Don’t Think You Have Any Quantum Use Cases? It’s Time To Take A Closer Look

Figure 1: The IBM Starling quantum computer. IBM

What do giants like IBM, Google, Amazon, Intel, and Microsoft have in common with smaller companies like Rigetti, IonQ, Quantinuum, Xanadu, PsiQuantum, Pasqal, and QuEra? They all believe in the future of quantum computing, that it is nearly here, and that each has the right strategy to make it a reality. By “real,” I mean that their qubit-based systems can far outperform traditional digital (1’s and 0’s) computers on meaningful tasks, commonly called Quantum Advantage. However, to make their dreams come true, they all need the same three things: reliable hardware, economically meaningful use cases, and accessible hardware. (IBM and Intel are clients of Cambrian-AI Research.)

Reliable Quantum Hardware

Quantum's tremendous potential has given rise to a plethora of approaches that have demonstrated the advantages of quantum computing. The various techniques, including Superconductivity, Trapped Ions, and Neutral Atoms, have all shown the feasibility of working quantum computers. Some companies have published roadmaps to deliver quantum computing at scale. However, to be useful, quantum hardware (qubits) must scale at a reasonable error rate, in addition to supporting compelling use cases and being affordable.

IBM has made a clear, rigorous, comprehensive framework for realizing a large-scale, fault-tolerant quantum computer by 2029 with Starling. The 100M gate machine will support ~200 logical qubits and will be succeeded by Blue Jay in ~2033, with over 1 billion gates and ten times as many logical qubits. IBM has also disclosed details about the first-ever accurate, fast, compact, and flexible error correction decoder — one that is amenable to efficient implementation on FPGAs or ASICs for real-time decoding.

Figure 2: The IBM Quantum roadmap has been updated to project advances through 2033. IBM

Quantum Use Cases That Matter

Possible use cases for quantum computing are practically unlimited, as many scientific and business problems simply cannot be solved by traditional computing methods. The Boston Consulting Group (BCG) has analyzed key industries and estimated the potential economic value that quantum computing can bring. The result is vast, with over half a trillion dollars in potential value by 2040.

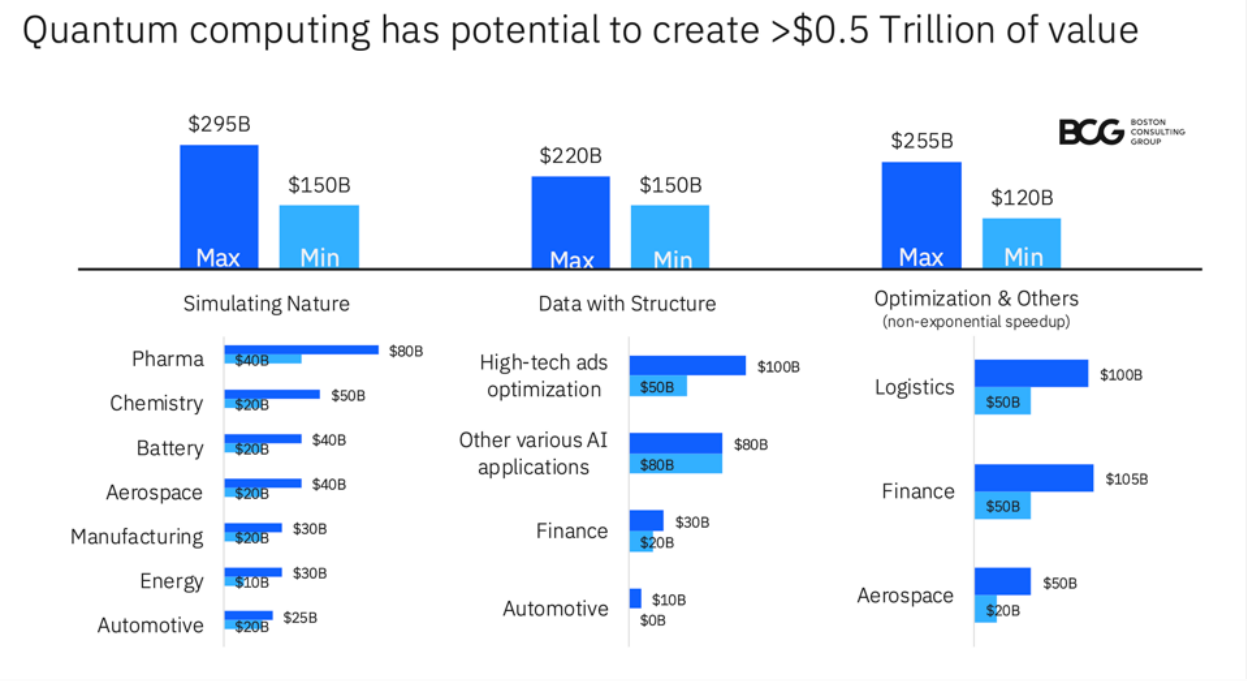

Figure 3:The Boston Consulting Group has compiled a list of use cases across various industries that could create over half a trillion dollars in value.

While the general impression today may be that there are few practical quantum use cases, research reveals that there are hundreds of economically attractive quantum applications.

IBM believes quantum computing will have impact across four problem areas—chemistry & materials, optimization & search, machine learning/AI, and numerical simulation—that will provide business value across various industry use cases.

IBM identifies numerous use cases and applications in Healthcare/Life Sciences, Electronics, Finance, Automotive, Energy, Logistics, Insurance, Airlines, and many other industries.

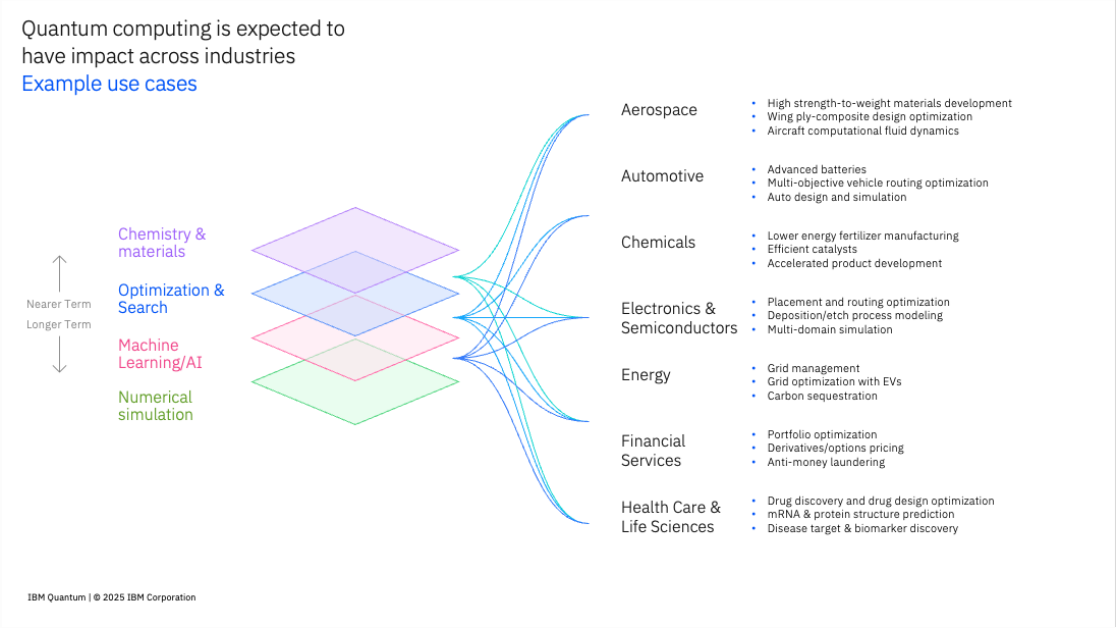

Figure 4: Quantum use cases across industries. IBM

IBM's commitment to developing a general-purpose quantum computing platform to drive these applications could be the company's most significant competitive advantage as quantum computing moves from academia to the broader industry, and its Qiskit application framework represents a key enabler and potential defensive moat. We think of Qiskit as IBM's quantum equivalent to Nvidia CUDA; a development platform that helps optimize and deploy applications. IBM leadership recognizes that it will be their partner ecosystem that will drive applications over time.

Quantum in the Energy Sector

E.ON, one of Europe's largest energy companies, is responsible for providing power 24x7, and must prepare well in advance to account for complex and dynamic changes in both supply and demand. E.ON procures energy before it knows the demand and pricing dynamics that will be at play when it is consumed. The company is exploring quantum computing to help conquer this challenge.

“We are a digital energy company,” said Dr. Giorgio Cortiana, Head of Data & AI, Energy Intelligence at E.ON Digital Technology GmbH. “Quantum Computing will be an essential complementary technology to help us master the complexity of future energy systems.”

Together, IBM and E.ON are working on multiple use cases for quantum computing. As one of the first and most interesting cases, they designed an algorithm for weather risk management intended to surpass classical approaches when executed on quantum hardware. Using Monte Carlo simulation, the solution evaluates the expected cost of offering energy at specific prices under various weather scenarios over the duration of a contract. By running the algorithm multiple times, E.ON can generate actionable insights for hedging strategies.

After validating the algorithm in principle, the team prepared to implement it on IBM Quantum hardware. The initial version required quantum circuits too lengthy for the quantum systems available in 2023. To address this, the team utilized IBM Qiskit’s dynamic circuits capability, decomposing the problem into smaller segments executable on a 27-qubit IBM Quantum system.

“With IBM’s announcement of the Starling fault tolerant quantum computer, E.ON is looking forward to running the risk management algorithm at operational scale in 2029.”, Dr. Corey O’Meara, Chief Quantum Scientist at E.ON Digital Technology GmbH. said.

Quantum in Life Sciences and Healthcare

The current development time for a new drug is from 10-15 years today, costing $3B on average, with a 90% failure rate. Utilizing quantum computing could halve this time and significantly reduce development costs. Consequently, many pharmaceutical companies are already investing in the development of quantum computing.

Figure 5: The Pharmaceutical market is a fertile ground for Quantum computing. IBM

Examining the top simulation use cases in the pharmaceutical industry reveals that the healthcare and life sciences sectors stand to benefit considerably from quantum computing. They can model molecular interactions, protein folding, and enzyme behavior with a level of precision that classical systems struggle to achieve—potentially accelerating drug target identification, screening, and other use cases.

Healthcare and life sciences companies are actively exploring these applications. The Cleveland Clinic, in collaboration with IBM, is investigating quantum-enhanced modeling for biomedical problems. Similarly, RIKEN in Japan is partnering to simulate complex biomolecular systems that can inform new therapies. Companies like Moderna, Amgen,

and others are integrating quantum research into their development pipelines, aiming to drive innovation in areas such as personalized medicine, oncology, and vaccine design.

The pharmaceutical market is a prime candidate for quantum advantage—and as quantum hardware and algorithms mature, its impact on drug discovery and development is expected to be transformative.

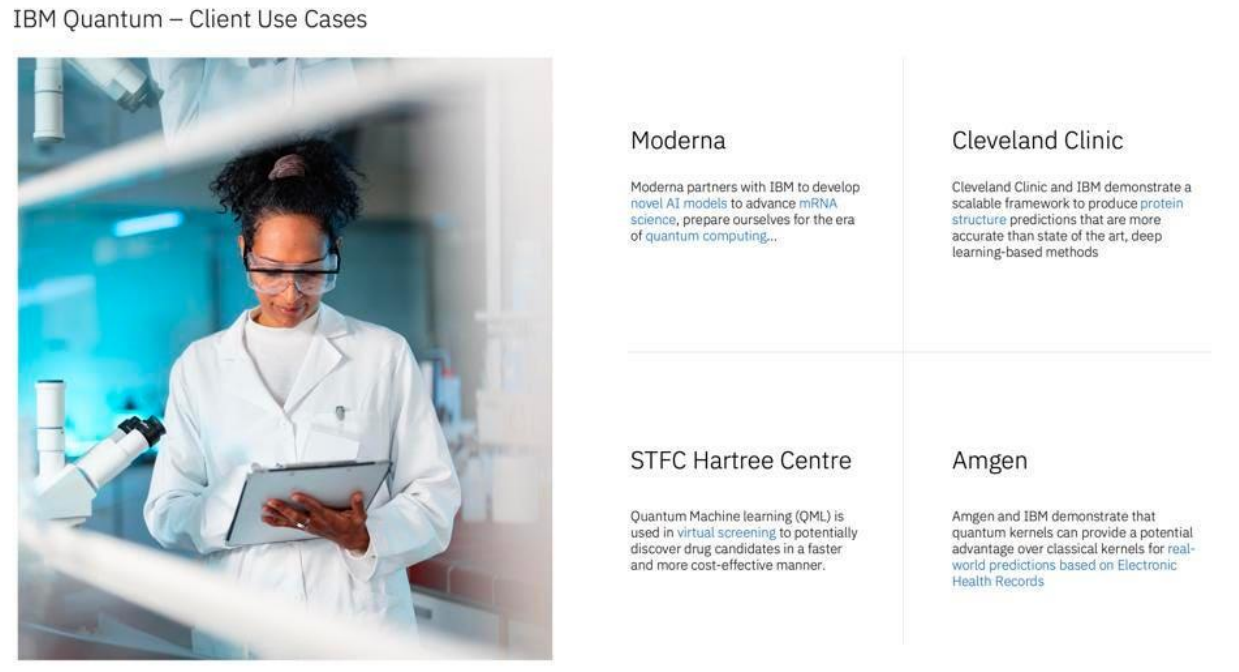

Figure 6: Quantum use case examples in health care. IBM

Quantum in Other Sectors

Most other segments see opportunities for quantum using quantum machine learning, optimization, and simulation. The key in each of these use cases is that you can't wait for better hardware. It will come inevitably, so researchers are working now to develop the algorithms and quantum circuits.

In Finance there is a considerable work being done in trading and in the insurance industry. The electronics industry is also ripe for a quantum revolution, utilizing machine learning and simulation techniques to discover more efficient solutions, develop more energy-efficient materials, and accelerate development at both the chip and system levels. Given the massive rise in semiconductor revenues driven by the AI opportunity,

companies are eager to reduce costs and accelerate time to market. Quantum could provide chip and system development with another much-needed boost.

The automotive industry is no different, as quantum machine learning and simulation are being developed to reduce manufacturing complexity, enhance electrification, expedite time to solution, and improve safety. In automotive engineering, quantum mechanics can aid in the discovery of advanced materials through molecular dynamics and mechanics simulations. McKinsey and Company has forecast that the application of quantum computing could drive $29 billion to $63 billions of value by 2035 in the automotive industry alone

Quantum Hardware Accessibility

All quantum hardware developers are making their early systems available to select scientists and researchers. However, the volume of available hardware is limited, and the cost of access remains a significant obstacle for developers. These companies need to find more affordable and flexible starting points to enable a larger ecosystem to work on their hardware.

IBM has learned a great deal over the last nine years, since it first began making quantum computing available via the cloud in 2016. Perhaps the most important lesson is that researchers need a modular access model that doesn’t break the bank. Now, the IBM Quantum Flex Plan offers a new access model designed for project-based work on the IBM fleet of quantum computers.

In this model, users pre-purchase minutes of access to IBM quantum computers, enjoying all the same access to IBM Quantum computers and services as Premium Plan users, but in smaller bites.

Target users include enterprise clients whose use cases require bursts of sustained execution, researchers aiming to maximize the efficient use of grants, educators whose courses require access to quantum computers during only part of the semester, and more.

The Flex Plan provides users with access to Premium Plan-level quantum computers at an entry point of just $30,000, with the option to buy more as their needs grow.

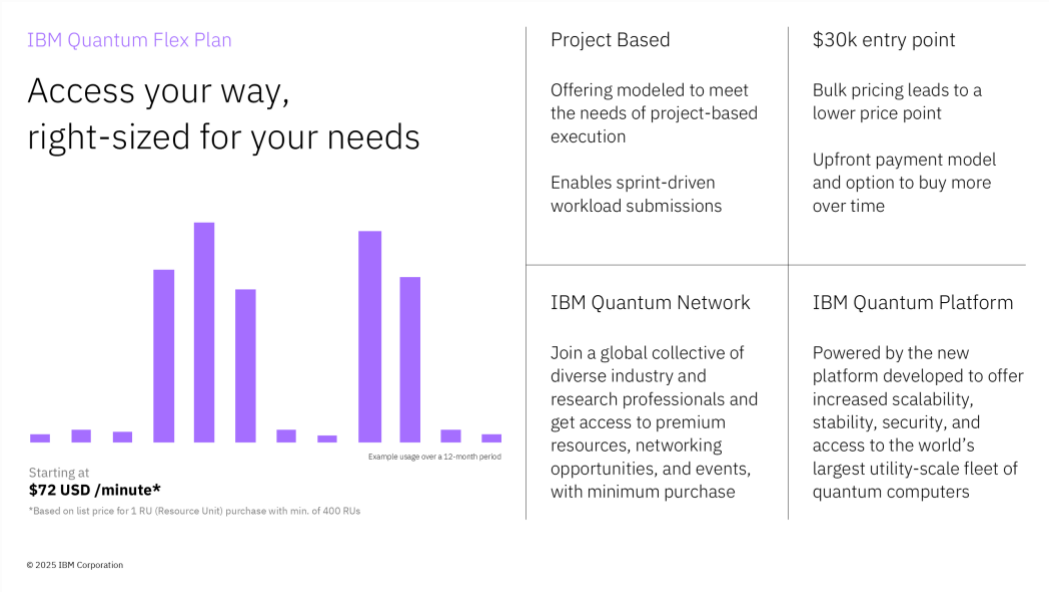

Figure 7: IBM now offers a flexible model to access quantum computing, which lowers the cost of getting on board. IBM

Should You Wait for Quantum?

Organizations that think ahead beyond this quarter's financials and plan for the future are already preparing for the deployment and benefits of quantum computing. Waiting for these three enabling features (fault-tolerant hardware, impactful uses cases, and affordable access) to fully materialize only means being late to the party. If you have quantum use cases, services like IBM's Flex Plan allow you to get started now. If you don't believe you have use cases requiring quantum computing, you may want to take a closer look. Adopting quantum computing too late could put you at a serious competitive disadvantage.