



QUANTUM COMPUTING AND OIL AND GAS: OPPORTUNITIES FOR QUANTUM APPLICATIONS IN UPSTREAM PRODUCTION

AUGUST 2026

About the Quantum Economic Development Consortium

The Quantum Economic Development Consortium (QED-C) is the world's premier association of pioneers in the quantum technology marketplace. QED-C members enable real-world application of quantum technology and, in turn, help build a robust commercial industry and supply chain.

Sitting at the intersection of technology, academia, business, entrepreneurship, and policymaking, QED-C fosters the collaboration the industry needs. Its experts and organizations share knowledge and collectively shape the growth of quantum technology. QED-C is managed by SRI.

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Executive Summary

Upstream oil and gas operations rely on high-performance computing (HPC) to analyze subsurface data, simulate reservoir behavior, plan wells, and optimize production. These activities inform high-cost decisions, so faster computation, more accurate and precise solutions, and broader scenario coverage can create substantial value. Despite decades of progress in HPC, several upstream problems remain unsolved at the desired scale or detail level. Quantum computing may eventually help address some of these bottlenecks, but its value, will depend on whether it can complement or outperform continually improving classical methods under realistic industry conditions.

To identify the most promising opportunities, the Quantum Economic Development Consortium (QED-C) and the Research and Development Technical Section of the Society of Petroleum Engineers (SPE) convened a two-day symposium in May 2026. The event brought together oil and gas specialists, many with expertise in HPC, and quantum computing experts to identify computational challenges suited to quantum or hybrid quantum-classical approaches. QED-C and SPE organized the discussions around three areas central to upstream operations: seismic imaging, modeling and simulation, and production optimization and flow assurance. Participants evaluated candidate applications based on technical suitability, potential business value, and readiness for further development.

The symposium participants identified five principal use cases across these three areas. In seismic imaging, participants identified elastic waveform simulation as the principal use case and examined seismic acquisition planning. Elastic waveform simulation is a computationally demanding method for modeling how seismic waves propagate through heterogeneous subsurface formations. Quantum simulation may eventually improve the scaling or time-to-solution of waveform calculations. Optimization methods could improve the placement of seismic sources and receivers under geological, operational, and cost constraints. Elastic waveform simulation is a longer-term opportunity that depends on advances in gate-based quantum computing, whereas optimization problems such as acquisition planning may offer an earlier opportunity using quantum annealing.

In modeling and simulation, participants identified faster porous-media flow simulation and materials design as candidate applications. Hybrid quantum-classical methods could accelerate selected calculations within existing reservoir simulators, allowing operators to evaluate more reservoir models, wider uncertainty ranges, and more development scenarios. Quantum computational chemistry may also help identify materials and chemicals that can withstand harsh subsurface conditions, improve recovery, or support flow assurance. These applications could create value, but quantum-enabled high-fidelity reservoir and materials simulations will depend on further advances in quantum hardware, algorithms, and data transfer methods between classical and quantum systems.

In production optimization and flow assurance, participants examined multi-well production optimization and hydraulic fracturing design. Field-level production decisions require choosing interventions under capital, infrastructure, crew availability, and network constraints. Hydraulic fracturing design involves parameters including stage and cluster spacing, fluid and proppant volumes, pressures, and injection rates. Because these problems are discrete, constrained, and

often nonlinear, they may be suited for experiments with hybrid optimization or quantum annealing. Demonstrating value will require comparison with leading classical optimization methods and, ultimately, validation with field data and scaled pilots.

Symposium participants viewed quantum computing as augmenting, not replacing, the HPC systems that currently support upstream operations. The strongest opportunities involve specific computational problems with defined performance measures and operational relevance. In most cases, quantum capabilities will likely be integrated into existing simulators, optimization platforms, cloud or HPC environments, or service-provider offerings. New computational technologies typically reach upstream operations through an established ecosystem of operators, oilfield service companies, software vendors, equipment manufacturers, and internal technology teams.

Deploying new HPC hardware, software, and methods at scale requires supplier qualification, technical validation, pilot testing, workflow integration, cybersecurity and data governance review, user acceptance, and ongoing operational support. Established vendors and partnerships may therefore play a role in translating quantum capabilities into deployable and supportable tools that fit existing industry workflows. Oil and gas companies will judge these capabilities based on operational performance, including accuracy, reliability, computational cost, ease of integration, and effects on decision-making, rather than on technological novelty.

The symposium highlighted steps that industry and government should consider accelerating the application of quantum computing to oil and gas computational challenges. This report offers four recommendations for industry, government, and technology stakeholders:

- Align quantum technology development with existing oil and gas adoption pathways, beginning with a limited set of industry-defined computational bottlenecks.
- Demonstrate performance using established oil and gas benchmarks, clearly defined classical baselines, and metrics covering accuracy, runtime, scalability, robustness, reproducibility, integration effort, and cost.
- Explore additional opportunities in midstream and downstream operations and in adjacent quantum technologies such as sensing.
- Improve the discoverability and usability of federal geoscience data through standardized metadata and curated, analysis-ready benchmark datasets suitable for algorithm development and validation.

The next stage for quantum computing in oil and gas should focus on precise problem formulation, access to representative data, rigorous comparisons with leading classical methods, and collaborative development of applications where better computation could affect operational decisions and field economics.

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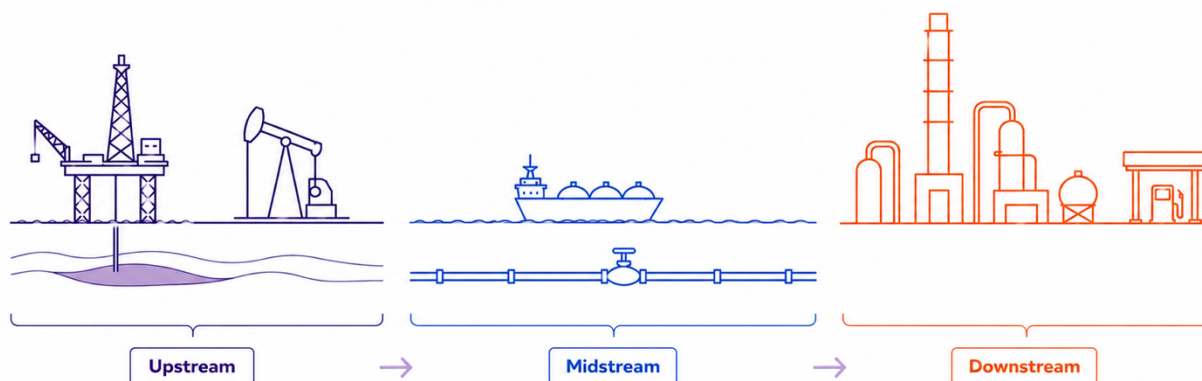
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Introduction

The modern oil and gas industry depends heavily on computation. Companies rely on high-performance computing (HPC) to evaluate subsurface images, reservoir models, drilling plans, and production options. Decisions based on these evaluations can affect investments worth millions or billions of dollars, so even modest gains in speed, fidelity, or scenario coverage matter when scaled. Yet many problems remain difficult despite decades of HPC advances. Quantum computing may address selected bottlenecks, but its role in managing workflows remains uncertain.

As shown in Figure 1, the oil and gas industry is conventionally divided into upstream, midstream, and downstream segments: extraction from the ground (upstream), transportation (midstream), and refining or processing (downstream).¹ Subsurface challenges primarily affect upstream operations, where companies must find and acquire hydrocarbons.

Figure 1: Segments of the Oil and Gas Industry



Source: SRI, diagram developed with DALL•E 3.

HPC has transformed upstream workflows, as three-dimensional seismic imaging illustrates. Although 3D seismic acquisition and processing techniques emerged decades earlier, advances in computing in the 1980s made 3D seismic imaging practical at scale, turning a specialized capability into a standard exploration tool.² Better imaging helped operators characterize the subsurface and develop resources that were difficult to identify or access.³

Despite this progress, computational bottlenecks remain. Modern seismic imaging workflows, including full-waveform inversion, require repeatedly solving wave equations and running large-scale optimization routines to produce subsurface models.⁴ Reservoir management poses similar demands: optimization and history-matching require many simulations to evaluate competing scenarios.⁵ Production optimization for design and intervention decisions requires large combinatorial searches.⁶ These challenges explain the industry's interest in approaches that complement HPC, including quantum computing.

Effectively implementing quantum computing in energy-related applications will depend on advances in both quantum computing hardware and algorithms.⁷ Quantum computing remains at an early commercial stage. There are different modalities of quantum computing which are advancing at different timelines and have strengths to solve different problem sets. Many current quantum information science (QIS) capabilities do not yet match energy-sector needs, but while some applications discussed remain in research and development, building proofs of concept could provide pathways to benchmarking the capabilities and feasibilities to ensure successful adoption. New tools must outperform or complement existing methods, integrate with established workflows, and fit industry procurement and deployment practices.

In May 2026, QED-C and the Society of Petroleum Engineers' Research and Development Technical Section (SPE RDTS) convened a symposium to examine oil and gas use cases.⁸ This report examines several upstream applications identified there, evaluates their suitability for quantum approaches, and assesses the factors likely to shape commercialization and deployment. By considering both technical opportunities and adoption pathways, the report assesses where quantum computing may create value for the oil and gas industry.

Subsurface Analytics in Oil and Gas

Fossil-derived hydrocarbons support much of modern life. Everything from the food we eat to the buildings we sleep in depends on oil or gas as an energy source, feedstock, or industrial input. Together, oil and natural gas supply more than half of the world's energy.⁹ To meet demand, producers increasingly target resources once beyond practical or economic reach because of ultra-deepwater or high-pressure settings, complex geology, low permeability, or directional drilling requirements. Reaching these reserves safely and profitably requires a detailed understanding of the subsurface.

Although the upstream lifecycle also includes mineral rights acquisition and well abandonment, this report focuses on exploration and production activities: seismic surveys, well planning, drilling, and production. The upstream segment of oil and gas adopted computational methods early to improve operations and production.¹⁰

The oil and gas industry draws on geology, physics, chemistry, materials science, and engineering. Development decisions can involve multibillion-dollar commitments over decades amid uncertain commodity prices.¹¹ In 2025, the United States produced a record 13.6 million barrels of crude oil per day, up 3 percent from the previous year despite using fewer rigs and new wells, as productivity gains offset reduced activity.¹² At that scale, even a small efficiency gain in exploration, drilling, or production can be worth millions or billions of dollars.

Major development decisions can require decades-long, multibillion-dollar commitments made amid **uncertain commodity prices** in a market worth several trillion dollars.¹³

Computing advances have repeatedly expanded industry capabilities. In the 1980s, 3D seismic surveys required large supercomputers. Advances have since made them routine across almost all complex exploration programs, even as larger surveys and more complex models keep the most demanding analyses at supercomputing scale.¹⁴

The need to reduce and manage uncertainty drives the oil and gas industry's adoption of computing, particularly for hydrocarbon exploration and production. Operators make expensive, hard-to-reverse decisions based on incomplete, indirect views of the subsurface at limited resolution. The market for oil and gas analytics, which turns field data into predictions, is valued at roughly \$12 billion.¹⁵ This section focuses on two computation-heavy upstream challenges: seismic surveys for subsurface imaging and well planning.

Computational Challenges in Upstream Oil and Gas

Raw petroleum typically contains a mixture of hydrocarbons such as methane, ethane, and propane, as well as contaminants such as nitrogen and carbon dioxide.¹⁶ These hydrocarbons release substantial energy when combusted. Downstream facilities process crude oil and raw natural gas into products such as gasoline, diesel, and jet fuel for use as fuels or feedstocks.¹⁷

Upstream activities encompass four phases: exploration, appraisal, development, and production.¹⁸ The four phases are often grouped under exploration and production (E&P).¹⁹ Exploration covers geological and geophysical work used to find a resource, including seismic surveys, data analysis, and risk estimation. It also includes exploratory wells, or wildcats, that confirm whether hydrocarbons are present and gather data through well logging.

Appraisal follows discovery. Additional wells map the find and assess its commercial viability. Development builds out the field through well planning, predrilling analysis, drilling, and completion of production wells. Finally, production covers the operating phase, including hydrocarbon flow to the surface and maintenance to sustain it.

Across these phases, two of the most computationally demanding problems are subsurface imaging from indirect measurements and simulation of fluid movement. Seismic surveys address the first; reservoir simulation addresses the second and informs well planning.

Seismic Surveys

Oil and gas exploration is risky and expensive.²⁰ E&P companies combine publicly available data with geologic, magnetic, gravimetric, and seismic surveys to assess exploration areas.²¹ Geologists, geophysicists, and geochemists use these data to estimate the quantity, type, and location of potential resources.²² Seismic surveys are valuable predrilling inputs because they can produce three-dimensional or four-dimensional (3D over time) subsurface maps, but they are computationally expensive.²³

Seismic surveys use source and receiver point arrays. Each source generates a known acoustic waveform, and receivers detect the reflected sound waves. Because sound travels at different speeds through formations of different densities, the reflections reveal subsurface layers and rock types. Passive seismic monitoring records seismic activity without an active source and supports tasks such as monitoring induced seismicity or geomechanical features.

Acquiring, processing, and interpreting these data is difficult. Scale is a primary challenge: large 3D seismic surveys can cover hundreds of square miles and generate petabytes of data to store, process, and interpret.²⁴

Methods such as full-waveform inversion can construct high-resolution 3D images of the subsurface, but they are costly. Full-waveform inversion iteratively solves complex elastic and acoustic wave equations across large grids, so teams typically use HPC clusters.²⁵ Processing a large seismic survey can take months and cost hundreds of thousands of dollars.²⁶ Geologists and geophysicists then interpret the processed data, with machine learning also supporting processing and interpretation.²⁷ Key challenges include filtering surface noise and improving model interpretability.

Modern seismic survey techniques have reduced but not eliminated “dry hole” drilling, in which an exploratory well fails to find an economically viable resource. A dry well can cost \$5 million to \$20 million per site.²⁸ Better seismic data collection, processing, and interpretation can therefore translate directly into economic value for E&P companies.

Reservoir Simulation and Well Planning

Development well planning combines seismic surveys, well logs, and other data to create a drilling plan. The problem is technically complex and central to field development. At the well level, engineers set the wellbore diameter, casing requirements, and other features. At the field level, they determine well spacing, well count, completion depth, and the balance between producing and injection wells. Injecting water or gas into the reservoir can maintain reservoir pressure and push more oil toward producing wells.²⁹ To guide these choices, engineers use reservoir models and simulations to forecast how fluids will flow through complex, heterogeneous porous media (i.e., rock) over time.

Data quality presents one challenge. Reservoir simulations draw on seismic surveys, well logs, and production records, which are often noisy or inconsistent.³⁰ Because wells are sparse, and rock properties between them are uncertain, engineers work with many plausible reservoir models that produce a range of production and pressure forecasts.

Physics simulation is another challenge. Models divide the reservoir into blocks and solve mass balance equations across them, increasing computation time.³¹ Engineers have particular difficulty capturing dynamic changes in the near-wellbore region because a wellbore is narrow but simulation grid blocks are much larger. Simulators must represent the well completion interval and surrounding rock within a coarse grid block. This task becomes harder for complex well geometries such as horizontal and multilateral wells.³²

Engineers also calibrate reservoir models against historical field production data. Known as history matching, this is one of the workflow’s most computationally demanding tasks.³³ Because multiple models can fit the same historical data, engineers maintain ensembles of models that fit the data well enough.

These models support optimization and resource allocation as engineers choose well locations and settings to maximize value. When well-planning decisions need not be immediate, teams can run time-consuming HPC simulations. Automated methods have long been limited by the cost of running thousands of candidate cases because each simulator run can take hours.³⁴ Teams therefore seek good solutions with as few runs as possible.

Quantum Computing Overview and Near-Term Opportunity

Oil and gas companies use computational tools for exploration, production planning, logistics, reservoir modeling, and materials analysis. These workflows can reach limits in cost, speed, and solution quality. HPC will remain critical to oil and gas operations, but the cost of adding more HPC resources may not be justified for every problem.³⁵

Quantum computing may help oil and gas companies address problems that classical methods solve slowly, at high cost, or only at limited scale. This section considers quantum computing as

an addition to the industry's computational toolkit. Adoption will require clear evidence of business value, especially where existing classical tools already work well.

To drive adoption, quantum methods must demonstrate sufficient value to justify experimentation despite the maturity of existing tools

What Is Quantum Computing?

Quantum computing uses quantum bits, or qubits, to represent and process information in ways that classical computers do not. Its potential for oil and gas depends on whether researchers can turn advances in quantum theory into capabilities the industry can use.

Classical computers use bits to hold information; the value of each bit can only be zero or one. Qubits in superposition occupy a combination of those states: partly zero and partly one. Entanglement links the properties of multiple qubits. These properties enable a different model of computation, not merely faster classical computing.

Qubits can be created from atoms, ions, superconducting circuits, photons, or other types of quantum systems. Quantum computers apply controlled operations to qubits, whose states evolve according to quantum mechanics. Quantum computing therefore requires different hardware, algorithms, and software.

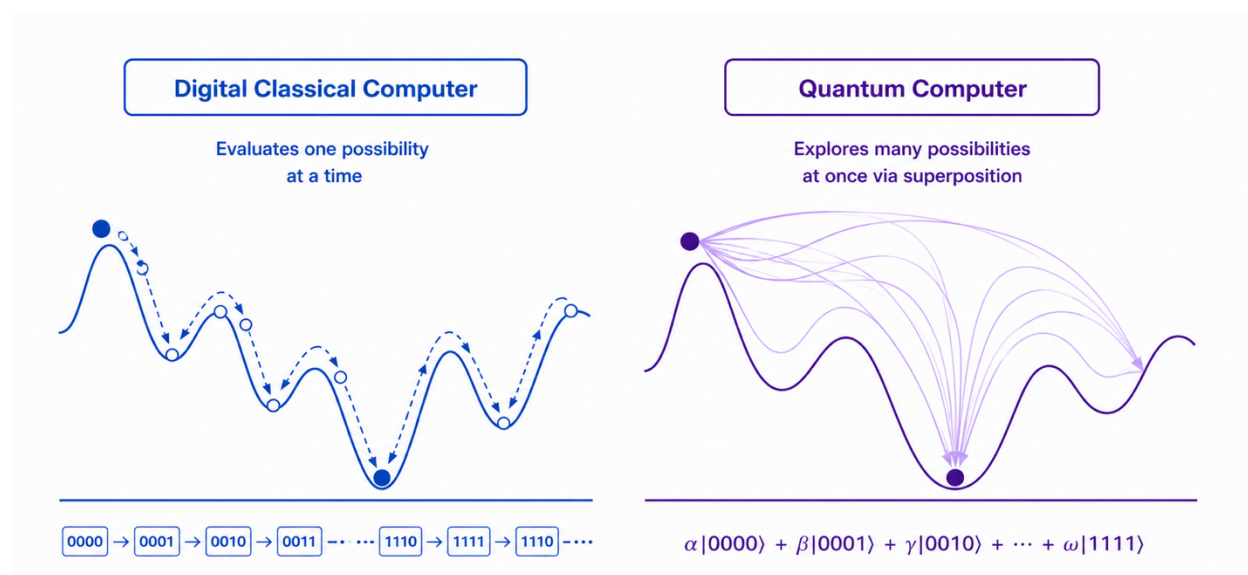
Classical and quantum computers excel at different problems (see Figure 2). The central question is whether a problem has a mathematical or physical structure that a quantum algorithm can exploit. Several algorithms demonstrate potential quantum speedups, including Shor's algorithm, quantum amplitude amplification, and the Harrow-Hassidim-Lloyd (HHL) algorithm.³⁶ These algorithms show theoretical potential, not near-term business value. The dominant modalities are quantum annealing and gate-based quantum computing. Annealing quantum computing systems use quantum mechanical effects to encode a problem so that its optimal solution corresponds to the lowest-energy (ground) state of a quantum system – making it a natural fit for combinatorial optimization problems.ⁱ

Gate-model systems carry out computation by applying sequences of quantum logic gates to qubits, and these systems are best suited for differential equations – such as quantum chemistry and materials science. Both systems have a software stack that you access from classical computers and solvers have been created to allow for quantum-classical hybrid systems technologies, where both HPC and quantum computers can be used together to solve a problem.

ⁱ Kim, S., Ahn, S. W., Suh, I. S., Dowling, A. W., Lee, E., & Luo, T. (2025). *Quantum annealing for combinatorial optimization: A benchmarking study*. NPJ Quantum Information, 11(1), 77. <https://arxiv.org/pdf/2504.06201>

The following sections examine each paradigm by maturity, problem type, and near-term relevance to oil and gas workflows. Gate-based quantum computing and quantum annealing require different evaluation: one offers a long-term potential for certain problems; the other offers better solutions for optimization problems and is more commercially mature.

Figure 2: Classical vs. Quantum Computing Problem-Solving Approaches



Source: SRI, diagrams developed with DALL•E 3.

Hybrid Gate-Based Quantum Computing

Gate-based systems may outperform annealers on problems such as multi-objective optimization. Their computational capabilities and improving hardware make them the likely longer-term direction for quantum computing.

All gate-based systems use quantum gates, analogous to classical logic gates, to run quantum algorithms. In the near term, they are most practical in hybrid workflows in which a quantum processor handles a subproblem within a larger otherwise classical computation.

Hybrid quantum computing parses a problem into subproblems that strain classical methods and suit quantum approaches. These subproblems are often combinatorial, highly correlated, or quantum native, as in molecular simulation. Researchers have explored hybrid quantum-classical approaches to oil and gas challenges, including identifying salt formations in seismic images, scheduling refinery operations, modeling corrosion, and detecting oil spills.³⁷ In the near term, gate-based systems are most relevant for hybrid approaches to important industry problems.

These examples demonstrate applicability but leave questions about scalability and business value. The strongest near-term opportunities are narrow tasks for which classical workflows face performance, scaling, or search-space limits. Even with large, fault-tolerant quantum

computers, classical systems would still handle most computations because they are mature, inexpensive, accessible, and effective.

Current and Expected Near-Term Gate-Based Capabilities

Despite steady progress, gate-based systems remain limited by noise, error rates, and qubit and gate counts.³⁸ Qubit counts, coherence times, and error-correction methods have improved, but many applications still require orders-of-magnitude gains. Large scale gate-model quantum computers are unlikely to run business-relevant oil and gas workflows within two years; practical applications will more likely rely on hybrid approaches in the near term and perhaps longer.³⁹

Overhead associated with implementing quantum computing solutions must also be considered. In particular, data encoding and decoding costs can prevent a theoretical quantum improvement from producing a real-world speedup. The practical question is whether a quantum algorithm improves a real workflow enough to justify adoption.

Recent progress supports cautious optimism. Improvements in hardware, software, and HPC have expanded practical hybrid quantum-classical approaches. In less than two years, researchers have moved from modeling 10-atom methane dimers to modeling biologically relevant molecules with more than 12,000 atoms.⁴⁰ This progress may support quantum chemistry simulations relevant to oil and gas.

Gate-based systems offer a long-term potential for materials science and quantum chemistry; quantum annealing has a nearer-term relevance that is suited for optimization-heavy workflows, such as operational decision problems in oil and gas.

Current gate-based systems have
demonstrated heuristic advantages for
HPC workflows in medicine, chemistry, and
other domains

Quantum Annealing

Computing based on quantum annealing is useful for optimization. Unlike gate-based quantum computing, annealing targets a different class of problems: finding good solutions among many alternatives.⁴¹ These problems often arise in scheduling, resource allocation, and logistics.

Adding stable qubits increases the size of the problems that quantum annealers can represent and may improve solution reliability and quality. Although not every problem is suitable for quantum annealing, its maturity warrants near-term industry attention. Companies such as D-

Wave Quantum offer commercial products, with several thousand qubits for applications such as resource optimization, planning, and emissions reduction.

Problems Suitable for Quantum Annealing

Annealing suits problems that can be expressed as minimum-energy optimization problems. It is most promising when a business problem can be formulated as a constrained optimization problem. Problem fit is the limiting factor: the problem must match the annealer's structure well enough to outperform established methods.

Problems with potential annealing speedups are **discrete, combinatorial, and nonlinear**

Quantum annealers and hybrid approaches have outperformed classical solutions in some cases, sometimes with better solutions and sometimes with solutions faster than classical alone. Optimized classical systems may still deliver benchmarked performance on some problems.⁴² Hybrid quantum annealing has improved cargo routing at the Port of Los Angeles and supported Pfizer's production planning.⁴³ In oil and gas, it could improve decisions such as well-field planning, workforce scheduling, and fracture treatment parameters.

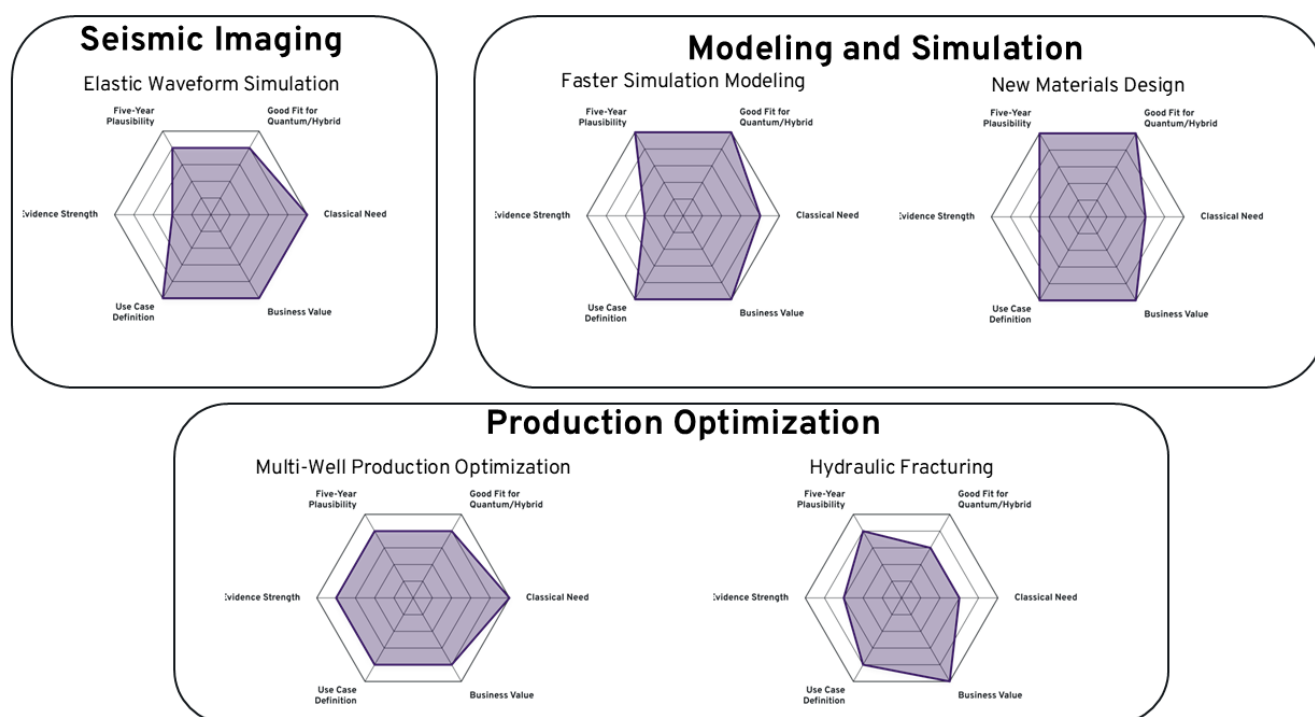
Current and Expected Near-Term Annealing Capabilities

Quantum annealers were the first commercially available quantum computing systems; D-Wave offered its first system in 2011.⁴⁴ The technology has moved beyond laboratory demonstrations, but its performance remains problem-dependent. Results depend on how well a business problem can be formulated for annealing and benchmarked against classical methods. Annealing merits exploration when problems pass fit screening and benchmarking.

Selected Use Cases in Upstream Oil and Gas

For carefully chosen subproblems, quantum computing may deliver faster analysis, better solutions, or lower computational costs. The symposium participants identified use cases for evaluation across three upstream oil and gas functions: seismic imaging, modeling and simulation, and production optimization. Figure 3 compares five use cases across expert-rated technical, business, and readiness criteria. The ratings reflect discussions and consensus decisions. The following sections summarize discussions among quantum computing and industry experts.

Figure 3. Results from Symposium Use-Case Analysis



Source: SRI, diagrams developed based on SPE Quantum Computing Symposium 2026.

Seismic Imaging

The oil and gas industry uses subsurface imaging to characterize reservoirs and estimate resource potential. Generating high-quality, high-resolution images and using them to guide resource deployment requires substantial computational resources. Quantum computing could accelerate survey design, wave simulation, and inversion, reducing lead times for exploration and development decisions.

Elastic Waveform Simulation

Elastic waveform simulation (EWS) predicts how seismic waves propagate through heterogeneous subsurface materials. Operators use EWS to improve subsurface models and reduce uncertainty in exploration, drilling, and reservoir development decisions. Because seismic data acquisition is expensive and high-resolution imaging is computationally intensive, advanced seismic imaging is usually reserved for high-value cases. Quantum computing may reduce EWS compute time and cost through “Schrödingerization,” which reformulates classical wave equations into a Schrödinger or Hamiltonian form suitable for quantum simulation.⁴⁵ By mapping elastic waveform equations, initial conditions, and boundary conditions to that form, quantum computers could improve scaling and time-to-solution for selected EWS tasks, enabling faster, lower-cost high-resolution imaging.⁴⁶ For example, Aramco Research Center Delft worked with D-Wave on the optimization problems related to seismic imaging. Building

subsurface maps from tens of gigabytes of seismic data and using a hybrid-classical application provided gains over classical solutions in both time-to-solution and scale.ⁱⁱ

Additional Use Cases

Other use cases include acquisition planning and field development planning. Acquisition planning, which precedes EWS, designs seismic surveys by selecting source and receiver locations, coverage, and operational constraints. A quantum-enabled workflow could optimize source and receiver placement, coverage, route feasibility, data quality, and cost. Because survey design must satisfy many operational and geological constraints, quantum or hybrid optimization methods could search the planning space more efficiently and identify configurations that improve imaging value.

Field development planning, which follows EWS, combines subsurface drilling, production, infrastructure, and economic scenarios to determine how to develop a field under geological uncertainty. A quantum-assisted workflow could compare development options more efficiently, supporting better well placement, multi-well planning, and resource decisions.

Modeling and Simulation

Subsurface models help oil and gas companies predict reservoir behavior. Predictions for fluid flow through porous media shape drilling plans, production strategy, and field profitability. Quantum-enabled modeling could let teams test more scenarios and make faster, better-informed decisions. Quantum simulation may also help to screen materials and chemicals designed for harsh field conditions.

Faster Porous Media Flow Simulation

Large reservoir models require teams to test many input datasets, time steps, and uncertainty ranges, but current simulation methods limit how many cases they can run. A hybrid quantum-classical workflow could preserve existing reservoir simulation infrastructure while using quantum algorithms to accelerate selected computations within the simulators. Even with advanced classical solvers, teams trade off model fidelity, scenario count, and decision speed. Higher throughput could help operators identify drilling thresholds and estimate reservoir value under with greater accuracy.

New Materials Design

Harsh subsurface conditions can exceed the limits of existing materials. Upstream producers and manufacturers need materials that withstand field conditions, improve recovery efficiency, and last longer. Current development often relies on trial-and-error laboratory testing, which is costly, uncertain, and slow. Quantum computation could screen for promising candidates before experimental validation. This use case leverages quantum computational chemistry, hybrid methods, and optimization or sampling workflows.

ii D-Wave Quantum Inc. (June 6, 2024). *D-Wave Extends Agreement with Aramco Europe to Explore Quantum-Powered Optimization of Geophysical Problems*.

Additional Use Cases

Additional opportunities include development planning, drilling optimization, multiphase flow behavior in pipes and other tubulars (including thermal effects), multiphysics partial differential equation (PDE) solving, and grid generation at scale. Quantum-enabled planning could help teams compare asset development options under uncertain reservoir properties. Drilling and development decisions combine subsurface characterization, modeling, cost constraints, timing, and economics. Multiphase flow challenges arise where fluids enter the wellbore, travel up tubulars to surface or subsea facilities under thermal effects, and ascend deepwater risers to surface facilities. A quantum-assisted workflow could search these planning and simulation spaces more efficiently.

Quantum PDE solvers could accelerate simulations of large physical models that span multiple scales and require large-grid numerical solutions. Grid generation at scale focuses on building better simulation meshes for finite element or finite difference models. Quantum optimization could identify grid structures that preserve accuracy while reducing simulation time. Together, quantum-enabled modeling and simulation could reduce costs, shorten analysis cycles, and improve confidence in decisions that affect recovery, drilling, and field economics.

Production Optimization and Flow Assurance

Once operators have evaluated a resource, they must produce oil and gas reliably and sustainably. Production optimization and flow assurance challenges span individual wells, fields, and production networks, including well placement, treatment timing, workovers, and maintenance scheduling. Better methods could improve production and maintain reliable flow across varying fluid chemistries.

Optimizing Multi-Well Production

Well intervention decisions are often piecemeal. Although these decisions draw on field and reservoir flow models, well-level economics, production forecasts, and optimization software, operators or engineers optimize only the wells they manage rather than the full field or production network. Common interventions include workovers, recompletions, and changes to or installation of artificial lift systems.

Each intervention carries costs and constraints related to duration, production effects, infrastructure, and crews. It can affect the gathering system: increasing production from one group of wells may create constraints elsewhere in the network. The task is to select the best portfolio of field interventions over the planning horizon, not to optimize wells one by one.

Hybrid quantum optimization may suit this use case, which combines mixed-integer nonlinear decisions, black-box objectives, and extensive operational constraints. Classical optimization tools, such as those offered by Gurobi and CPLEX, provide comparison baselines. Field-level optimization could reduce the gap between expected and actual output, improve crew use, or increase production value within capital and operating constraints.

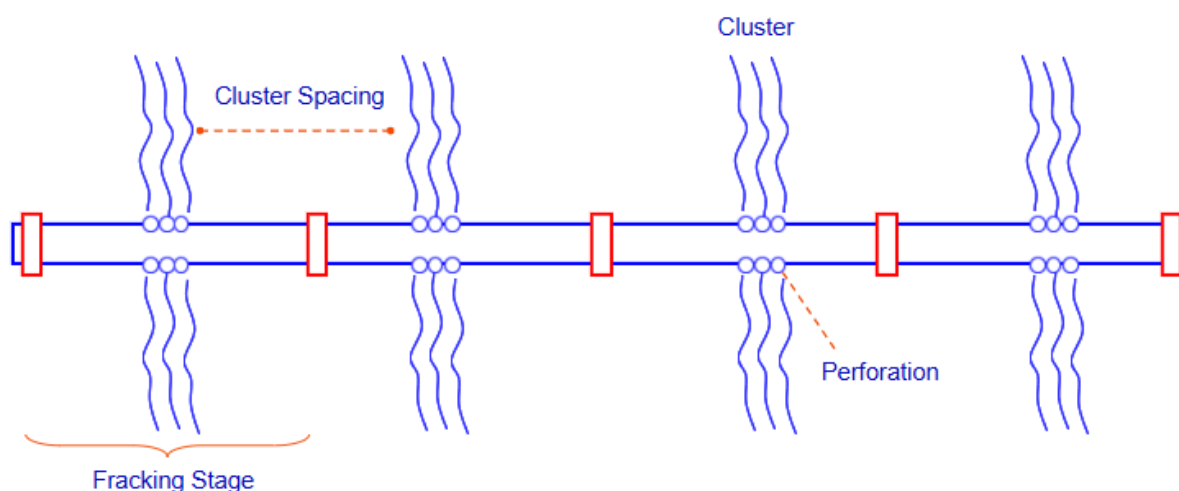
To demonstrate value, a quantum-based approach must use available operational and production data, handle nonlinear production-system effects, and outperform existing field-level decision processes or classical optimization baselines.

Optimizing Hydraulic Fracturing Well Construction

In unconventional hydraulic fracturing, operators create fracture networks along horizontal well sections to produce oil and gas. A lateral section typically extends two to four miles, and fracture wings extend several hundred to two thousand feet from the wellbore (see Figure 4). Fracturing usually costs more than drilling the well. Operators have therefore developed extensive expertise in fracture treatment optimization, but room for improvement remains.

Operators choose treatment parameters (stage spacing, cluster spacing, injected fluid volumes, proppant schedules, pressures, and rates) using historical data, heuristics, and physics-based predictions from fracture modeling tools.⁴⁷ They compare model results with field measurements and production outcomes reported in proprietary and industry studies.

Figure 4. Schematic Depiction of a Hydraulic Fracturing Lateral



Source: SRI, diagrams developed with DALL•E 3.

In unconventional resources, low permeability typically limits recovery to about 8–10 percent of the resource in place. Even a gain of several percentage points through better treatment designs, materials, or procedures would be highly valuable. Commercial viability may require a substantial gain, such as increasing per-well recovery from a baseline of 8 to 10 percent to 20 percent. It remains unclear whether spacing or treatment design alone could produce that gain. Potential approaches include quadratic unconstrained binary optimization (QUBO), the quantum approximate optimization algorithm (QAOA), hybrid optimization, and quantum physics-informed neural networks (QPINNs). Hybrid quantum annealing could support parameter optimization in a multidimensional decision space.

A single well test could show whether quantum-optimized treatment parameters improve recovery from unconventional wells. Demonstrating commercial uplift would require a broader pilot, potentially across 20 or more wells, with production observed for at least a year. A logical next step is to define the parameter space, identify input data, develop candidate formulations, and compare quantum and classical optimization approaches.

Additional Use Cases

Other use cases include modeling corrosion-resistant well construction materials, coatings, and process chemicals with improved interaction properties. Quantum optimization could also improve gathering network design to maximize throughput. Quantum-aided flow modes, including more accurate multiphase flow models, could improve production decisions.

Use and Adoption of High-Performance Computing in Oil and Gas

HPC has supported upstream oil and gas processes through digital oilfield and automation systems.⁴⁸ Operators and service providers use HPC and other computing systems to improve efficiency, reduce risk, and optimize performance.⁴⁹

Quantum computing would compete with a mature computing ecosystem that is embedded in technical and operational systems. Procurement and deployment usually require supplier qualification, testing, and multistage approvals.⁵⁰ A pilot may demonstrate technical feasibility, but full deployment requires integration, field validation, workforce adoption, and continuity across distributed networks.⁵¹

Companies assess new technologies by operational value, not novelty: improved reliability, less downtime, optimized production, or better decisions.⁵² Quantum computing will face the same standard. Existing workflows depend on established software, industrial control environments, and operating procedures. Emerging technologies face lower barriers when they not only outperform industry benchmarks, but also fit existing workflows and support interoperability.⁵³

Procurement and Partnerships

Upstream oil and gas depends on an ecosystem of operators and vendors. New technologies usually enter operations through this ecosystem rather than through isolated deployments. Oilfield service companies increasingly combine digital tools with field support in integrated services.⁵⁴ Long-term contracts, integrated service agreements, and partnerships support continuity across upstream environments.⁵⁵

Procurement does more than purchase technology; it manages deployment risk. Supplier qualification, category management, technical validation, logistics planning, and multistage approvals shape how companies evaluate and deploy new technologies.⁵⁶ Procurement systems prioritize reliability, safety, interoperability, continuity, and technical performance.

Integrated digital systems have made interoperability central to upstream workflows. Technologies that fit into these environments face lower adoption barriers than systems that require major workflow replacement or operational restructuring.

Because interoperability requires coordination among software platforms, field systems, suppliers, and internal teams, emerging technologies will likely move through collaborative structures that link operators, oilfield service providers, software vendors, and equipment manufacturers. Integrated service providers can also connect technology developers with upstream operators by incorporating new capabilities into broader workflows.⁵⁷

Quantum tools will face **lower adoption barriers** when vendors make them usable within existing workflows

Some operators and oilfield service providers also maintain in-house development capabilities. They have built proprietary software, analytics platforms, drilling technologies, and digital monitoring tools for internal workflows and field operations.⁵⁸ Together, vendors, partnerships, and internal development form a tightly linked procurement environment across the upstream value chain.

Vendor Relationships

Because upstream technologies often move through established vendor and service ecosystems, vendor relationships will shape how quantum computing reaches operational use.

For many upstream applications, operators may adopt quantum capabilities embedded in existing technologies rather than as stand-alone products. These capabilities could sit within software platforms, simulation environments, optimization tools, cloud or HPC workflows, or service-provider offerings. Established vendors can translate emerging capabilities into deployable tools, validated workflows, and supportable operational services.

Procurement and operational governance reinforce this vendor-mediated pathway. Upstream procurement requires formal validation before deployment.⁵⁹ Established vendors may therefore become channels for qualifying, integrating, and scaling quantum-enabled technologies, especially when deployment affects safety-critical systems or continuity.

Interoperability also constrains adoption. Quantum-enabled capabilities will face lower deployment barriers when they fit vendor-supported architectures and workflows instead of requiring major infrastructure replacement or procedural change.

Partnerships

Partnerships let companies combine capabilities, coordinate expertise, and adapt new technologies to complex upstream environments. Collaboration can address operational challenges that exceed any one organization's resources or expertise.⁶⁰ For emerging computational technologies, adoption requires not only access to the tool but also problem formulation, workflow integration, field validation, user adoption, and operational support.

Partnerships distribute resources, knowledge, and risk across organizations. Oilfield service companies use strategic alliances to obtain technical expertise, specialized equipment, innovation capabilities, and market opportunities that would be difficult or costly to develop independently.⁶¹ In technology-intensive settings, these arrangements help transfer expertise, adapt solutions to operational needs, and build internal capacity for sustained adoption.

The Rumaila Digital Oilfield program in Iraq illustrates partnership-based deployment. BP, China National Petroleum Corporation (CNPC), Basra Oil Company, software providers,

engineering teams, and field-service personnel coordinated the deployment of digital infrastructure across a large producing field.⁶² The project shows that large-scale digital initiatives require coordinated implementation, workforce training, stakeholder engagement, and ongoing operational support across organizations.

In an example of a quantum computing partnership, ExxonMobil joined the IBM Q Network in January 2019. Together, ExxonMobil and IBM quantum explored a midstream application for maritime inventory routing of LNG, tracking daily ship positions against delivery-site demand.ⁱⁱⁱ

Similar partnership structures can translate quantum computing capabilities into deployable upstream workflows. Partnerships provide ways to test, validate, and scale new capabilities within established environments.⁶³ B Quantum-enabled applications are more likely to gain traction when operators, service providers, software vendors, and domain experts develop them together and align technical performance with operational objectives, integration requirements, and field constraints.

In-House Technology Development

Large operators and oilfield service companies maintain in-house software development teams. These teams are important when methods depend on asset-specific data, practices, and decisions. Internal development starts with operational problems rather than stand-alone research. Teams may test methods with field data, synthetic models, benchmarks, or pilots.⁶⁴ Even after a pilot demonstrates feasibility, deployment may require validation, software hardening, cybersecurity and data governance reviews, testing, and workflow integration.

Unlike conventional procurement, this pathway makes the operator both user and developer, especially when a problem depends on its assets, proprietary data, or operating philosophy. Internal development still relies on external resources, including commercial software, cloud or HPC infrastructure, specialized hardware, external libraries, and research partners.

In-house R&D lets operators test quantum claims against their own data before committing to deployment

In-house research and development can screen quantum claims. Internal teams can identify candidate use cases, translate operational problems into quantum-relevant formulations, benchmark quantum and hybrid algorithms against classical methods, and determine whether proposed advantages matter in field settings.⁶⁵ This capability helps distinguish speculative

ⁱⁱⁱ Harwood, S., Gambella, C., Dimitar, T., and Simonetto, A. (2021). *ExxonMobil & IBM explore quantum algorithms to solve routing formulations*. Medium. <https://ibm-research.medium.com/exxonmobil-ibm-scientists-explore-state-of-art-quantum-algorithms-to-solve-routing-formulations-e7ce39f8741c>

quantum claims from operationally relevant opportunities and determine which applications to continue exploring, co-develop, or integrate into operational workflows.

Quantum Adoption Pathways

Upstream oil and gas companies will adopt quantum computing with proven measurable business value. That value depends on whether a quantum solution competes with an existing classical method or enables a new computational capability without a mature operational benchmark.

Quantum Substitution and Enhancement of Existing Workflows

The earliest operational quantum solutions will likely compete directly with classical methods. In these cases, the quantum component may operate as a black-box enhancement within an existing workflow. Users need not know whether the improvement comes from quantum subroutines or classical advances. What matters is whether the new approach produces materially better results than the incumbent method under realistic conditions.

Adoption will depend on comparisons with classical benchmarks. A quantum machine-learning tool for predictive maintenance, an optimization method for production allocation, or a quantum-enhanced solver in simulation must demonstrate value using familiar metrics: runtime, accuracy, robustness, computational cost, model update frequency, or decision impact. In this pathway, performance, not the quantum label, is the selling point.

Speed matters only when it changes the decision process. A faster method may let teams evaluate more scenarios, update models more often, reduce turnaround time, or enable near-real-time optimization that current tools cannot support. Speed matters less when the current workflow already fits the decision cycle, downstream review or execution is the bottleneck, or integration risk offsets the gain. In such cases, quantum-enabled methods must also produce better answers, such as more accurate predictions, more robust optimization results, better uncertainty characterization, or stronger performance on larger coupled problems.

Quantum-Enabled New Computational Capabilities

Quantum computing may enable new computational capabilities for oil and gas. Instead of improving an established workflow, it could enable a new class of analysis, simulation, optimization, or decision support. Such applications may be strategically significant but face higher adoption barriers because operators may lack standard evaluation pathways.

Examples include high-fidelity molecular simulation for new materials or flow assurance chemistry, broader coupled-system optimization under uncertainty, and rare-event analysis that is not routinely used because classical approaches are too costly or require substantial simplification. The value lies not in improving an existing output, but in running analyses that are impractical today at the required fidelity, scale, or decision cadence.

Without direct classical competitors, companies will need a different evaluation approach. Rather than ask whether the quantum-enabled method beats an incumbent tool on existing benchmarks, operators may need to define new measures of decision value, validation procedures, and operational relevance. Evaluation may require custom validation and input

from internal technical teams, domain experts, and operational users to determine how the capability would affect workflows, staffing, governance, and decision authority.

Quantum computing may face higher adoption barriers because **operators may lack standard evaluation pathways**

In this pathway, the quantum nature of the capability may matter more commercially because its value depends on access to a qualitatively different form of computation. Still, adoption must meet the broader standards described above: proof that the capability improves decisions that matter to upstream performance and the bottom line.

Recommendations

Recommendation 1: Align Quantum Technology Development with Existing Oil and Gas Adoption Pathways

Upstream oil and gas companies will adopt quantum computing when it addresses industry-defined problems. Quantum technology developers, operators, service companies, and research organizations should jointly identify a small set of problems for which computational limits materially affect performance, cost, risk, or decision quality. Operators judge new tools by whether they solve operational problems either better or faster, improve decisions, reduce costs, or strengthen workflows, as well as how easily and affordably they integrate. Quantum-enabled solutions are most likely to gain traction when computational limits constrain business or operational outcomes and developers design solutions around those problems rather than around a particular quantum technology.

Technical feasibility is not enough. Quantum computing providers need to understand current workflows, how operators evaluate performance (see Recommendation 2), which operational requirements govern adoption, and where a quantum enhancement would fit. For each priority use case, developers should document the current workflow, incumbent methods, users, data requirements, performance limits, and decision points; identify the computational bottleneck; and assess how the proposed capability would integrate with existing software, data infrastructure, validation processes, cybersecurity requirements, and operational procedures.

Most viable near-term quantum solutions will likely use hybrid quantum–classical approaches. Developers that align products with operational requirements and deployment models will be better positioned to move from demonstration to commercial implementation.

Recommendation 2: Demonstrate Performance Using Established Oil and Gas Benchmarks

The oil and gas industry has established performance metrics and evaluation standards for workflows such as reservoir simulation, seismic imaging, optimization, and predictive analytics. These standards help operators compare methods and determine whether a new tool will improve current practice. Quantum-enabled solutions should be assessed against established benchmarks whenever possible, with clearly defined classical baselines and computing environments. Performance metrics should be set before testing begins and, where relevant, cover accuracy, runtime, computational resources, scalability, robustness, reproducibility, integration effort, and cost. New computational capabilities are the main exception. Even then, developers need an evaluation framework that identifies the operational decision or outcome enabled, the minimum acceptable accuracy and reliability, and the best available alternative process.

Benchmarking serves both technical and commercial purposes. Industry-recognized metrics let operators compare quantum-enabled approaches with incumbent tools using criteria they understand and trust. Where possible, predefined performance and reproducibility thresholds should determine whether a solution is ready for an operational pilot. Appendix A lists benchmark datasets and performance metrics that may support these evaluations.

Recommendation 3: Explore Additional Opportunities Across the Oil and Gas Ecosystem

Computational challenges extend beyond upstream operations. Midstream transportation, downstream refining and processing, and adjacent technologies such as quantum sensing also rely on computationally intensive workflows for planning, optimization, monitoring, and strategic decisions. Domain experts and operational users should assess each area's distinct requirements and potential quantum applications.

The upstream opportunities identified here provide a model for examining the rest of the oil and gas value chain. Many midstream, downstream, and sensing applications rely on the same capabilities: data analysis, simulation, optimization, and decision support. Further work could test whether upstream opportunities apply more broadly and clarify where quantum technologies are most likely to deliver operational value. Potential opportunities should be screened by industry need, computational intensity, data availability, maturity of existing alternatives, compatibility with hybrid methods, implementation difficulty, and expected quantum-resource requirements.

Recommendation 4: Improve Access to Federal Geoscience Data

Publicly available federal geoscience datasets could accelerate the development and validation of quantum applications for upstream oil and gas. The U.S. Geological Survey, Bureau of Ocean Energy Management, U.S. Department of Energy, and National Energy Technology Laboratory maintain seismic, well, and other subsurface data. However, these datasets are spread across repositories and vary in documentation, curation, preprocessing, and access methods. Improving discoverability, availability, and usability would lower barriers for researchers and developers while making greater use of existing federal investments.

A centralized federal geoscience portal could provide one interface for finding and accessing datasets across agencies without changing agency ownership of the underlying resources. It could offer standardized metadata, documentation, search tools, and guidance on appropriate uses. Where appropriate, it could also catalog or host curated, analysis-ready benchmark datasets for algorithm development, validation, and evaluation against established classical methods. Examples appear in Appendix B: Seismic Benchmark Data Resources.

Conclusion

Quantum computing will not replace the high-performance computing systems that support upstream oil and gas operations. Classical computing is mature, deeply embedded in industry workflows, and improving. Quantum and hybrid quantum-classical approaches will have a role only if they produce meaningful gains over the best classical methods under conditions that resemble industry use.

This report identifies several areas that merit evaluation. Seismic imaging, reservoir simulation, materials design, and production optimization present computational challenges with technical and economic consequences. Faster computation, better optimization, or broader scenario analysis could affect exploration risk, drilling plans, recovery strategies, production, and field economics. The strongest candidates are specific bottlenecks with defined inputs, outputs, benchmarks, and decision relevance, not generic oil and gas problems.

The use cases differ in timeline and technical pathway. Elastic waveform simulation and high-fidelity materials modeling are longer-horizon possibilities that depend on advances in error correction for gate-based quantum computing and algorithm development. Optimization-heavy workflows such as acquisition planning, well intervention planning, hydraulic fracturing design, and production scheduling may advance sooner through hybrid or annealing-based approaches. In most cases, quantum computing will enter as a supporting component within existing workflows rather than as a stand-alone replacement for current infrastructure.

For the quantum computing industry, the implication is clear: development should begin with industry-defined problems rather than quantum capabilities. Developers need to understand how oil and gas companies currently solve these problems, where classical methods fall short, which performance metrics operators trust, and how much improvement would justify experimentation, integration, and adoption. Demonstrations without strong classical baselines or attention to workflow constraints are unlikely to persuade operational users. Quantum developers must also understand how oil and gas companies evaluate and acquire technologies through processes refined over decades and relationships with specialized vendors and partners.

Useful quantum applications also require active participation from oil and gas companies. Operators, service companies, software vendors, and domain experts need to define use cases, supply representative data or models, establish and share benchmarks, validate results, and identify where better computation would improve decision making. This collaboration is especially important when quantum computing may enable a new analytical capability rather than improve an existing workflow.

Accordingly, quantum technology development should align with existing oil and gas adoption pathways, and candidate solutions should be tested against established benchmarks whenever possible. Additional opportunities should also be explored across the broader oil and gas ecosystem, including midstream, downstream, and adjacent technologies such as quantum sensing. These steps can move the discussion from speculative promise to disciplined evaluation. The next stage should focus not on premature commercialization, but on targeted problem discovery, rigorous benchmarking, and collaborative development around challenges where better computation can create operational value.

Appendix A: Existing Industry Benchmarks and Metrics

To evaluate quantum computational approaches to oil and gas problems, developers need to understand industry benchmarks and metrics. The oil and gas industry is computationally intensive, with mature commercial software, extensive datasets, benchmark tests, and standard computational methods. New quantum solutions should account for existing products, models, and methods and, where applicable, use standard test datasets to compare their performance with the industry practice.

The Society of Petroleum Engineers (SPE) has led this work through the Comparative Solutions Project (CSP), a series that provides benchmark datasets for comparing algorithm and simulator performance. SPE also manages the Petroleum Resources Management System (PRMS), which sets international standards for evaluating and classifying petroleum resources. For reservoir modeling, the 1979 textbook *Petroleum Reservoir Simulation* by Khalid Aziz and Antonin Settari, often called “The Green Book,” has become a standard reference for developers and users of numerical models for fluid flow in reservoirs.⁶⁶

SPE’s Comparative Solutions Projects

Between 1981 and 2024, SPE conducted 11 CSPs, each addressing a different reservoir simulation challenge using benchmark datasets. The following timeline briefly describes them.

SPE1 (1981) – 3D Black-Oil Simulation. Initiated by Aziz S. Odeh, the first CSP compared participants’ solutions to a 3D black-oil reservoir simulation problem. It remains a widely cited simulator validation benchmark.⁶⁷

SPE2 (1986) – Three-Phase Coning Study. Eleven companies participated in the second CSP. The benchmark used a three-phase coning problem modeled as a radial cross section with one central producing well.⁶⁸ Rate variations and unusually high gas-oil ratios made the problem difficult and increased its value as a simulation benchmark.

SPE3 (1987) – Gas Cycling of Retrograde Condensate Reservoirs. Nine companies participated in this artificial modeling study of gas cycling in a rich retrograde gas-condensate reservoir.⁶⁹ Surface-oil rate predictions varied during the early years of cycling but converged later. Participants also produced widely varying estimates of condensate precipitation and evaporation rates near the production well.

SPE4 (1987) – Steam Injection Simulators. Six organizations presented simulation results for three related steam injection problems.⁷⁰ The first problem involved three cycles of cyclic steam injection; the other two involved steam displacement in an inverted nine-spot pattern. The first two problems were of the “black-oil” type; the third was of a compositional type. The results led to good comparison for most problems important to field operations.

SPE5 (1987) – Miscible Flood Simulators. The fifth CSP compared four-component miscible simulators with fully compositional simulators across three miscible gas injection scenarios.⁷¹ In one test case, the four-component simulators and the compositional simulators agreed on the key metric of cumulative oil production as a function of cumulative water injection.

SPE6 (1990) – Dual-Porosity Simulators. Led by Abbas Firoozabadi and L. Kent Thomas, this project benchmarked simulators for naturally fractured reservoirs using dual-porosity models, which represent fracture and matrix systems separately.⁷²

SPE7 (1991) – Modeling of Horizontal Wells. This project compared simulation runs for production from a horizontal well in a reservoir where coning tendencies are important performed by 14 organizations.⁷³ The project examined how well length and production rates affected recovery. Participants predicted less coning behavior as well length increased, but the results showed no consistent trend.

SPE8 (1993) – Gridding Techniques in Reservoir Simulation. Led by Philippe Quandalle, this project examined gridding techniques in reservoir simulation.⁷⁴ Participants compared structured and flexible grid approaches; results showed that flexible grids could substantially reduce grid-node counts while maintaining accuracy.

SPE9 (1995) – Reexamination of Black-Oil Simulation. The ninth CSP reexamined black-oil simulation using a moderately sized 9,000 cells model with a highly heterogeneous, geostatistically based permeability field.⁷⁵ Nine participants provided data for the comparison based on a dipping reservoir with 25 randomly placed producers and a single water injector.

SPE10 (2001) – Upscaling Techniques. This study posed two test cases.⁷⁶ The first was a compact 2D gas-injection scenario, simple enough to generate a fine-grid reference solution for comparison against both upscaling and pseudoization approaches. The second case modeled waterflooding a large, geostatistically generated model, for which generating a true fine-grid solution was difficult but feasible.

SPE11 (2023–2024) – CO₂ Storage Simulation. Running from 2023 to 2024, the 11th CSP benchmarked numerical simulation tools for geological carbon dioxide (CO₂) storage.⁷⁷ This international effort saw 45 research groups from academia and industry register, with 18 ultimately contributing results. The project contained three versions: SPE11A was a 2D geometry at laboratory scale; SPE11B rescaled that geometry to realistic field dimensions; and SPE11C extruded SPE11B to a full 3D field model.

These 11 projects provide realistic, open-source datasets that quantum computing companies can use to evaluate hybrid approaches to reservoir simulation. Notably, grid sizes increased over time as computational methods became cheaper and more widely available.

Appendix B: Seismic Benchmark Data Resources

Table B1 lists selected publicly available federal geoscience data resources maintained by U.S. federal agencies. These resources provide seismic, well, and other subsurface data that could support the development, validation, and benchmarking of quantum applications for upstream oil and gas.

Table B1: Public Federal Databases

Public Federal Database	Agency	Description	Access Note
National Archive of Marine Seismic Surveys (NAMSS)	U.S. Geological Survey (USGS) in partnership with the Bureau of Ocean Energy Management (BOEM)	A public archive of marine seismic reflection data acquired within the U.S. Exclusive Economic Zone (EEZ). The archive currently includes 972 3D seismic surveys and 610 2D seismic surveys and continues to expand as additional surveys become available.	Marine seismic surveys become publicly available after the BOEM proprietary period expires. Data are provided in SEG-Y format with associated metadata and documentation.
NETL's Energy Data eXchange (EDX)	National Energy Technology Laboratory (NETL), U.S. Department of Energy (DOE)	A DOE platform that provides access to datasets, models, tools, and publications supporting energy and environmental research. Resources include hydrocarbon, carbon management, geothermal, and subsurface energy data generated through DOE-funded research.	Published datasets and associated resources are publicly available. Some collaboration features and private workspaces require user registration and appropriate permissions.
The DOE Geothermal Data Repository (GDR)	U.S. Department of Energy (DOE), Geothermal Technologies Office	A repository and catalog for data generated through DOE Geothermal Technologies Office-funded research. The GDR includes	Data are publicly available and supported by curated metadata that improves discoverability and interoperability.

Public Federal Database	Agency	Description	Access Note
		datasets supporting geothermal exploration, reservoir characterization, drilling, distributed acoustic sensing (DAS), geophysical surveys, and other subsurface research, including publicly available datasets from the Frontier Observatory for Research in Geothermal Energy (FORGE). The repository currently contains 1,407 datasets representing 764 TB of data from 144 providers.	Metadata are shared across a network of federal data partners, increasing discoverability while preserving a single authoritative data source.
National Petroleum Reserve-Alaska (NPRA) Data Archive Explorer	U.S. Geological Survey (USGS)	An archive of geological and geophysical data collected during exploration of the NPRA between 1944 and 1982. It includes records from 36 test wells, 45 core tests, more than 12,000 line miles of seismic data, and related analyses and documents.	Data are publicly available through ScienceBase and can be explored using the USGS NPRA Data Archive Explorer.

Appendix C: Workshop Agenda

The QED-C workshop “SPE Quantum Computing Symposium 2026: Roadmap and Use Cases in Oil & Gas Applications” was held in Houston, Texas, on May 14 and 15, 2026. About 70 experts from industry, government, and the quantum community participated in presentations, panel discussions, and breakout groups designed to elicit expert insight and foster cross-sector dialogue. These activities aimed to

- describe the current quantum landscape,
- communicate technical challenges in the oil and gas sector, and
- assess the current state of relevant quantum technologies.

The sessions established a shared understanding of the quantum technology landscape and real-world mission needs. They also prepared participants for breakout sessions that asked them to

- identify oil and gas challenges across three relevant problem tracks and evaluate potential quantum solutions, and
- develop specific, promising near-term quantum solutions to oil and gas problems.

Agenda

Time	Session	Description
Day 1		
7:00–8:00 AM	Registration & Check-In	Badge pickup at the registration table
8:00–8:20 AM	Welcome & Workshop Orientation	Celia Merzbacher, Thomas Halsey, Gaurav Agrawal, Jeff Bailey
8:20–8:50 AM	The Workings & Potential of Quantum Computing Hardware	Chris Monroe (Duke and IonQ)
8:50–9:20 AM	State of Quantum Software	Martin Roetteler (IonQ)
9:20–10:20 AM	Panel Discussion & Q&A	Panelists: Alex Kozsegi (D-Wave), Mykhaylo Zayats (IBM), Trevor Chaleaux (QuEra), Michael Lubasch (Quantinuum) Moderator: Carl Dukatz (Accenture)
10:20–10:50 AM	Networking Break	Snacks and refreshments
10:50–11:20 AM	High-Compute Needs in Oil and Gas	Xiaojun Huang (XOM)
11:20–11:50 AM	Quantum Applications for Oil and Gas	Bob Parney (IBM)
11:50 AM–1:00 PM	Lunch – Mixed Group Seating	
1:00–1:45 PM	Reverse Q&A: Quantum Meets Oil and Gas	

Time	Session	Description
1:45–2:00 PM	Overview of Breakout Activities	
2:00–3:45 PM	Breakout Session 1: Problem Discovery & Use-Case Ideation	Parallel tracks include Production Optimization & Flow Assurance, Simulation & Modeling, and Seismic Imaging
3:45–4:00 PM	Networking Break	
4:00–4:45 PM	Breakout 1 Reports	
4:45–5:00 PM	Day 1 Wrap-Up	
Day 2		
8:00–8:15 AM	QED-C / Rice University Short Talk	
8:15–8:45 AM	Oil and Gas Use Cases in Quantum Computing	Jyotsna Sharma (ARPA-E)
8:45–9:15 AM	Oil and Gas Use Cases in Quantum Computing	Divakar Vashisth (Stanford Doerr School of Sustainability)
9:15–9:30 AM	Networking Break	
9:30–10:00 AM	Quantum Adoption in Other Industries	Rima Oueid (DOE)
10:00–11:30 AM	Breakout Session 2: Feasibility & Fit Analysis	
11:30 AM–12:15 PM	Breakout 2 Reports	
12:15–1:45 PM	Lunch – Mixed Group	
1:45–3:15 PM	Breakout Session 3: Execution Pathways	
3:15–3:30 PM	Networking Break	
3:30–4:15 PM	Breakout 3 Reports	
4:15–4:45 PM	Workshop Summary & Next Steps	
4:45–5:00 PM	Closing Remarks	

Workshop Participant List

First Name	Last Name	Company
Aleksandr	Kunitsa	Xanadu
Alex	Koszegi	D-Wave Quantum
Ali	Dogru	Aramco Americas
Alvaro	Escorcía	Net Zero Technology Centre
Amir	Nejad	ConocoPhillips
Anantha	Sundaram	ExxonMobil

First Name	Last Name	Company
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Beau	Rollins	Devon Energy
Bill	Brouwer	SLB
Bill	Cockerill	Essential Knowledge Systems
Bo	Gong	Chevron
Bob	Parney	IBM
Brent	Schwarz	Inflection
Buddy	Stavinoha	D-Wave (Susan Davis)
Carl	Dukatz	Accenture
Carol Lee	Anderson	IBM
Celia	Merzbacher	SRI / QED-C
Chang-Yu	Hou	SLB
Charles	Wright	NOV
Chris	Monroe	Duke University / IonQ
Corey	McClelland	IonQ
Dale	McMullin	LINQX
Dilma	Da Silva	National Science Foundation
Dimitrios	Pirovolou	Weatherford
Divakar	Vashisth	Stanford University / SLB
Divya	Kulkarni	Texas A&M University
Donald	McClatchie	Computer Modeling Group
Enina	Egiebor	Rice University
Eric	Mefford	Aramco Americas
Isaac	Prem Singh	Everest Group
Ivan	Aldana	Texas A&M University
Jacob	Wang	University of Texas
Jeffrey	Bailey	Society of Petroleum Engineers (SPE)
Jessica	Avery	SRI / QED-C
Jordan	Bass	SRI / QED-C
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Madhava	Syamlal	Qubit Solve
Martin	Luling	Luling Tech SAS
Martin	Roetteler	IonQ
Mary Beth	Kelly	SRI / QED-C
Michael	Lubasch	Quantinuum
Michael	Lyons	Conoco Phillips
Miguel	Gonzalez	Aramco Services

First Name	Last Name	Company
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Oz	Egri	Quantum Machines
Pallavi	Chitta	DMV
Parth	Shah	Texas A&M University
Patrick	Trainor	Ridgeline Engineering
Paul	Cole	Invisible
Quadri	Popoola	Rice University
Rima	Oueid	U.S. Department of Energy (DOE)
Rodney	Lessard	SLB
Ryan	Nesselrodt	SRI / QED-C
Ryan	Woodson	IBM
Sebastian	Engelmann	IBM
Steven	Samoil	University of Calgary
Talal	Nehme	Mi4 Corporation
Thomas	Halsey	Rice University
Timothy	Pope	Trinity Operating
Trevor	Chaloux	QuEra Computing
Willow	Liu	SPE
Xiaojun	Huang	ExxonMobil
Yi Hua	Shen	Quanta Computer
Yoshi	Pradhan	IronLady Energy Advisors
Facundo	Siviero	
Jeremiah	Hoyle	
Michael	Brule	
Rajiv	Aggarwal	
Yeqing	Fu	

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