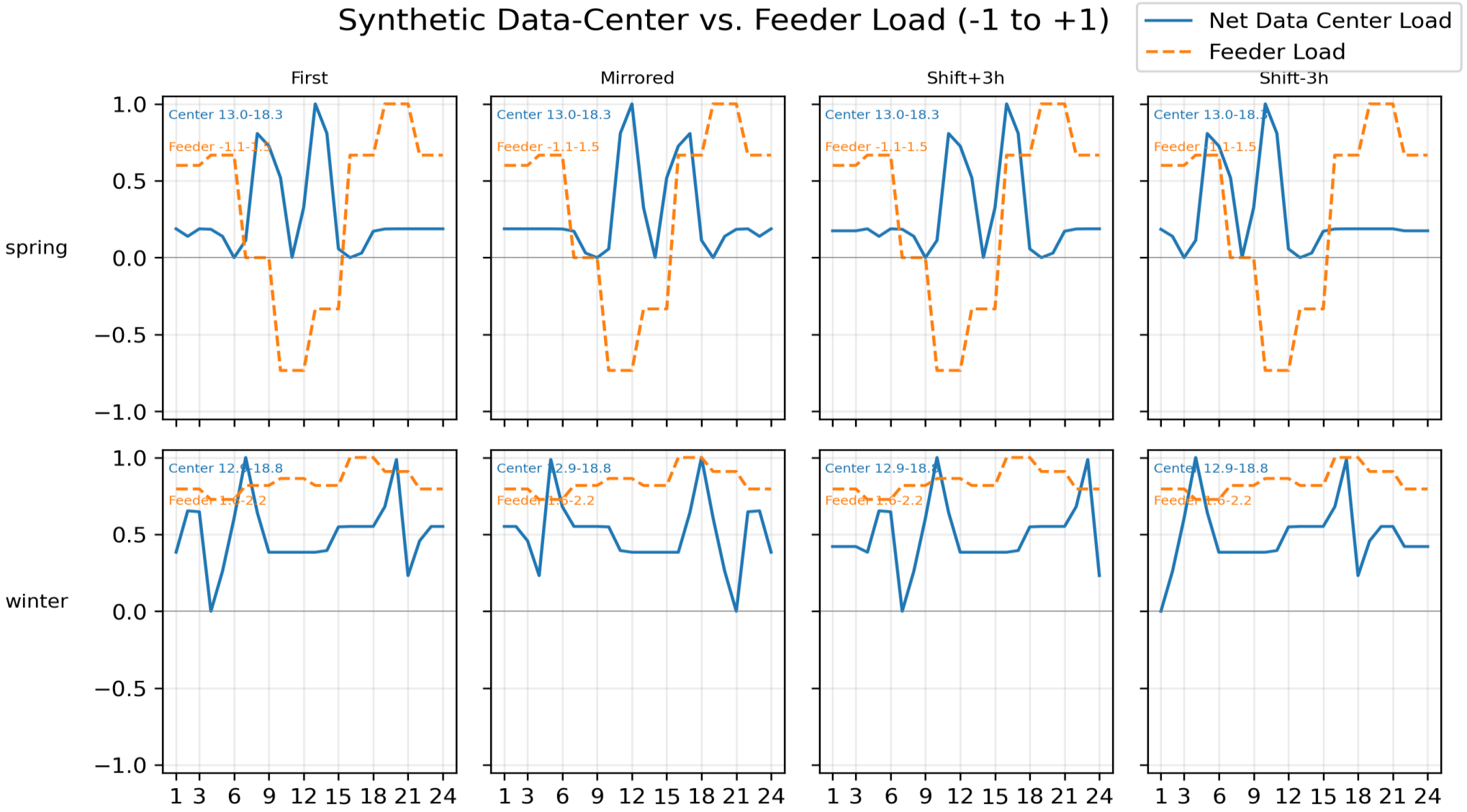
Fundamental Foundation of V&V

Task 3: Frontier Load Duration Curve Baseline Data Center



*Approximately 440 hours of data over the entire year were lost due to planned maintenance and unplanned downtime of Frontier HPC and data acquisition systems. These intervals account for less than 5% of Frontier's operating time.

Task 3-4: Synthetic Data Center Profiles



Stage 1: County-level Feasibility Framework

County level variables such as impact duration, consumer sentiment ….

Data Dev & Curation

variables

eia

United States Census Bureau

Utilities

Regulators

Consumer Sentiment

TASTI- GRID Resilience

Database

Prices, Current affordability

Affordability Engine

1. Electricity affordability model
2. Gas affordability model
3. Water affordability model
4. Rent affordability model

Affordability indices

Feasibility Optimization

Bench Marking

Pareto Optimization

Scalarization

Change in affordability for consumer

Reserve

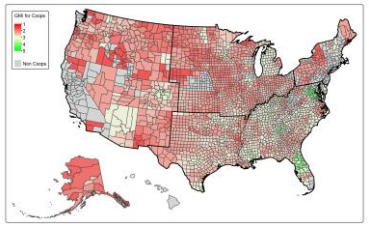
User Input (Scenario)

Δprice

Web Interface

Web page

Optimized locations



Grid-level Optimization

Data center load creation

Grid Allocation

Run Simulations

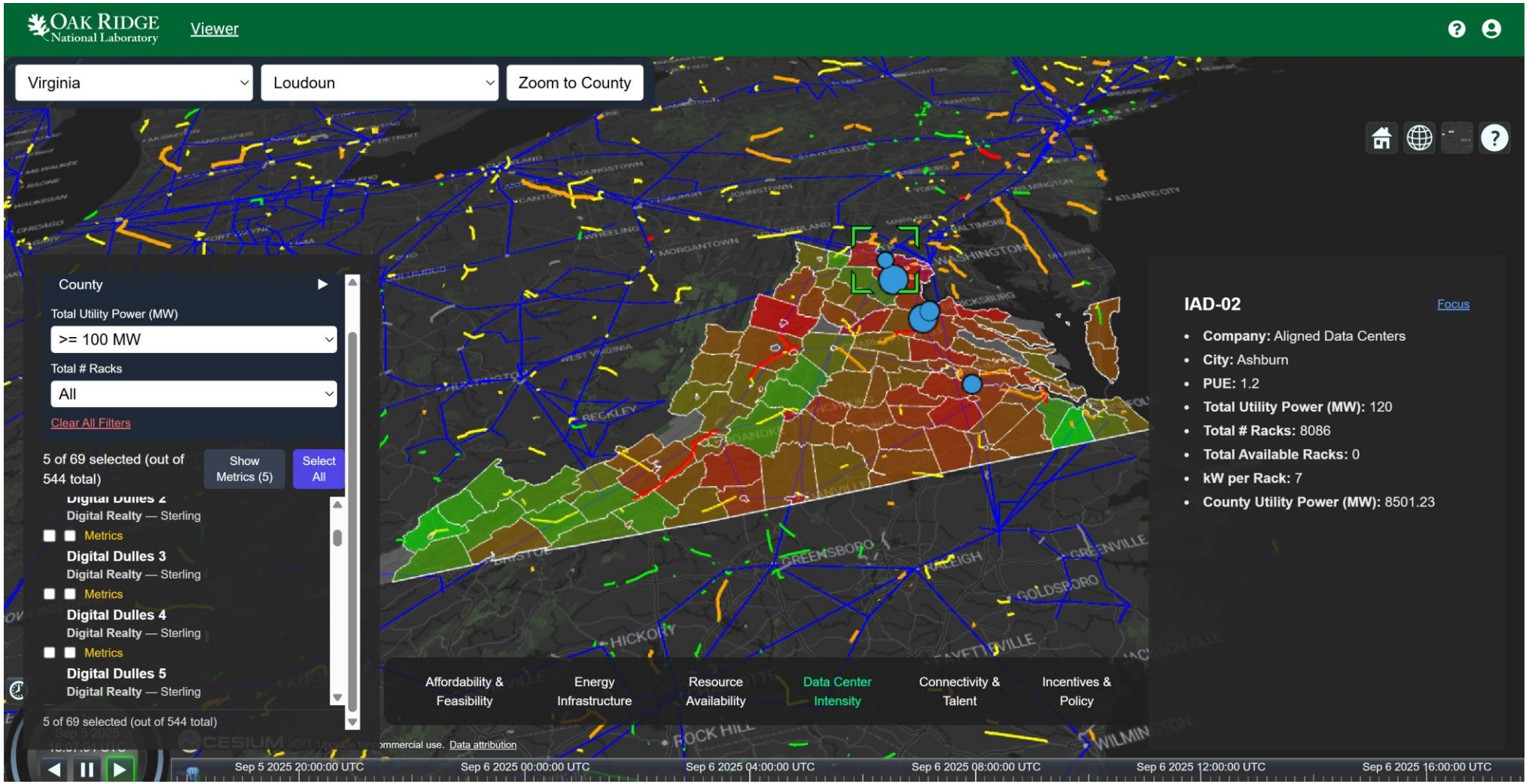
Validation

The feasible places provided by the algorithm are validated by the ORNL state experts

+

External advisor board

MEGA-DC Web Platform



MEGA-DC Advisory Board- Data Centers

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Thanks!

Questions & Comments

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