QuEra

Quantum and the HPC Center

Accelerating Research and Innovation with Quantum Computing in Your HPC Center

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QuEra Computing Inc.
White Paper

Target Audience
HPC Managers
Business leaders

Note to readers, October 2026

Published June 2023. This paper was written in June 2023. Its guidance on evaluating quantum computing for an HPC center, and on choosing between on-premises, co-located and remote access, still applies. Product and company details have been updated to October 2026.

Where QuEra is today. Aquila, our analog system, has been on Amazon Braket since 2022. Gemini, our digital, gate-based system, has been deployed on premises since 2025, including beside the ABCI-Q supercomputer at AIST in Japan. Libra, our fault-tolerant system, is planned for Amazon Braket in 2028.

Facility requirements. The installation specifications in section 9 describe the system offered in 2023. Current requirements are provided during an on-premises consultation.

Next steps. Book an on-premises consultation at quera.com/request-a-quantum-consultation, read about on-premises systems at quera.com/on-premise-quantum-computers, or see the roadmap to Libra at quera.com/our-quantum-roadmap.

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1. Executive Summary

High-Performance Computing (HPC) centers have long been essential to the advancement of scientific research and innovation for decades, tackling complex computational problems that traditional computers struggle to solve. Today, a new frontier is emerging in computing technology: quantum computing. By embracing quantum computing, your HPC center can unlock unprecedented capabilities, providing a competitive edge to your customers and empowering researchers to drive innovation and groundbreaking discoveries across multiple fields.

Where are quantum computers useful? What should HPC center managers think about before integrating a quantum computer? When does an on-premises system make sense, and when is remote access the better fit? Which type of quantum computer fits your center? When is the right time to engage?

This whitepaper addresses these and many other questions.

2. The Past, Present, and Future of HPC Centers

The history of HPC centers can be traced back to the 1960s when supercomputers first emerged as powerful tools for scientific research and engineering. Over the years, HPC centers have evolved, incorporating major advancements in hardware, software, and operational practices to deliver unprecedented computational capabilities.

A key milestone in the early history of HPC centers was the establishment of the first national supercomputing centers in the United States during the 1980s. These centers, such as the National Center for Supercomputing Applications (NCSA) and the San Diego Supercomputer Center (SDSC), provided researchers with access to cutting-edge supercomputing resources for tackling complex problems in various scientific domains.

In terms of hardware, HPC centers have integrated various types of computing architectures throughout their history. Early supercomputers, such as the Cray-1 and the IBM System/360, relied on vector processing, while later generations embraced massively parallel processing (MPP) architectures, like the Connection Machine and the Intel Paragon. The advent of commodity processors and cluster computing in the 1990s enabled HPC centers to build powerful, cost-effective systems using off-the-shelf components.

The introduction of Graphics Processing Units (GPUs) in the 2000s marked another significant milestone for HPC centers. The massively parallel architecture of GPUs proved to be highly effective for scientific computing, and many HPC centers began to integrate GPU accelerators into their systems, significantly boosting performance and energy efficiency.

Over the next few years, HPC centers are likely to undergo several transformations, driven by advancements in technology, evolving computational demands, and the need for increased efficiency and sustainability. Some key initiatives for HPC centers include:

1. **Integration of quantum computing**: As quantum computing matures, HPC centers may start integrating quantum processors into their systems, either as standalone units or in hybrid configurations. This will enable HPC centers to offer their users access to quantum resources for tackling problems that are intractable for classical computers.

2. **Expansion of AI and machine learning capabilities**: HPC centers will continue to expand their AI and machine learning capabilities, with a focus on integrating specialized hardware accelerators, like GPUs, TPUs, and custom AI chips. This will allow researchers to run complex AI models and simulations at scale, unlocking new insights and innovations.
3. **Focus on energy efficiency and sustainability**: As energy consumption and environmental impact become pressing concerns, HPC centers will prioritize energy efficiency and sustainability in their operations. This may involve the adoption of energy-efficient hardware, innovative cooling technologies, and power-aware scheduling algorithms, as well as exploring alternative energy sources like solar or wind power.

3. Quantum Computing: A Game-Changer for HPC

Quantum computing harnesses the unique properties of quantum mechanics, such as superposition and entanglement, to perform calculations that are infeasible for classical computers. Qubits, the basic units of quantum computers, can represent multiple states at once, enabling the parallel exploration of vast solution spaces. This unique capability allows quantum computers to address complex problems and provide significant speedup for specific tasks, fueling innovation and scientific breakthroughs.

Here are three key disciplines that stand to benefit significantly from quantum computing:

1. **Optimization**: Many real-world problems involve finding the optimal solution to a complex optimization problem, such as optimizing the routing of a transportation network or maximizing the efficiency of a manufacturing process. Quantum computing offers the potential to solve these problems faster and more efficiently than classical computers by leveraging quantum algorithms such as quantum annealing or the quantum approximate optimization algorithm (QAOA), a hybrid method that alternates quantum and classical steps. These algorithms can provide a speedup for a wide range of optimization problems, including NP-hard problems, a class for which no efficient classical algorithm is known, that are difficult to solve using classical methods.
2. **Machine learning**: Machine learning involves training algorithms to learn from data and make predictions or decisions based on that data. Quantum computing can benefit machine learning by providing faster algorithms for training and inference tasks, such as the quantum support vector machine or the quantum Boltzmann machine. These algorithms can take advantage of quantum parallelism and interference to perform certain computations faster than classical algorithms, which could be particularly useful for large-scale machine learning problems.
3. **Simulation**: Simulation involves modeling and analyzing complex systems, such as the behavior of molecules, materials, or financial markets. Quantum computing can benefit simulation by providing faster algorithms for simulating quantum systems, such as the variational quantum eigensolver (VQE), a hybrid method for estimating the energy of molecules, or the quantum phase estimation algorithm. These algorithms can leverage the properties of quantum mechanics to simulate quantum systems more efficiently than classical methods, which could be particularly useful for problems in chemistry, physics, and materials science.

Navigating the Quantum Revolution: Quantum, Quantum-Inspired, and Hybrid Quantum/Classical Algorithms

As the era of quantum computing dawns, it is essential for HPC managers to stay informed about quantum, quantum-inspired, and hybrid quantum/classical algorithms to harness their potential and drive groundbreaking discoveries.

Quantum algorithms exploit the unique characteristics of quantum bits (qubits) to perform calculations that are infeasible or impossible using classical computing techniques. Qubits exist in multiple states simultaneously, known as superposition, and their states can be intertwined, a phenomenon called entanglement. These properties enable quantum algorithms to explore vast solution spaces concurrently, providing substantial speedups for specific problems. Notable examples include Shor's algorithm for factoring large numbers, Grover's algorithm for searching unsorted databases, and Harrow-Hassidim-Lloyd (HHL) algorithm for solving linear systems of equations.

Quantum-inspired algorithms, on the other hand, draw inspiration from quantum mechanics to enhance classical computing methodologies. They do not rely on qubits but rather emulate quantum phenomena like superposition and entanglement to attain more efficient solutions.

4. Revolutionizing Research and Delivering Real-World Benefits

Integrating quantum computing into your HPC center opens new possibilities for your commercial customers across various industries:

1. **Drug Discovery and Bioinformatics**: Quantum computing can simulate complex molecular interactions and protein folding processes, enabling the discovery of new drugs and treatments at a faster pace and lower cost.

2. **Supply Chain Optimization**: Quantum algorithms can optimize global supply chains by efficiently solving complex routing and scheduling problems, reducing costs and improving delivery times.

3. **Financial Modeling**: Quantum computing can enhance portfolio optimization, risk assessment, and fraud detection, providing more accurate insights and enabling better decision-making in the financial sector.

For HPC centers catering to academic researchers, integrating quantum computing can transform research across various scientific fields:

1. **Quantum Chemistry and Material Science**: Quantum computing can simulate complex molecular interactions and novel materials, enabling researchers to discover new compounds and design advanced materials with unprecedented properties.

2. **Climate Modeling and Environmental Science**: Quantum computing can enhance the accuracy and efficiency of climate models, providing deeper insights into climate change and guiding the development of sustainable solutions.

3. **Theoretical Physics and Astronomy**: Quantum computing can enable researchers to tackle complex problems in quantum field theory, particle physics, and cosmology, driving advancements in fundamental science.

Examples include quantum-inspired optimization algorithms that excel at solving combinatorial optimization problems, such as the traveling salesman problem, and the quantum-inspired Monte Carlo method, which can speed up stochastic simulations

Hybrid quantum/classical algorithms blend the strengths of both domains, leveraging quantum computing for specific subproblems while relying on classical methods for the overall computation. These algorithms can be particularly valuable when tackling problems that only require partial quantum speedup or when quantum hardware is still in its infancy. Promising approaches include the variational quantum eigensolver (VQE) for simulating quantum systems, the quantum approximate optimization algorithm (QAOA) for addressing optimization problems, and the quantum-assisted cluster algorithm (QACA) for machine learning tasks.

To get the most from each approach, HPC managers must thoroughly evaluate all three options - quantum, quantum-inspired, and hybrid quantum/classical algorithms. By carefully assessing the strengths and limitations of each approach in the context of specific problems, managers can make informed decisions that maximize performance, efficiency, and resource utilization while remaining adaptable and responsive to evolving customer needs.

5. Top Ten Aspects to Consider before Quantum Integration

As a thoughtful HPC center manager, you might consider the following aspects when considering the integration of quantum computing into your HPC center:

1. **Use cases and benefits**: Identify the specific use cases and benefits that quantum computing can bring to your HPC center and its customers, such as optimization problems, machine learning, and quantum simulations.
2. **Hardware compatibility**: Determine the requirements and compatibility of quantum computing hardware with your existing HPC infrastructure, including power, cooling, and connectivity.
3. **Integration strategy**: Develop a plan for integrating quantum computing into your HPC center's workflow, including how to interface with existing classical systems and efficiently allocate resources between quantum and classical computing.
4. **Software ecosystem**: Evaluate the availability and maturity of software tools, libraries, and platforms that support quantum computing and facilitate the development of quantum applications for your HPC center.
5. **Performance metrics and benchmarking**: Establish performance metrics and benchmarks for evaluating the effectiveness and efficiency of quantum computing solutions in your HPC center.
6. **Cost and ROI analysis**: Conduct a thorough cost and ROI analysis to assess the financial viability of integrating quantum computing into your HPC center and evaluate the potential return on investment for your customers.
7. **Vendor and partnership selection**: Identify potential vendors and partners that can provide quantum computing hardware, software, and support services, and carefully evaluate their capabilities and track records.
8. **Support and maintenance**: Plan for ongoing support and maintenance of quantum computing systems, including regular upgrades and troubleshooting, to ensure smooth operation and optimal performance in your HPC center.
9. **Hybrid quantum-classical computing**: Investigate how to effectively integrate quantum and classical computing resources to solve complex problems using hybrid algorithms and architectures.
10. **Training and workforce development**: Consider the need for training and workforce development to build a team of experts capable of working with quantum computing technology, as well as fostering collaborations with academia and industry partners.

6. On-prem quantum computers vs. remote cloud access to them

Once a decision has been taken to incorporate quantum computers into the HPC center infrastructure, managers face the critical decision of choosing between on-site or remote cloud-based access to quantum computers. To make an informed choice, it is important to weigh the pros and cons of both approaches.

6.1.On-Site Quantum Computers

Pros:

1. **Control**: On-site quantum computers provide HPC managers with complete control over scheduling and priorities. Managers can decide who gets priority access and don't have to share the quantum resource with other users outside the organization.
2. **Data Security**: Hosting quantum computers on-site minimizes data transfer and ensures that sensitive information remains within the organization's security perimeter, reducing the risk of breaches.
3. **Latency**: With on-site access, latency is minimized, allowing for faster communication between the quantum computer and other HPC resources.

Cons:

1. **Cost**: Acquiring, installing, and maintaining quantum computing hardware can be more expensive than cloud-based access.
2. **Maintenance**: Quantum computers require specialized expertise and resources to manage and maintain. A hosted quantum computer requires arrangements with the computer manufacturer to ensure ongoing operation.
3. **Upgradability**: Quantum computers evolve rapidly, which may render on-site hardware obsolete relatively quickly. HPC managers need to work with vendors that provide guaranteed upgrades or risk being left behind in the fast-paced quantum technology landscape.

6.2. Remote Cloud-Based Access

Pros:

1. **Cost-Effective**: Remote access to quantum computers via the cloud allows organizations to leverage quantum capabilities without the upfront investment in hardware and infrastructure, making it a more cost-effective option.
2. **Trial Period**: Remote access can serve as a low-risk way to evaluate the usefulness and potential impact of quantum computing for an organization's specific needs before committing to purchasing and installing on-site hardware.
3. **Upgradability**: Cloud-based quantum computing services are frequently updated to incorporate the latest advancements in quantum technology, ensuring that users always have access to cutting-edge resources.

Cons:

1. **Latency**: Remote access may introduce latency issues, particularly for hybrid quantum/classical algorithms that require frequent interaction between the classical and quantum resources.

2. **Data Security**: Relying on external providers for quantum computing resources can introduce potential risks to data security and compliance, particularly for organizations handling sensitive information.
3. **Limited Control Over Scheduling and Prioritization**: Utilizing cloud-based quantum computing services may result in reduced control over scheduling and prioritization of tasks. Since resources are shared with other users, HPC managers might experience delays or limitations in resource allocation, potentially affecting their ability to meet time-sensitive requirements or project deadlines.

7. Which Quantum Computer Fits Your HPC Center?

There are several distinct types of quantum computers, each based on a different technology, such as superconducting qubits, trapped ions, neutral atoms, and photonic systems. They differ in error rates, connectivity, and how readily they support error correction, the technique that combines many physical qubits into more reliable logical qubits and makes large-scale, fault-tolerant computing possible. For an HPC center, the practical question is fit: which systems match your users' workloads today, and which offer a credible, dated path to fault tolerance. Accessing or owning more than one type of quantum computer can offer several advantages:

1. **Enhanced Versatility**: Each type of quantum computer has its unique set of strengths and weaknesses, as well as varying levels of coherence and error rates. By accessing or owning multiple types of quantum computers, organizations can capitalize on the specific advantages of each technology, depending on the nature of the problem at hand. For instance, superconducting qubits may be more suitable for tasks that require high-speed operations, while neutral atom systems offer a scalable and reconfigurable platform for quantum computing, enabling the implementation of various quantum algorithms with high connectivity. In addition, accessing multiple types of quantum computers allows organizations to perform benchmarking, comparing the performance of different quantum computing technologies against one another.
2. **Wider Range of Problem Solving**: Different quantum technologies suit different classes of problems. By having access to or owning multiple types of quantum computers, organizations can experiment with various approaches to problem-solving, enabling them to identify the most suitable technology for their particular use cases.
3. **Hedging the Investment**: As quantum computing technology continues to advance rapidly, it is likely that different types of quantum computers will become better suited to particular tasks. By investing in multiple types of quantum computers, organizations can match each workload to the system that suits it as the technologies mature.
4. **Collaboration and Innovation**: Accessing or owning multiple types of quantum computers can foster collaboration within an organization and promote innovation. Researchers and engineers from different backgrounds and expertise areas can work together on a range of quantum computing platforms, potentially leading to the development of novel algorithms and solutions that might not have been possible using a single type of quantum computer.

In summary, accessing or owning multiple types of quantum computers can provide organizations with numerous advantages. As the quantum computing landscape continues to evolve, organizations that invest in diverse quantum technologies will be better positioned to adapt to emerging trends and capitalize on the capabilities of each type of quantum computer. Error correction is the milestone to watch: QuEra plans to deliver its fault-tolerant system, Libra, on Amazon Braket in 2028.

8. Should HPC Managers Wait a Few Years?

Given that we are in the early days of quantum computers, it is understandable that some HPC managers are concerned about the maturity of quantum technology and might consider waiting for further advancements before acting. However, there are several reasons why starting the quantum computing journey now can be advantageous for your HPC center and customers:

1. **Competitive edge**: By getting involved in quantum computing early, you position your HPC center as a forward-thinking leader in the industry. This will not only give you a competitive advantage but also help you attract clients who are seeking cutting-edge solutions for their challenges.
2. **Learning curve**: Quantum computing has a steep learning curve, and starting now allows your team and clients to build the necessary skills and expertise to effectively leverage the technology. Waiting too long may put you at a disadvantage as others gain experience and develop quantum solutions.
3. **Influence future developments**: Early adopters can shape the direction of quantum computing technology, provide valuable feedback to vendors, and influence the development of tools and applications that best serve their needs and those of their clients.
4. **Hybrid quantum-classical solutions**: Even in its current state, quantum computing can provide value when combined with classical computing in hybrid approaches. These hybrid solutions can help solve complex problems more efficiently, providing tangible benefits to your clients today.
5. **Incremental advancements**: Quantum computing is experiencing rapid progress, with new breakthroughs and improvements emerging regularly. By starting now, you can take advantage of these incremental advancements and be prepared to harness the full potential of quantum computing as the technology matures.
6. **Research and development funding**: Many governments and organizations are allocating funding for quantum computing research and development. Starting now can increase your chances of securing grants and partnerships that will help you stay at the forefront of this emerging field.

Waiting carries additional risks. An April 2023 study[i] by the Boston Consulting Group "quantum computing in most industries is likely to be a winner-take-most technology, and a disproportionate share of the value created (we estimate as much as 90%) will go to early adopters." Latecomers to the quantum field may face challenges such as the time required to build expertise, limited availability of skilled talent, and difficulty securing intellectual property rights.

While it's true that quantum computing is still evolving, there are numerous advantages to engaging with the technology now. By starting your quantum journey today, you can build the necessary expertise,

influence future developments, and create a strong foundation that will enable your HPC center and clients to reap the full benefits of quantum computing as it matures.

9. The QuEra Approach to Quantum Computing and HPC Integration

QuEra is building fault-tolerant quantum computers for real work, on Amazon Braket from 2028 and inside HPC centers, from ingredients already demonstrated in peer-reviewed research. Founded in 2018 by scientists from Harvard University and MIT, QuEra is based in Boston.

Aquila, our analog system, has been on Amazon Braket since 2022, meeting strict service level agreements for commercial and academic users worldwide. Gemini, our digital, gate-based system, has been deployed on premises since 2025, including beside the ABCI-Q supercomputer at AIST in Japan. Libra, our fault-tolerant system, is planned for Amazon Braket in 2028.

Our path to fault tolerance rests on published results. With collaborators at Harvard and MIT, QuEra scientists demonstrated a logical quantum processor running algorithms on up to 48 logical qubits, groups of physical qubits that work together so errors can be detected and corrected [Bluvstein2024]. The same collaboration later demonstrated magic state distillation on logical qubits, a key ingredient for universal fault-tolerant computing [Rodriguez2025]. QuEra was also selected for Stage B of DARPA's Quantum Benchmarking Initiative.

9.1.The Dual-Mode Computer

QuEra's neutral-atom systems support two computation modes, digital (Gemini) and analog (Aquila), each with its own advantages. Users can choose the mode that fits the problem they want to solve.

The digital, or gate-based, mode breaks a computation into a sequence of simple operations called gates, each acting on one or two qubits at a time, much like logic gates in a classical processor. The sequence of gates moves the whole system from its starting state to a final state, which is measured as a string of 0s and 1s that captures the outcome. Gate-based operation provides an elegant recipe for universal functionality and programmability with only a small set of elementary operations, and it is the mode used for error-corrected, fault-tolerant computing.

In the analog mode, the user does not apply discrete gates. Instead, the laser controls are varied smoothly over time, and the qubits evolve continuously according to the system's Hamiltonian, the mathematical description of how its energy and interactions change over time. Analog mode is not universal, but it can map some problems, such as optimization and the simulation of physical systems, directly onto the hardware without breaking them into many small steps. This keeps programs short and reduces their exposure to noise.

9.2. Our Field-programmable Qubit Array (FPQA™) Technology

Our FPQA technology allows dynamic configuration of the qubits in our quantum computer. Similar to how FPGAs have revolutionized the digital computing industry, Field Programmable Qubit Arrays offer the potential for reconfigurable quantum hardware, enabling rapid prototyping and customization of

quantum circuits. The FPQA technology allows us to arrange the qubits in a nearly-arbitrary geometrical configuration.

FPQAs provide benefits for optimization, simulation, and machine learning. In optimization, arranging qubits simplifies geometric problems and enables solving larger problems more easily. In simulations, qubit arrangements can imitate the physical structure of the system being simulated, using the qubits' natural properties to study previously unsimulatable systems. For machine learning, configurable arrangements give flexibility in how input data is encoded.

9.3. Bloqade™: our Software Development and Simulation Environment

Bloqade[ii] is our open-source package for neutral-atom architectures. Bloqade enables simple design and fast execution of programs in our analog computing mode. With Bloqade, users can develop and test algorithms before deploying them on the quantum computer.

Bloqade has multithreading-support built-in for faster simulation on multi-core CPUs. This is accomplished through separate Sparse-Matrix Dense-Vector (SpMV) backends, the numerical routines at the core of quantum simulation, that a user can explicitly choose from to further fine-tune performance.

Bloqade also supports CUDA acceleration, using NVIDIA's GPU programming platform, provided that an NVIDIA graphics processing unit (GPU) is available. Converting CPU-based simulations to CUDA-based simulations is extremely simple. For emulation, users can convert everything into the GPU memory with a single function call.

Bloqade is highly versatile and adaptable. It can run seamlessly on a desktop computer, but when deployed on HPC resources, Bloqade truly shines, unlocking its full potential. By harnessing the power of HPC, Bloqade can simulate a significantly larger number of qubits and execute simulations at a much faster pace. This enhanced capability enables users to tackle more complex problems and explore the limits of quantum computing, further expanding the scope of potential applications and discoveries. Beyond QuEra's quantum computer, HPC centers can offer high-performance Bloqade access to their community.

9.4. Support for Quantum-Inspired Algorithms

QuEra provides the open-source *GenericTensorNetwork*[iii] package, that can solve several types of optimization problems including the Independent Set problem, Maximal Independent Set problem, Spin-glass problem, Cutting problem, Vertex Matching problem, Binary Paint Shop problem, Coloring problem, Dominating Set problem, Set Packing problem, Satisfiability problem and Set Covering problem.

The package allows defining the solution space properties of a class of hard combinatorial optimization including: the maximum/minimum solution sizes, the number of solutions at certain sizes and the enumeration/sampling of solutions at certain sizes.

9.5. HPC Integration Models

To provide HPC managers with maximum flexibility, we offer three options for integrating QuEra quantum computers with HPC center: Premium Cloud Access, co-location, and on-premises.

- **Premium Cloud Access gives users dedicated, direct access to QuEra systems over the internet, with reserved capacity and support from QuEra scientists. It complements public access to Aquila through Amazon Braket, which is open to any AWS user. This option is ideal for users who need to perform quantum computing tasks but do not require physical access to the machine. It is cost-efficient and flexible, as users can access the quantum computer from anywhere.**
- **Co-location** provides users with the ability to physically co-locate their HPC system with the QuEra quantum computer. This option is ideal for users who require low-latency connections and high-performance computing, without requiring a quantum computer in their HPC center. It offers a dedicated off-site machine, ensuring privacy and security, while also allowing for updates to the machine. This option is suitable for users who require frequent access to the quantum computer and need to process large amounts of data quickly.
- **On-premises** installs the QuEra quantum computer within the HPC center. This option is ideal for users who require complete control over their quantum computing operations, prioritize privacy and security, and prefer not to depend on third-party vendors. It is suitable for users with a clear business advantage that requires low-latency connections for data processing. With on-premises installation, users have complete ownership of the quantum computer and can customize it to suit their specific needs. In this option, QuEra will provide maintenance service to keep the machine running in top condition.

9.6. Training and Support

Our commitment to your success goes beyond the hardware. We provide comprehensive training and support to equip your team and users with the skills and knowledge needed to utilize quantum computing effectively. Our support includes email assistance, direct access to our scientists, and scheduled office hours for discussing effective ways to solve specific problems using our computer. Additionally, we will collaborate with you on pilot projects and proof-of-concept initiatives, ensuring that your HPC center can confidently offer quantum computing resources to your user base.

9.7. Installing a QuEra quantum computer in the data center

Installing a QuEra quantum computer at your facility is a convenient process, thanks to its adaptable design and minimal environmental requirements. The machine comes with its own enclosure and air conditioning setup, ensuring environmental resilience. It also features continuous HEPA air filtration, which may reduce the necessity for strict cleanroom classifications. Class 100,000 cleanliness, ±1 degree temperature stability, and <60% humidity should be adequate.

Designed to fit within a 7-tile pitch data center layout, the machine occupies a 4ft x 12ft floor space and requires a clear ceiling height of 9ft. The quantum computer is suitable for on-grade facilities. If you have raised floors, we can evaluate the scenario to accommodate loads and vibration for the machine table accordingly. The total electrical power consumption is under 7kW, typically supplied through two three-phase 208V circuits, but customization is possible if needed. The machine includes UPS systems with a runtime of over 20 minutes, and it's recommended to have a backup power generator with a startup time of less than 1 minute.

QuEra's quantum computer requires "chilled water" with a cooling capacity of over 10kW for equipment cooling. The system is compatible with a wide range of cooling water temperatures, from 45°F to 70°F,

depending on your facility's infrastructure. These specifications describe the system offered in June 2023. Current requirements for Gemini-class systems are provided during an on-premises consultation.

10. Conclusion

The rapid development of quantum computing technology gives your HPC center an opportunity to prepare its users for fault-tolerant quantum computing and provide new value to your clients. Starting your quantum computing journey now can offer several immediate and long-term benefits:

1. **Competitive advantage**: By embracing quantum computing now, your HPC center can be among the first to offer this transformative technology to your users, giving them a competitive edge in their industries and setting your center apart from competitors.
2. **Enhanced problem-solving capabilities**: Integrating quantum computing into your HPC center will enable your clients to explore problems that are hard for classical systems alone, opening new possibilities for innovation and optimization.
3. **Attract high-value clients and talent**: Offering quantum computing services can help you attract high-value clients from a wide range of industries, such as pharmaceuticals, finance, logistics, and energy, who are seeking to leverage the power of quantum computing to drive their businesses forward. Integrating quantum computing into your HPC center will also enhance your reputation as an innovative leader, attracting world-class team members, researchers, and collaborators who seek to work on cutting-edge projects and technologies.
4. **Secure funding and partnerships**: Early involvement in quantum computing research can increase your chances of securing grants, funding, and partnerships with government agencies, industry, and other research institutions that recognize the immense potential of this technology.
5. **Foster interdisciplinary collaboration and cultivate the next generation of researchers**: For academic users, quantum computing's wide-ranging applications can encourage interdisciplinary research and collaboration among various departments within your university, fostering a culture of innovation and driving scientific breakthroughs. Additionally, by providing training and access to quantum computing resources, you can ensure that your students are equipped with the skills and knowledge required to excel in the rapidly evolving job market and contribute to the advancement of quantum technologies.

By integrating quantum computing into your HPC center, you can give your researchers and customers a head start on the problems fault-tolerant machines will address. To plan next steps, book an on-premises consultation, and see how Libra will reach users through Amazon Braket in 2028 on our quantum roadmap page.

11. About QuEra Computing Inc

QuEra Computing is building fault-tolerant quantum computers for real work, on Amazon Braket from 2028 and inside HPC centers, from ingredients already demonstrated in peer-reviewed research. Founded in 2018 by scientists from Harvard University and MIT and based in Boston, QuEra operates Aquila on Amazon Braket, has deployed Gemini on premises, including beside ABCI-Q at AIST in Japan, and was selected for Stage B of DARPA's Quantum Benchmarking Initiative. QuEra works with partners including AWS, NVIDIA, HPE and Dell, and with national centers including the UK's National Quantum Computing Centre and NERSC. For more information, visit quera.com and follow us on LinkedIn.

References

[Bluvstein2024] Bluvstein D., Evered S. J., Geim A. A., et al. "Logical quantum processor based on reconfigurable atom arrays." Nature 626, 58–65 (2024). doi.org/10.1038/s41586-023-06927-3

[Rodriguez2025] Rodriguez P. S., Robinson J. M., et al. "Experimental demonstration of logical magic state distillation." Nature 645 (2025). doi.org/10.1038/s41586-025-09367-3

[i] https://www.bcg.com/publications/2023/enterprise-grade-quantum-computing-almost-ready
[ii] https://queracomputing.github.io/Bloqade.jl/dev/
[iii] https://github.com/QuEraComputing/GenericTensorNetworks.jl

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