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[redacted]

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Calvin Huggins
Legislative Clerk
Committee on Energy and Commerce
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Washington, DC 20515
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Dear Mr. Huggins:

Thank you for the opportunity to respond to additional questions for the record following the March 5, 2025 hearing, "Scaling for Growth: Meeting the Demand for Reliable, Affordable Electricity." Please find my responses to the questions submitted by Members of the Subcommittee on Energy below, which I am submitting in my personal capacity and not on behalf of Duke University.

Sincerely,

Tyler H. Norris

Attachment

<u>The Honorable Robert E. Latta</u>

1. **We all agree on the importance of modernizing our infrastructure to ensure we reliably get power to AI data centers. As the co-chair of the Grid Innovation Caucus, I am interested in grid enhancing technologies that improve the performance of the transmission system. An example is the use of advanced power conductors that can double capacity of the grid using the same right of way.**

    a. **Can you please comment on this approach to ensure we get the most out of the current grid by deploying modern technology?**

Thank you for highlighting the important role of Grid-Enhancing Technologies (GETs), including advanced power conductors. As you know, these technologies are a linchpin for increasing the utilization of both the existing grid and the new transmission infrastructure we're building. As I noted in my testimony, our power system is dramatically underutilized in most hours – meaning that smarter use of our existing assets is one of the fastest and most cost-effective ways to integrate new load and generation and improve reliability. GETs such as Dynamic Line Ratings (DLR), Advanced Power Flow Controllers, and topology optimization tools allow operators to safely increase transmission throughput without new rights-of-way or lengthy siting processes. For example, DLR systems that integrate real-time weather and line condition data can unlock significant latent capacity on existing lines, especially during peak renewable production hours.

In addition, emerging operational technologies and practices such as Dynamic Contingency Management (DCM) have significant potential but have received less attention compared to other GETs. Traditionally, transmission systems are operated with substantial unused capacity to preserve N-1 reliability – ensuring that if one line fails, customers aren't affected. DCM allows operators to safely utilize more of the grid's existing capacity under normal conditions by providing a real-time "contingency buffer." Through intelligent software and fast-response coordination with inverter-based resources, flexible loads, and storage, DCM enables operators to manage contingencies dynamically, rather than relying solely on physical redundancy.

This approach has already been successfully deployed. For example, in the Calama region of Chile, DCM implemented by the company Splight reportedly increased system throughput by more than 100%, saved an estimated $3.4 million in one year, reduced renewable energy curtailments, avoided nearly 18,000 tons of CO_2 emissions, while preserving N-1 reliability. These systems operate in real time, leveraging digital twins, remote telemetry, and millisecond-level control of participating resources.

To fully unlock the latent capacity enabled by GETs and flexible grid operations, complementary steps will be necessary, including but not limited to:

- <u>Creation of new interconnection and transmission service tiers</u>: In FERC Docket No. EL25-49, PJM and stakeholders are exploring the need for new service classes for large co-located loads, such as data centers, that are willing to accept curtailment or flexible operating parameters. These kinds of fit-for-purpose service products can accelerate access to existing grid capacity while preserving fairness and system reliability. They also align with the operational models enabled by DCM.

- <u>More widespread and standardized participation of flexible loads</u>: One critical enabler will be adoption of interoperability standards such as OpenADR, which allow utilities, ISOs, and building or industrial loads to exchange dynamic price and reliability signals in a uniform way. Broader adoption of OpenADR will reduce integration costs, prevent stranded assets, and help scale demand-side flexibility as a system resource.

Broader deployment of GETs, particularly when paired with flexible service arrangements and standardized communications, represents one of the most promising frontiers for modernizing the grid. These tools allow us to maximize existing infrastructure, reduce costs and timelines for interconnection, and expand access for emerging electricity demands such as AI data centers, without compromising reliability.

2. **The report that you co-authored, and referenced in testimony, concludes that 76 GW or 98 GW of headroom may be available (depending on assumed level of load curtailment). This analysis is premised on real-time operations as opposed to long-term planning. The report states that the analysis does not include real-time operational factors: "The analysis does not consider the technical constraints of power plants that impose intertemporal constraints on their operations (e.g., minimum downtime, minimum uptime, startup time, ramping capability, etc.) and does not account for transmission constraints."**

    a. **Why were these constraints excluded, and do you have any sense on how they may affect the ultimate conclusion in the report if they were included?**

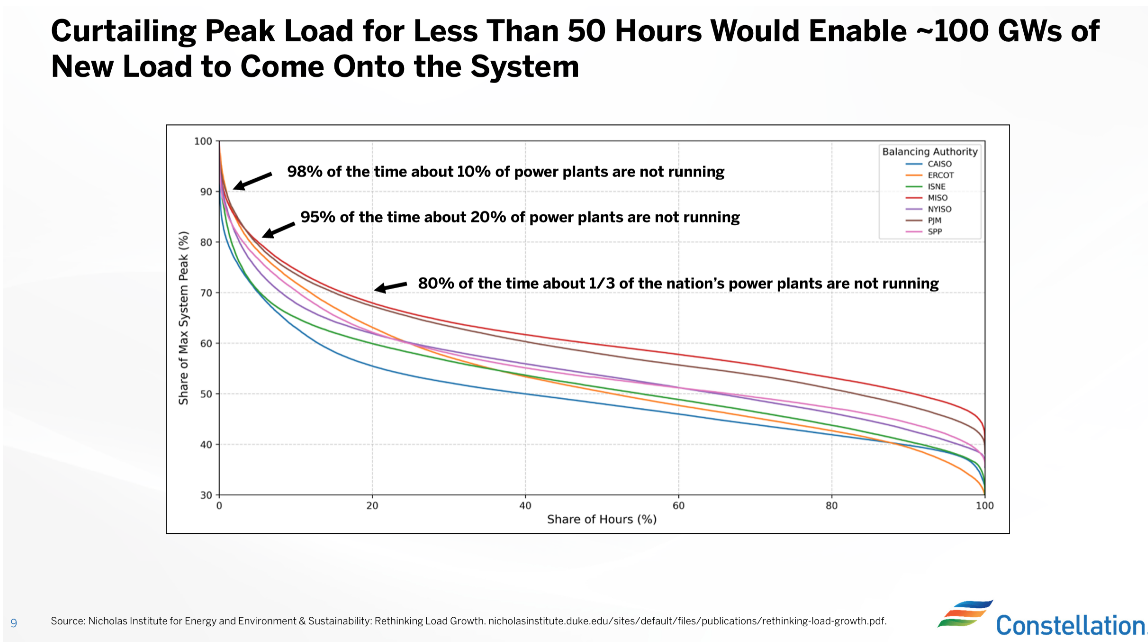
Our analysis was intentionally scoped as a first-order assessment of potential headroom that exists on the U.S. grid in most hours, based on reasonable simplified assumptions that could be scaled across 22 balancing authorities to offer an estimate of national technical potential. This approach was chosen because developing realistic simulations of hourly or sub-hourly grid operations, complete with unit-level constraints, reserve requirements, and network flows, would have required substantially more time and computational resources than was feasible within the scope and timeline of the project. We judged it more valuable, given the urgency of the load growth challenge, to deliver a timely analysis that could identify where the grid may be underutilized and where further investment in flexibility or modeling is most warranted.

While we expect some reduction in estimated headroom when adding intertemporal and transmission constraints, other factors may push in the opposite direction. These include reserve capacity not counted in our first-order estimates, potentially lower actual peak loads than assumed, and non-constant load shapes that may reduce the absolute MWh of curtailed load. To illustrate this interplay, our team recently conducted a more detailed simulation for the combined Duke Energy Carolinas and Duke Energy Progress systems. This analysis incorporated intertemporal constraints of thermal generators and pumped hydro storage and identified nearly twice as much headroom as our first-order estimate. However, that same simulation did not fully account for the average rate of planned and unplanned generator outages, underscoring how modeling choices can push results in either direction. Localized transmission constraints are likely to be the most binding limitations in some areas, particularly if large new loads are highly concentrated rather than dispersed. Ultimately, while we expect some downward adjustment to headroom estimates in some areas as more detailed simulations are performed, we also anticipate that flexibility, on the part of new loads and the grid itself, will be a substantial offsetting force.

    b. **Given the exclusion in the report of key planning considerations such as ensuring adequate transmission capacity, ramping capacity, and ramp-feasible reserves, should policymakers take away from this study a conclusion that, in concept, certain grids in the United States may have headroom to accommodate new loads?**

Yes – with sufficient load flexibility, policymakers can confidently conclude that many U.S. balancing authorities can accommodate substantial new demand with the infrastructure already in place. As Constellation Energy CEO Joseph Dominguez stated during the company's recent Q1 2025 earnings call, "In most hours, we dramatically underutilize the grid… Eighty percent of the time, one-third of the grid isn't being used. That means we have plenty of room in most hours to accommodate new [load]."[1] Mr. Dominguez presented a figure from our report (Figure 1 below) and further noted, "Demand response is an incredibly powerful tool to meet all this new data center demand. What it will do is utilize the slack in the system and cover those peak hours where there is a gap."

Figure 1: Constellation Energy Corporation Q1 2025 Earnings Call, Presentation Slide #9



c. What additional work is being done to examine this "headroom" potential?

Our research team at Duke's GRACE Lab is currently conducting more detailed simulations of individual balancing authorities using enhanced modeling techniques. This analysis will utilize modeling frameworks developed by GRACE Lab with support from the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) and build on GRACE Lab's existing protocol for constructing realistic representations of power plants, transmission networks, and load distribution based on publicly available data. We anticipate sharing updated findings over the next year and would be pleased to brief your office and the House Energy & Commerce Committee when results are available.

d. In terms of analyzing headroom and maximizing the benefit of investment within this headroom or to meet incremental needs, is an integrated utility planning construct the best way to evaluate such investments for generation and related infrastructure?

Integrated planning frameworks, such as the Integrated Resource Planning (IRP) process used by vertically integrated utilities, can be valuable tools for aligning infrastructure investments with long-term load growth. They offer a structured approach for assessing generation needs, reserve margins, and transmission expansion.

That said, vertically integrated models are not the only structures capable of addressing growing demand. In ISO and RTO markets, system operators often play a role in assessing reliability and reserve adequacy over time, though these responsibilities vary by region and market design. Energy-only markets like ERCOT are

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[1] Constellation Energy Corporation. Earnings Conference Call First Quarter 2025. May 6, 2025. https://investors.constellationenergy.com/events/event-details/q1-2025-constellation-energy-corporation-earnings-conference-call

less planning-centric but have demonstrated a strong track record of timely investment by leveraging clear, transparent price signals that guide private capital toward new generation and flexibility.

These models have advantages and limitations. Vertically integrated utilities can coordinate generation and transmission investments, but their cost-of-service model may create incentives to favor new capital projects over more efficient use of existing infrastructure. This can result in underutilization of the grid's latent capacity. Organized markets can be slower to build new transmission due to coordination and siting challenges, but their competitive structure often promotes faster deployment of new generation and storage – especially where price signals are strong and clear, as in ERCOT.

Ultimately, no matter the market structure, what matters most is ensuring that planning and procurement processes – whether centralized or decentralized – have the tools and incentives to recognize available headroom, account for the value of flexible load, and invest in modern operational capabilities like grid-enhancing technologies and dynamic contingency management. Different regions may pursue different mixes of planning and market-based approaches, but all will benefit from more dynamic and flexible strategies for integrating new load.

3. Regarding planning for transmission, what specific impediments have you identified to current state and regional planning for the siting of transmission projects?

a. What are examples of impediments you have identified and what is necessary for system planners to overcome these impediments?

b. What reforms do you recommend to improve state and regional planning to overcome these impediments?

While my testimony focused primarily on near-term tools for integrating new load, I emphasized that proactive transmission planning is a critical long-lead resource. In a landscape marked by supply chain constraints, rising equipment costs, and accelerating infrastructure needs, more anticipatory and cost-effective planning is essential. FERC Order No. 1920 was a major step in the right direction, requiring long-term, scenario-based planning that considers a broader set of benefits and improves state coordination. To further improve outcomes, we can address the following challenges and opportunities:

- <u>Align incentives through independent oversight:</u> Local planning is often led by incumbent utilities with incentives to favor capital expansion over shared, cost-effective upgrades. Independent transmission monitors could help ensure transparency and objectivity.
- <u>Modernize benefit-cost frameworks:</u> Many planning processes still undervalue long-term and system-wide benefits like emissions reduction, economic development, and load integration. Multi-value planning, as advanced by Order 1920 and groups like Brattle and Grid Strategies, should become standard.
- <u>Treat GETs as first-order resources:</u> Solutions like Dynamic Line Ratings and Dynamic Contingency Management can unlock latent capacity on existing infrastructure and should be fully integrated into planning models.
- <u>Address developer siting uncertainty:</u> As I shared at FERC's 2024 interconnection workshop,[2] one of the biggest planning challenges is predicting where new generation will locate. Making more network data publicly available, including buses pre-screened for non-thermal constraints, could help developers better align with underutilized grid capacity.

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[2] Norris, T. H. (2024). Pre-Workshop Comments to Federal Energy Regulatory Commission. Staff-led Workshop on Innovations and Efficiencies in Generator Interconnection. FERC Docket No. AD24-9-000. August 26, 2024. https://nicholasinstitute.duke.edu/publications/comments-ferc-workshop-innovations-efficiencies-generator-interconnection

- Improve and streamline energy-only interconnection (ERIS): As I further discussed at FERC's 2024 interconnection workshop, getting more generators online through ERIS can provide valuable data to inform transmission planning. One of the central challenges for proactive grid planning is accurately predicting where new generators will seek to interconnect. The presence of more interconnected generators (and generators with executed interconnection agreements) helps address this information gap and improve certainty regarding where new generators are located on the grid and their expected production costs. This enhanced coordination between generation and transmission planning could lead to more efficient grid development, helping transmission providers to identify better and prioritize the highest-value upgrades.
- Invest in tools and workforce: Modern scenario planning requires robust modeling platforms and trained engineers. Federal and state support for power system education and analytical capacity is essential.

The Honorable Doris Matsui

1. Given the unprecedented growth in electricity demand and the lack of transmission available to serve that demand, what should utilities and the federal government do to accelerate the use of technologies, such as advanced conductors, that will quickly and cost effectively increase the capacity and efficiency of the existing grid along current rights of way?

Thank you, Congresswoman Matsui, for raising this important question. As the grid faces unprecedented demand growth driven by AI, electrification, and large-scale industrial development, we must ensure that we're not only expanding the grid but also getting much more out of what we already have. Technologies such as advanced conductors, Dynamic Line Ratings (DLR), power flow controllers, and Dynamic Contingency Management (DCM) can significantly increase the capacity and efficiency of existing transmission lines – often faster and at lower cost than building new infrastructure.

Despite their potential, the deployment of these technologies remains limited. There are several concrete steps that utilities and the federal government can take to accelerate their adoption:

- Incorporate GETs into routine transmission planning and cost recovery frameworks: Regulators should require that utilities evaluate GETs on equal footing with traditional upgrades in transmission planning processes. FERC Order No. 1920 opens the door to more multi-value assessments, but follow-through is needed to ensure GETs are consistently considered in comparative evaluations.
- Establish clear incentives and accountability for utilities: Where utilities lack performance-based incentives to improve utilization, GET deployment lags. Federal or state performance metrics, such as targets for increasing asset utilization or reducing congestion costs, could encourage adoption, especially when paired with cost-recovery clarity.
- Fund public benefit pilots and accelerate technical standards: DOE and FERC can expand support for pilot deployments that de-risk GETs and demonstrate real-world value, particularly in high-priority areas with constrained interconnection capacity. Supporting open standards and data interoperability for tools like DLR and DCM can also lower adoption barriers.
- Encourage states and RTOs to prioritize congestion relief through existing corridors: Many of the most congested grid bottlenecks are already known. A coordinated push –leveraging federal support, state planning, and RTO tariff reforms – can target upgrades in these areas using advanced conductors and other GETs within existing rights of way.
- Invest in planning tools and the transmission workforce: Effective GET deployment requires sophisticated modeling, situational awareness, and trained engineers. Federal funding to modernize utility and RTO planning tools, along with support for university-based power system education, will help ensure successful integration.