Written Testimony

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Dr. Jeremy Renshaw

Executive Director – AI and Quantum

EPRI

"Powering Demand: Nuclear Solutions for AI Infrastructure"

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Chairman Weber, Ranking Member Ross, and members of the subcommittee:

Thank you for the opportunity to testify today on the evolving energy needs of artificial intelligence (AI), the role of data centers, and the potential for advanced nuclear technologies to support this growing demand. I am Jeremy Renshaw, executive director for AI and Quantum at EPRI.

Background

EPRI is an independent, non-profit, global energy research, development, and deployment (RD&D) institute organized under section 501(c)(3) of the Internal Revenue Code. EPRI's experts collaborate with more than 450 companies in 40+ countries, driving innovation to support clean, safe, reliable, and affordable access to electricity for the public across the globe.

EPRI brings together electric utility companies, scientists, and engineers, along with experts from academia, industry, and other centers of research to:

• Collaborate in solving challenges in electricity generation, delivery and use;

• Provide technical, scientific, and economic analyses to drive long-range research and development planning;

• Support multi-disciplinary, objective research in emerging technologies; and

• Help accelerate the commercial deployment of advanced electricity technologies for the benefit of the public.

The Exponential Growth of AI and Its Energy Implications

EPRI has been working with artificial intelligence (AI) technologies for decades and has accelerated activities around AI and data science over the last seven years.

AI is an exponential technology. For decades, we have witnessed rapid growth in model size, data usage, and computational needs. Recent breakthroughs in generative AI and large language models (LLMs) have only accelerated this trend. While advances in hardware, particularly graphics processing units (GPUs), have improved energy efficiency, these gains have been outpaced by the energy required to support the increasing scale and complexity of AI models.

AI is moving society into fundamentally redefining how knowledge will be created in the future. Similar to how the Industrial Revolution utilized machines to turn raw materials into goods more efficiently, the AI revolution is utilizing the volume of data collected over many years to accelerate knowledge distillation and discovery. However, the vast majority of data remains private, with estimates that ~95% of all data is not public, meaning that additional insights and discoveries could be unlocked with access to more data. AI has accelerated both productivity and knowledge discovery across industries. For example, AI is accelerating drug discovery and protein folding in healthcare, automating and optimizing various aspects of transportation and logistics, and improving predictive maintenance and grid optimization in energy.

Through recent advancements, the AI and energy industries have become significantly intertwined. EPRI has identified an opportunity to meet the needs of both industries, with more energy needed to support AI training and inference, and AI enabling more efficient and productive operations for energy applications.

For this reason, EPRI recently launched the Open Power AI Consortium [1], seeking to build connections between the energy and technology industries by supporting the development of a collaborative ecosystem and seeking opportunities for mutual benefit and maximizing benefits to the public. With more than 100 energy and technology-focused organizations already engaged, the consortium will focus on building more efficient and performant AI models to achieve better outcomes with less compute and energy needs. This effort seeks to improve utility operations, such as congestion management; balancing load and demand forecasting; generation, transmission, and distribution operations; and optimizing power flow in grids. AI tools and resources may also be able to accelerate interconnection queues [2] which have led to bottlenecks in connecting new generation and transmission and distribution infrastructure to support growing energy demands. Another key focus of the consortium is deploying tools in a virtual sandbox to evaluate performance and then support deployment with member organizations.

While these efforts seek targeted deployment and implementation of efficient and performant AI systems, predicting the future energy needs of AI is inherently challenging. Recent work by EPRI and others [3-5] points to significant uncertainty in the future power consumption of data centers due to the increasing needs of AI. Despite this uncertainty, it's clear the energy demands from data centers are expected to significantly grow over the next several years due to increased utilization of AI. The high variability in estimated energy consumption is influenced by multiple factors, including:

- Model size and architecture
- Volume and type of training data
- Frequency and intensity of inference workloads, including limiting the number of tokens (words) generated per LLM query
- Inclusion of reasoning capabilities
- Hardware efficiency and utilization

Moreover, future innovations could significantly alter the trajectory of energy needs. These include:

- Next-generation chip designs
- Advanced computing and AI model architectures
- Emerging computing modalities, such as neuromorphic and quantum computing
- Improvements in software optimization and workload scheduling

It's important to note though that any forecast is reliant on a large number of assumptions about future needs and capabilities.

AI has been delivering value to various industries for years and with recent and ongoing advances in the technology, these advances are projected to continue. This will require intelligent and responsible use of AI, support from various energy sources, and continued growth in data center utilization.

Data Centers: Critical for AI and a Grid Opportunity

Data centers are the physical infrastructure supporting a significant portion of AI workloads for training and utilization (such as inference and reasoning). Data centers are also needed to support cloud services, streaming platforms, social media, and much more. AI-specific data centers can consume up to five times more energy than traditional data centers. The

International Energy Agency [5] predicts that global data center energy use in 2030 will double from 2024 levels to 945 TWh, largely driven by increases in AI energy consumption, which is slightly more than Japan's total electricity consumption today.

In addition, AI data centers may have highly variable load profiles. Some AI data center load profiles appear to be more similar to a steel mill or arc furnace's energy profile (which may contain spikes in energy demand as energy-intensive equipment is turned on and off) than a traditional data center, which is generally relatively flat.

This variability presents both a challenge and an opportunity for the electric grid. While data centers represent a significant new load, especially in certain regions of the world, they also offer unique opportunities, such as:

- **Workload Flexibility**: In some cases, compute workloads can be rerouted to other locations or scheduled in different timeframes, reducing peak demand in constrained regions – though it is not always possible to do so.
- **Backup Generation as a Grid Resource**: Data centers maintain backup generators to ensure high levels of reliability. These assets, which typically sit idle except during periodic testing, could be leveraged during peak loading events to reduce net demand and provide lower-cost energy to both the data center and consumers, while saving utilities money as well.
- **Flexible Generation and Storage:** In addition to the above options, flexible generation sources combined with long-duration energy storage systems can augment the ability of a utility to meet peak demand loads and enhance grid stability.

EPRI launched the DCFlex initiative [6] to explore how data centers can provide the above grid services, supporting utilities, operators, and consumers alike. The initiative has more than 40 members, including Meta, Google, Microsoft, NVIDIA, QTS, Compass Datacenters, and many more. These efforts will complement the efforts of the Open Power AI Consortium.

Many perceive data centers to be power hungry, straining the grid, and on an unsustainable growth pattern. Through initiatives like the Open Power AI Consortium, DCFlex, and other global initiatives, we can change perspectives to utilize data centers as a knowledge factory that can accelerate knowledge generation, productivity, and innovation across all sectors while growing in a sustainable fashion using advanced forms of energy generation and utilization. This is where advanced nuclear and other energy generation technologies may be able to support data center energy consumption needs.

The Role of Advanced Nuclear in Supporting Flexible Loads

Having worked in the nuclear industry for over 15 years, I can speak to both the benefits and limitations of nuclear energy to support data center energy demands. It is important to note that no energy source is perfect; each source of energy has benefits and limitations and a robust energy mix typically combines multiple sources to improve overall system performance, reliability, resilience, and reduce risks associated with over-reliance on any single source of energy. Recognizing that a diverse generation mix can improve electricity reliability and affordability and strengthen energy security, for the purpose of this hearing, I will focus this testimony on one component of the energy portfolio – nuclear.

Traditional nuclear plants provide safe, reliable, and carbon-free baseload power. Nuclear power has a track record of being one of the safest forms of energy generation over the last several decades [7]. In the U.S., nuclear power plants are not typically cycled frequently, as steady operation minimizes wear and tear and extends component life.

Advanced nuclear reactors may offer additional capability for flexible operation, supporting high-intensity, variable loads like AI data centers. This includes:

- **Enhanced Flexibility**: Many advanced designs are capable of ramping energy production to meet current needs, making them suitable for variable demand profiles. Advanced nuclear designs may utilize fuels that are more suitable for flexible operations, such as TRISO-based fuels and molten salt reactors.
- **Improved Safety**: Features such as passive safety systems and walk-away safe designs reduce operational risk.
- **Fuel Diversity**: Some reactors can utilize alternative fuels, including uranium, thorium, and other actinides or even used fuel (also referred to as spent fuel) recycled from existing plants, reducing the environmental footprint of not only advanced reactors, but also traditional plants in use today.
- **Higher Efficiency**: High-temperature reactors can achieve greater thermal efficiency and support industrial applications beyond electricity, such as district heating, hydrogen production, etc.

These characteristics make advanced nuclear one option for powering the next generation of AI infrastructure – especially in regions where clean, dispatchable power is needed to complement intermittent sources. However, as noted above, there is no perfect energy option and advanced nuclear systems are no exception. Many advanced nuclear designs have yet to be built, posing the potential for additional risks related to first-of-a-kind construction delays and cost overruns. In addition, while used fuel inventories are generally reduced using advanced designs, used nuclear fuel and irradiated materials will still need to be managed. As with any technology, first-of-a-kind implementations may also introduce additional risks that are difficult to predict and quantify.

In addition to traditional and advanced nuclear, other clean, reliable generation sources and energy storage sources systems can be considered to further augment overall energy system flexibility, reliability, and affordability.

Conclusion

AI is transforming our economy and society, but its energy demands are growing rapidly and unpredictably. Improvements in chip efficiencies reduce energy consumption concurrently as larger models and increased utilization increase consumption. AI is accelerating productivity and knowledge generation across all industries today and is poised to continue generating additional value into the future.

Due to increased AI utilization, meeting data center energy needs is a growing challenge and many solutions are being evaluated. While energy-intensive, data centers, while can also be part of the solution when viewed through a new lens of flexible operation and grid integration. Data centers can be viewed as knowledge factories, supporting all sectors of industry in the future.

While there is no perfect energy generation technology, advanced nuclear technologies are among the options that offer potential solutions to provide safe, reliable, flexible, and clean power to meet the needs of a digital future. Traditional and advanced nuclear generation technologies can play important roles in future energy systems to support the growing needs of AI and the benefits it can provide to society.

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