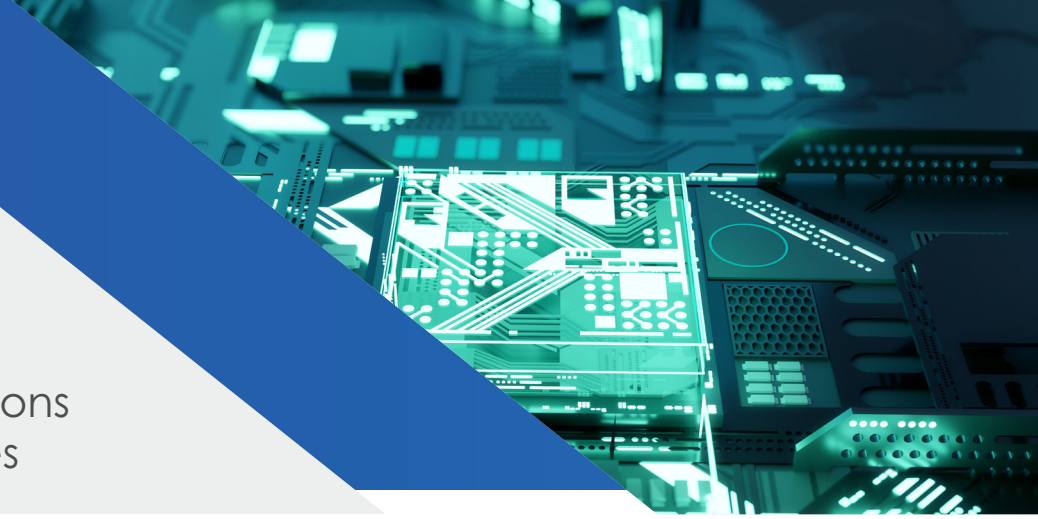


Quantum Science and Technology:

Energy System Applications and Future Opportunities

Quantum science and technology may offer significant benefits for the energy systems of the future. Quantum technology shows great promise for addressing threats as well as finding solutions to energy industry issues that cannot be easily or quickly solved by classical systems, such as cybersecurity, grid optimization, and climate modeling [1]. This emerging technology has the potential to revolutionize many industries, such as information technology, materials, communications, and energy.

Quantum computing still requires significant development to be commercially viable; however, the pace of innovation is accelerating, and the technology may be positioned to disrupt conventional approaches and current applications over the next decade. The field of quantum science and technology is rapidly growing and evolving, with significant investment from both public and private sectors.

Modern power systems require a strong computational foundation converting data into actionable information. Power grid operators are already stretched to operate today's power system; however, the power grid is becoming exponentially more complex due to the expansion of distributed energy resources (DERs), such as renewable energy sources, energy storage, and prosumers (entities that can be both producers and consumers of energy). These activities combined with the emergence of new loads from electrification efforts and electric vehicles (EVs) require a transformation of the energy industry to adapt. Advanced technologies, such as artificial intelligence (AI) and quantum computing (QC) provide significant promise to support the computational needs of the energy systems of the future.

Quantum has the potential to impact the energy industry by enabling more efficient, secure, and sustainable energy production, distribution control, and consumption, specifically:

Grid optimization – Optimize the grid for efficiency and reliability. For example, it could be used to develop algorithms that improve forecasting of renewable energy sources, optimize the dispatch of generation sources to reduce costs, and optimize power flow on the grid.

High-performance computing – Perform complex simulations not feasible for classical computers, such as simulations of fluid dynamics, materials science, and combustion. This could lead to increased efficiency and cleaner energy production from improved high-temperature materials and enhanced power generation processes.

Cyber – Develop next generation cybersecurity solutions for the energy industry. Quantum cryptography, for example, uses principles of quantum mechanics to ensure secure communication channels are protected from interception/hacking.

Fusion – Leverage quantum computing to simulate the behavior of plasma in fusion reactors, possibly in combination with AI, enabling more efficient and reliable fusion energy production.

AI – Turbocharge AI in the energy industry on tasks such as predictive maintenance, load forecasting, and energy management. Quantum computing could accelerate AI algorithms by requiring smaller training data sets, enabling more accurate and timely predictions including the potential of single shot and zero shot learning.

Sensors – Quantum sensors enable more precise and efficient measurements of physical systems, such as time (quantum clocks), acoustics, and magnetic fields, etc. This could lead to more efficient, secure, and reliable energy production, transmission, and storage.

Few, if any, companies working on quantum computing are doing it alone; no single entity possess all the required expertise or funding. Within the energy industry, various partnerships have been undertaken to further explore the potential advantages of quantum computing [1].

EPRI Collaborative Quantum Initiative

In 2022, EPRI published a technology update white paper[1], had a second paper published by the American Nuclear Society, hosted a quantum challenge [2,3], and held a panel discussion on quantum opportunities at the EPRI AI Summit.

2023 Planned Activities Include:

Quantum Interest Group In-Person Seminar – September 25, 2023, Washington, D.C.

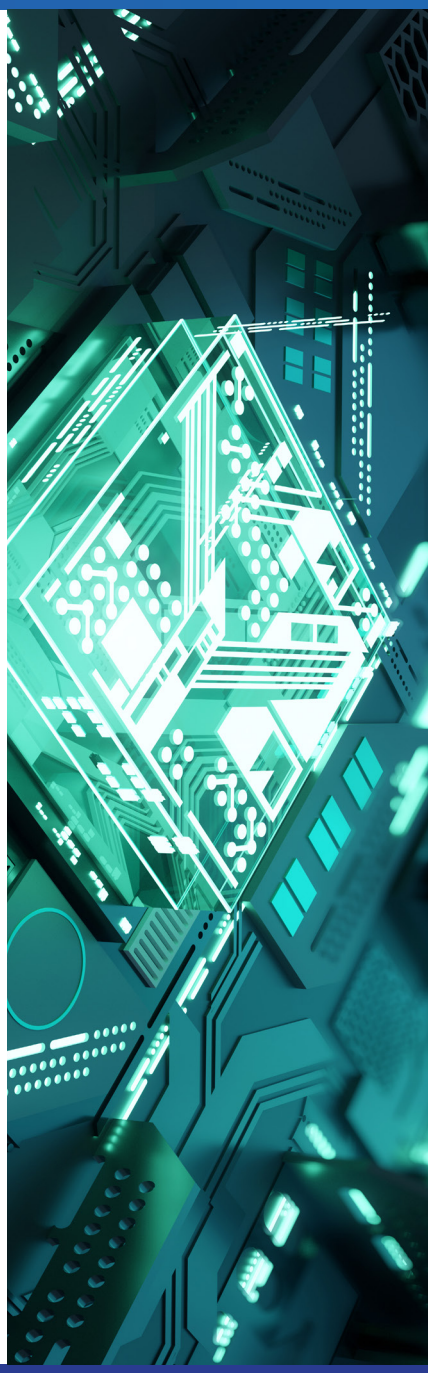
2023 Quantum Challenge, Topic: Quantum Sensors

Publications - 2022 Quantum Challenge Results [3]

EPRI's Quantum Science and Technology Initiative is exploring ways EPRI's members may incorporate quantum technologies into their operations and across their organizations. The Initiative's research includes:

- Surveying and investigating state of the art quantum technologies and use cases relevant to the energy industry.
- Assembling QC and energy industry experts through a quantum interest group to collaborate on relevant use cases and increase the energy industry's awareness of QC to prepare for a quantum future. Please reach out to EPRI if you are interested in joining the quantum interest group.
- Examining how quantum technologies may inform and drive business practices, such as IT infrastructure, cybersecurity, data processing, algorithm and model optimization, autonomous operations, and real time grid monitoring, among others.
- Hosting challenges to bring the QC and energy industry together around specific topics of mutual interest and accelerate innovation in these areas [2].

The energy industry can significantly benefit from technology advancements in AI and quantum computing. For example, EPRI has evaluated quantum computing use cases for cybersecurity of the grid and beyond with results published in an EPRI report [3]. The rapidly evolving quantum landscape has many technical hurdles to overcome, including cryogenic cooling require-ments, and noise that may affect the accuracy of the calculations a quantum computer performs. However, broad adoption of these technologies could occur once these hurdles are overcome and the industry moves beyond the current limitations of existing quantum computers to achieve large-scale, error correcting quantum computers. EPRI's research goal in the next several years will be to research the possible uses cases using quantum, keeping abreast of the rapid changes in the science and technology. EPRI aims to continue fostering collaboration opportunities to evaluate and enhance quantum's viability and potential impact across the energy industry.



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[2] *Quantum Challenge: Quantum Technologies for AI Enhanced Utility Cybersecurity.* EPRI, Palo Alto, CA: 2022. https://www.epri.com/quantum-computing.
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