

TECHNOLOGY AND ENERGY: THE DEEP-TECH FRONTIER

QUANTUM COMPUTING AND NUCLEAR FUSION

Where two deep-tech bets meet: tritium chemistry, computing and implications for the investor

Updated as of October 2026

Thematic report — Deep-tech asset class

Document intended exclusively for professional and institutional investors

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1. Executive Summary

Quantum computing does not yet accelerate fusion, but it has found a concrete problem: simulating the chemistry of the salt that must produce tritium. Below we refer to the fusion report (hereinafter the “Report”), which can be downloaded from our [website](#).

- **The fact.** On 29 June 2026 IBM, Oak Ridge National Laboratory and Cleveland Clinic calculated nine FLiBe configurations, a molten salt for blankets, on quantum hardware. It is the first calculation of its kind; the results match classical ones and the preprint is not yet *peer-reviewed*.
- **The problem.** The world produces about 20 kg of tritium a year, roughly 44 days of consumption for a 1 GW plant: the reactor must manufacture its own fuel. Classical DFT can get the salt's free energy wrong by up to 10%, and that is where quantum computing adds its value.
- **The limits.** A real blanket contains on the order of 10^{24} particles; on plasma the quantum contribution is theoretical and, in the nonlinear case studied in Quantum, costs more than the classical approach.
- **The dates.** Starling, IBM's fault-tolerant computer, is expected in 2029; fusion pilot plants by the late 2030s. Both roadmaps are corporate plans, not guarantees.
- **For the investor.** It is an option on an option: no change to the Report's barbell strategy. The most concrete link is the shared supply chain: cryogenics, superconductors and helium-3.

2. Why fusion has a computing problem

Many obstacles to commercial fusion will not be overcome by a new plasma record, but by data that is missing today: no plant has ever been continuously exposed to the heat and radiation of a fusion reaction. That data can be obtained by building very expensive machines or by simulating. The Report identifies three bottlenecks where simulation matters:

- **Tritium:** the reactor must produce more than it consumes (tritium breeding ratio above 1), but breeding has only been demonstrated in the laboratory. The Report places it among the “unknown unknowns”.
- **Materials:** bombardment by 14.1 MeV neutrons embrittles components. Mohamed Abdou (UCLA) estimates that first-generation components could fail on average every 20 minutes, with repairs taking “many months”.
- **Plasma:** it is unstable by nature; keeping it hot, dense and stable for long periods remains among the hardest engineering problems ever tackled.

The Report's SWOT already lists AI- and simulation-assisted engineering among the opportunities. The question of this new document has a narrower scope: where can a quantum computer add something that supercomputers and AI cannot provide?

Deep-Dive Box: what is DFT

DFT (*Density Functional Theory*) is the method computational chemists use by default to calculate how electrons are arranged in a molecule or a material, and from there binding energies and chemical properties.

The underlying problem is that following every electron with exact quantum mechanics becomes impossible as the system grows: the possible configurations explode. DFT sidesteps the difficulty with one idea: instead of tracking

individual electrons, it is enough to know the electron density, that is, how much charge there is at each point in space. A theorem (Hohenberg–Kohn) states that, in principle, everything else can be derived from that density.

The price is an approximation. The theory requires a term, the exchange-correlation functional, that nobody knows exactly, and all the versions used in practice are estimates. That is why DFT is fast and often very useful, but it can be wrong in systems where electrons interact in complex ways.

For our purposes DFT is exactly the qualifying point for quantum computing. According to IBM's blog, in earlier work DFT got the free energy of the molten salt FLiBe wrong by up to 10%: too imprecise to tell whether tritium binds to fluorine (forming corrosive tritium fluoride) or stays free as a gas. In the three-stage workflow DFT does most of the work at the second stage, with AI surrogates to speed it up; the quantum computer only steps in on the calculation where DFT is less accurate.

Scheme 1. Density Functional Theory.

3. The IBM–ORNL case: simulating the salt that produces tritium

On 29 June 2026 a team from Oak Ridge National Laboratory (ORNL), Cleveland Clinic and IBM published on [arXiv](#) the first quantum-computer calculation of a fusion blanket material: nine configurations of FLiBe, a molten salt of fluorine, lithium and beryllium. It is a proof of feasibility, not a quantum advantage: the preprint is not yet peer-reviewed ([Live Science](#)) and the results only matched the best classical methods ([IBM Quantum Blog](#)).

Why the salt matters. The blanket surrounds the plasma: neutrons strike lithium-6 and produce tritium, beryllium multiplies the neutrons, and the salt shields the magnets and carries away the heat. The chemical crux is where the tritium ends up: if it binds to fluorine it forms tritium fluoride, which is corrosive and hard to extract; if it stays free it escapes as a gas. Predicting this requires very precise binding energies, and DFT (the standard classical method) in earlier work got the salt's free energy wrong by up to 10%, according to IBM's blog.

What was done. The researchers extracted nine configurations from the simulations, each a cluster of 21 ions, and calculated their energy with and without tritium. An embedding technique breaks the calculation into fragments: classical computers solve the simpler ones, an IBM Heron quantum processor the most entangled ones, and the classical computers then reassemble the molecule. The work reuses the method with which Kenneth Merz (Cleveland Clinic) had already calculated the electronic structure of a 12,635-atom protein.

What was not demonstrated:

- **No new result.** The nine calculations were compared with reference classical methods and coincide: they validate the method, they do not discover anything.
- **Scale.** A real blanket is about a metre thick and contains on the order of 10^{24} particles; according to IBM it will remain beyond the reach of computational chemistry for the foreseeable future. The plan is to move from 21 ions to larger clusters and from nine to hundreds of configurations.
- **One stage out of three.** The quantum step is the most delicate in the full workflow, but also the only one this work puts to the test.

ORNL's stated goal is to give fusion engineers a way to design and vet a salt on a computer before mixing and heating it in the laboratory.

The study tests only the last of the three stages

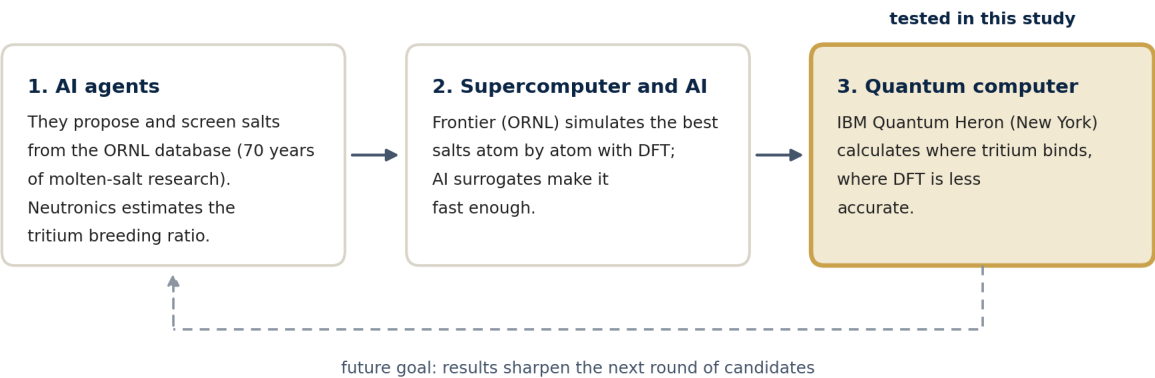


Figure 1. IBM–ORNL workflow · 3 stages and feedback loop.

The loop starts with AI, passes through the supercomputer and ends with the quantum step, the only one tested by the study; feeding the results back into salt selection is a future goal.

4. Tritium in numbers: it cannot be bought, only produced

About 20 kg of tritium are produced worldwide each year: enough to run a single 1 GW plant for about 44 days, and decay makes stockpiling impossible. That is why the blanket is not an accessory but the tool that decides whether a fusion reactor can exist: the Report sums it up in the requirement of a tritium breeding ratio above 1.

Quantity	Value	Source
Global tritium production	~20 kg/year	Live Science
Half-life	12 years (loss ≈ 5.6% a year)	Live Science; author's calculation
Consumption of a 1 GW plant	~0.45 kg/day, ~165 kg/year	IBM Quantum Blog ; author's calculation
Global production ÷ consumption of a 1 GW plant	~44 days	author's calculation
Deuterium in seawater	33 g per m ³	Live Science
Energy of 1 g of D-T fuel	≈ 9,100 litres of oil	US Department of Energy, cited by Live Science

Table 1. The numbers on tritium.

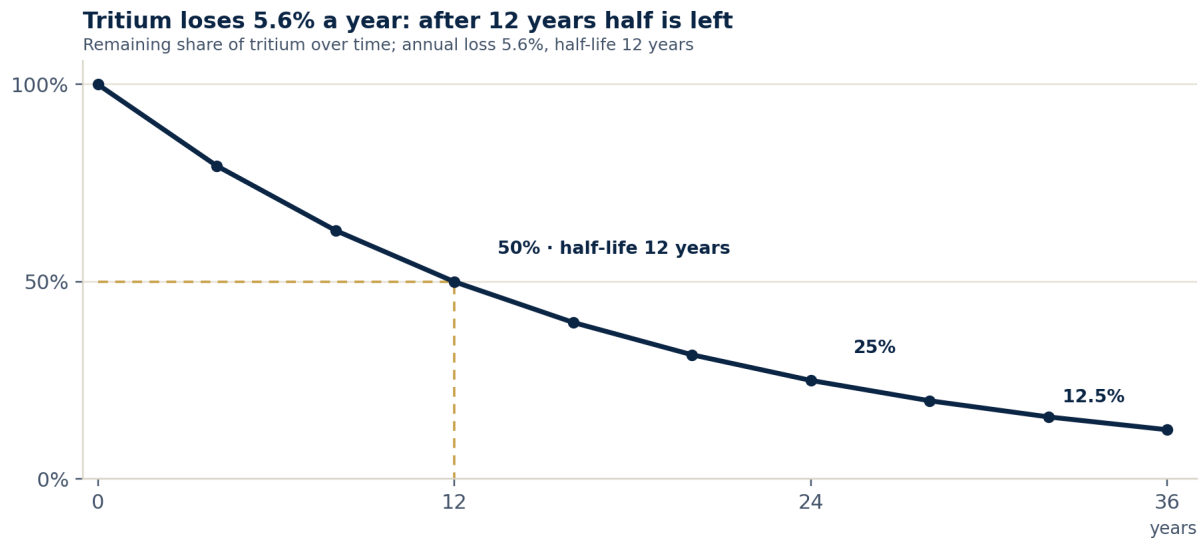


Figure 2. author's calculation based on a 12-year half-life (Live Science) · 36 years.

A tritium stockpile built today halves in 12 years (see Figure 2): the fuel has to be produced as it is needed.

The annual consumption of a single 1 GW plant (~165 kg) is about eight times global production. Deuterium is not a problem; tritium is, and the only route is to produce it in the reactor itself, with a chemistry that nobody has yet been able to observe for years under real conditions.

5. Where quantum can help fusion, and where it cannot

The most credible quantum contribution concerns blanket chemistry; on plasma it remains theoretical, and real-time control is not its territory. A [community roadmap](#) (May 2026) on post-Moore technologies for plasma simulation reaches the same conclusion: no technology will replace supercomputers, and quantum is the least mature but potentially the most disruptive, in particular for the physics of warm dense matter (*warm dense matter*) and for the microphysics of inertial fusion.

Challenge (from the Report)	Dominant tool today	Where quantum would enter	Maturity of the quantum contribution	Source
Blanket chemistry (tritium in the molten salt)	DFT on supercomputers, with AI surrogates	Binding energies where DFT is off by up to 10%	Proof of feasibility: 9 configurations of 21 ions, results equal to classical	IBM Quantum Blog
Materials under neutron irradiation	Classical molecular dynamics and DFT	Electronic states of defects, if DFT proved insufficient	No demonstration in the sources consulted	Author's assessment
Plasma: turbulence and confinement (nonlinear kinetics)	Supercomputers and AI	Algorithms for the Vlasov equation	Theoretical: in the 1D nonlinear case the algorithm studied costs more than the classical one; a preprint proposes a speedup for a weakly nonlinear model	Quantum 10, 2206
Inertial fusion microphysics (stopping power, opacity)	Classical methods, limited in strongly correlated regimes	Stopping-power calculations for target design	Long horizon: ~10 ³ logical qubits and 10 ¹⁵ –10 ¹⁷ Toffoli gates needed	Community roadmap

Challenge (from the Report)	Dominant tool today	Where quantum would enter	Maturity of the quantum contribution	Source
Real-time plasma control	FPGA and machine learning	No plausible role	Not applicable	Author's assessment; community roadmap for FPGAs

Table 2. The main challenges in moving from laboratory nuclear fusion to industrialization.

The distance between ambition and hardware is measured in orders of magnitude. The [IBM roadmap](#) targets Starling in 2029, with 200 logical qubits and 100 million operations, and Blue Jay with 2,000 logical qubits and one billion operations. The stopping-power calculation requires 10^{15} – 10^{17} gates: 6 to 9 orders of magnitude beyond those milestones (indicative comparison by the author: the two metrics count different operations).

The preprint [Berntson et al.](#) on weakly nonlinear plasma and the study published in Quantum show that the advantage depends on the formulation of the algorithm, not only on the hardware: in the sources consulted it has not been demonstrated for any plasma problem of practical interest.

Deep-Dive Box: post-Moore technologies

Post-Moore refers to computing technologies that go beyond Moore's law, the observation that the number of transistors on a chip doubles roughly every two years. For decades this made processors faster and cheaper almost automatically. Today that growth is slowing: transistors have reached sizes close to physical limits, and the bottlenecks are shifting to data movement, memory access and energy consumption.

The "post-Moore" alternatives are architectures different from traditional CPUs and GPUs:

- Specialized accelerators (FPGA, SmartNIC, DPU), which run the most repetitive steps on dedicated hardware.
- Non-von Neumann architectures, in which computation and memory are not separate: neuromorphic, thermodynamic, in-memory, photonic.
- Quantum computing, which exploits quantum phenomena instead of classical bits.

The term comes from the community roadmap on plasma simulation, which assesses precisely these three families. Its conclusion is that none will replace today's supercomputers: accelerators are ready for targeted uses in the short term, non-von Neumann architectures in the medium term, and quantum is the least mature but potentially the most disruptive, above all for the microphysics of inertial fusion.

Scheme 2. Post-Moore technologies and how they can help the development of nuclear fusion.

6. Two trajectories, a possible crossing

If the IBM roadmap holds, fault-tolerant quantum hardware will arrive in 2029, before fusion pilot plants come into operation (late 2030s): in time for the final iterations on blanket materials, not necessarily for the first choice (author's assessment).

Where quantum stands today. On 30 July 2026 IBM and partners presented three papers claiming quantum advantage with built-in validation: experiments of up to 74 qubits on Floquet dynamics, 56 qubits on an operator Loschmidt echo, and a 70-logical-qubit computation with an effective error per gate reduced by about 10 times ([IBM Quantum Blog](#)). These are physics problems chosen to be hard for classical computers, not industrial

chemistry problems, and they remain under verification: the Quantum Advantage Tracker compares them with the best classical methods, and IBM itself writes that the announcement opens the result to a new level of scrutiny.

The IBM roadmap. Loon in 2025, Kookaburra in 2026, Cockatoo in 2027, then Starling in 2029 with 200 logical qubits and 100 million operations ([The Quantum Insider](#)). It is a corporate plan, as are the dates of fusion developers: in that sector slippage is the historical norm (General Fusion went from the 2022 promised in 2014 to the current 2035, according to the Financial Times), and neither roadmap is a guarantee.

Deep-Dive Box: Floquet dynamics and the Loschmidt echo

Floquet dynamics describe how a quantum system behaves when it is repeatedly "hit" by pulses of energy at regular intervals, instead of being left to evolve on its own. The name comes from Floquet's theorem, which says that if the system is driven periodically, its evolution in turn has a recurring structure that can be studied step by step, at each cycle.

Why they matter: a system of many interacting particles, driven periodically, can show behaviours it would not have without the drive, for example oscillations that persist over time instead of dying out. They are also a natural testbed for quantum computers, because simulating these dynamics with many particles quickly becomes too costly for classical methods.

In this document they appear in the paragraph on the state of the art of quantum. According to IBM's blog, researchers at Qedma, with RIKEN and BlueQubit, used circuits of up to 74 qubits to follow the magnetization of a system over time and observed persistent oscillations that two classical simulation methods, run on one of RIKEN's largest supercomputers, did not reproduce. In the hardest regime the two classical methods gave answers that disagreed with each other.

It is a physics problem chosen precisely because it is hard for classical computers, not an industrial chemistry problem: that is why in this document I cite it as an example of a quantum-advantage demonstration still under verification, not as a result useful for fusion.

The Loschmidt echo measures how sensitive a system is to small disturbances, by letting it evolve over time and then, ideally, "rewinding" it.

The idea. One starts from an initial state and lets it evolve for a time t . Then the evolution is reversed, but with a small error: the Hamiltonian (the rule that governs the system) of the return differs slightly from that of the outward leg. Without the error, the system would return exactly to the starting point. The echo is the degree to which it really does return: in formulas, the overlap between the starting state and the one obtained after the round trip.

Why it is interesting. If the echo stays high, the system is robust: the disturbance matters little. If it collapses quickly, the system is chaotic: the small error is amplified and the initial information disperses. That is why it is a standard tool for studying quantum chaos and decoherence, that is, the loss of "quantumness" caused by the environment.

The name. It comes from Loschmidt's paradox (19th century): microscopic laws are reversible in time, yet macroscopic phenomena are not (a broken egg does not reassemble itself). The echo is the way of turning that paradox into an experiment: how truly "rewindable" is the evolution?

The operator version. Instead of looking at the state of the system, one looks at how a measurable quantity (an operator) evolves. According to the IBM blog cited in this document, this quantity tracks how information propagates in heterogeneous quantum systems. It is on this measure that Algorithmiq worked with 56 qubits, in a regime where three classical simulation groups gave inconsistent predictions.

Scheme 3. The state of the art in quantum computing.

Starling (2029) comes 8-10 years before fusion pilot plants

Planned dates: IBM roadmap, company announcements and researchers' estimates, not guarantees

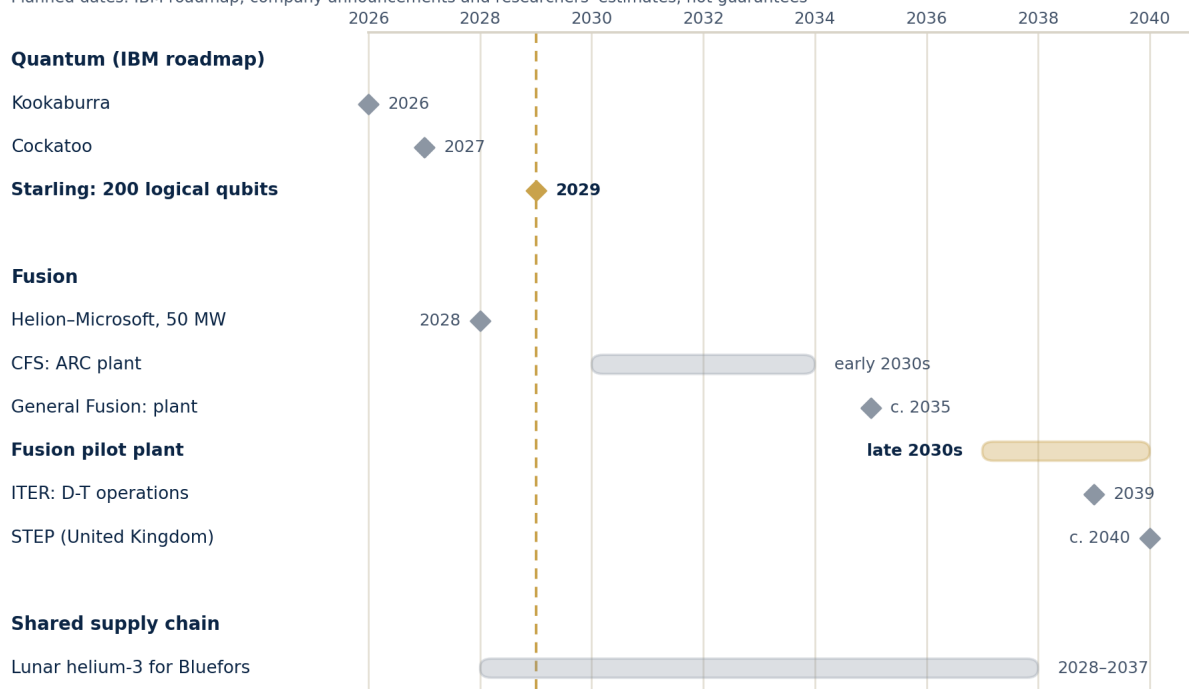


Figure 3. Planned dates · IBM roadmap, the Report, Financial Times, Quantum Computing Report.

The useful window for quantum runs from 2029 to the late 2030s: if Starling arrives in time, materials calculations can serve the pilot plants; if it slips, they will serve the next generation (author's assessment).

7. A shared ecosystem: cryogenics, helium-3 and energy

Fusion and quantum do not share a product but an industrial supply chain, and the most concrete link today is helium-3.

Supply chain	Role in fusion	Role in quantum	Overlap
Cryogenics	Cooling of HTS superconducting magnets, at temperatures below -180 °C	Dilution refrigerators: processors operate below 10 millikelvin	Shared industrial skills; not the same product (about four orders of magnitude of difference)
Helium-3	Fuel for the D-He3 reaction, rare on Earth	Necessary component of dilution refrigerators	Concrete commercial demand today only from quantum
Superconductors	HTS tapes (REBCO) for the magnets, with suppliers such as Fujikura	Superconducting qubits	Shared know-how, separate supply chains
Vacuum and control electronics	Plasma chamber and power electronics	Isolation and control electronics for qubits	Similar suppliers and skills (author's assessment)

Table 3. The production supply chain: for both nuclear fusion and quantum computing.

Helium-3: quantum got there first. The Report cites helium-3 as the fuel of the D-He3 reaction and judges lunar mining more speculative than practical. But the agreement that turned it into a business belongs to quantum: Bluefors, a maker of dilution refrigerators (over 1,500 delivered), agreed to buy up to 10,000 litres a year from

Interlune, with deliveries from 2028 to 2037 ([Quantum Computing Report](#)). A fusion path based on D-He3 would therefore have to compete with a buyer that has already contracted the supply (author's observation).

Computing and energy call on each other. China's data centres will quadruple their consumption to 774 TWh by 2030 according to Wood Mackenzie, or about 88 GW of average load. The 50 MW Microsoft–Helion contract, expected from 2028, would cover about 0.06% of it (author's calculation; scale comparison between different operators). The link with AI is therefore financial before it is physical, as already written in the fusion report: hyperscalers are the first customers, not yet the solution to their hunger for energy. And computing, in turn, helps design fusion, as the IBM–ORNL case shows. No link in the circle is guaranteed: each depends on technologies that are not yet commercial.

8. Implications for the investor: an option on an option

Quantum applied to fusion has value only if two uncertain and largely independent events occur together: that fusion becomes commercial and that the quantum computer beats classical methods precisely where it matters. As in the fusion report's framework, the value is read as a real option, here nested:

$$V_{\text{quantum} \rightarrow \text{fusion}} \approx P(\text{commercial fusion}) \times P(\text{useful quantum advantage} \mid \text{fusion}) \times \Delta V$$

Formula 1. Approximation of the value of quantum computing applied to nuclear fusion.

where:

$V_{\text{quantum} \rightarrow \text{fusion}}$: the value of quantum applied to fusion.

$P(\text{commercial fusion})$: the probability that fusion becomes commercial.

$P(\text{useful quantum advantage} \mid \text{fusion})$: the probability that quantum delivers a useful advantage, given that fusion arrives (the bar $\mid$ reads "conditional on").

ΔV : the incremental value that quantum would add in that case.

The product of two probabilities is smaller than either: quantum does not make fusion measurably more likely today, and fusion is not necessary for quantum to have a market. That is why it does not change the Report's barbell structure; at most it strengthens the picks and shovels level.

Level	What you buy	Players	Exposure to quantum and fusion	Risk
1. Diversified IT and HPC core	Groups integrating quantum, AI and supercomputing	IBM, protagonist of the case study	Diluted: quantum is one line among many	Moderate
2. Shared picks and shovels	Cryogenics, superconductors, vacuum, power electronics	Fujikura (fusion); Bluefors (quantum)	Benefits from both technologies without betting on either	Medium-high, diversified
3. Listed quantum pure-plays	Companies specialized in quantum hardware or software	not named in this report	Fusion is a marginal application	Very high
4. Fusion pure-plays	Reactor developers, private or recently listed	Helion, CFS, TAE, General Fusion (GFUZ)	Quantum is not the main lever of their thesis	Very high or extreme

Table 4. The options for the investor.

What to monitor, in order of relevance:

- Peer review and replication of the IBM–ORNL result, today only a [preprint](#).

- The move from 21-ion clusters to larger systems and from nine to hundreds of configurations ([IBM Quantum Blog](#)).
- Kookaburra in 2026, Cockatoo in 2027 and Starling in 2029 delivered on the schedule of the [IBM roadmap](#).
- A demonstration of quantum advantage on a materials chemistry problem, with a fair classical comparison (the [Quantum Advantage Tracker](#) exists for this purpose).
- Experimental verification: salts chosen on the computer tested in the laboratory and tritium breeding in real plants, the real test of the report.
- Contrary signals: work showing that AI-enhanced DFT is enough, and quantum becomes superfluous.

9. Scenarios 2026–2040

The most likely case is that quantum remains a niche tool for fusion materials, not its accelerator. The probabilities are qualitative assessments by the author, not numerical estimates, in the same spirit as the Report's scenario analysis.

Scenario	Description	Probability (qualitative)	Implication for the investor
1. Convergence	Starling arrives on time (2029), quantum enters the blanket design cycle and the pilot plants of the 2030s start with better-chosen materials	Low	Strengthens shared picks and shovels and fusion together; it is the scenario for which no stock is already priced
2. Classical is enough	Improved DFT, AI surrogates and irradiation experiments close the gap; quantum remains marginal for fusion	Medium-high	The fusion thesis does not change; quantum should be judged elsewhere
3. Quantum useful, fusion delayed	Quantum works on chemistry (also in other sectors), but pilot plants slip beyond 2040	Medium	Value for quantum, not for fusion; diversification matters
4. Both delayed	The quantum and fusion roadmaps slip together, as has already happened to General Fusion and TAE	Medium	Nested option with value close to zero over the horizon; the cost of waiting weighs

Table 5. Possible scenarios 2026–2040. The qualitative probabilities are the author's own, produced without estimation models, and therefore reflect his personal opinion.

10. Risks, limits and caveats

The strongest evidence today is a preprint on nine configurations; any stronger conclusion should be treated as a hypothesis.

- **Preliminary evidence.** The IBM–ORNL work is not peer-reviewed, concerns 21-ion clusters and only matched reference classical methods.
- **Stacked hype.** Fusion and quantum share the same narrative of long-term promises. The Report has already flagged the "Theranos moment" risk; combining two sectors exposed to the same risk does not dilute it, it multiplies it.
- **The model does not replace the experiment.** Tritium breeding has only been demonstrated in the laboratory. ORNL's goal is to vet salts on the computer *before* the laboratory, not instead of the laboratory.
- **Contested quantum advantage.** Claims of advantage are publicly compared with the best classical methods; some could be overtaken by new classical methods.

- **Misaligned sources.** On tritium volumes, IBM speaks of a few pounds a year and Live Science of 20 kg; the conclusion on scarcity does not change, the precise numbers do.
- **Unproven supply-chain dependencies.** Lunar helium-3 is a commercial plan with deliveries expected from 2028, not a supply in progress.
- **Limits of this report.** It is based on public sources and preprints; the probabilities and the assessments marked as the author's are judgments, not measurements.

11. Conclusions

Quantum computing does not yet accelerate fusion: today it is a promising tool for a narrow problem, blanket chemistry, within a workflow in which AI and supercomputers do the larger part of the work.

- **A real step, a modest result.** The IBM–ORNL case is the first quantum calculation of a blanket material, but the nine calculations coincide with the classical ones.
- **The potential value lies in tritium's "unknown unknowns".** It counts only if the hardware reaches the fault-tolerant scale IBM foresees for 2029 and if the results survive experimental testing.
- **On plasma quantum remains theoretical; on control it is not needed.**
- **For the portfolio nothing changes in the barbell structure:** one monitors the indicators, and does not bet on a crossing that has yet to be demonstrated.

The decisive test will not be another qubit record, but a salt designed on the computer that produces and releases tritium in a real reactor.

12. Sources

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