Nordic Innovation

Nordic-Baltic Quantum Ecosystem

Overview of the quantum technology landscape across the Nordic and Baltic region



Contents

Foreword	3
Executive summary	4
Introduction	7
Quantum technologies	8
National quantum ecosystems	20
Mapping of Nordic-Baltic quantum business ecosystems	36
Nordic-Baltic quantum strongholds	43
Policy recommendations	62
Concluding remarks	77
Methodology	78
Authors and contributors	79
Acknowledgements	80

This publication is also available online in a web-accessible version at:
link to publication

Foreword

The Nordic collaboration is governed by vision 2030, which aims for the region to be the most integrated and sustainable in the world. Through this report, Nordic Innovation sets out to promote sustainable growth, innovation, global competitiveness, and resilience of Nordic companies and society. Quantum technology is important for advancing national security, medical research, material science, energy storage, climate modeling, and many more areas. Quantum technology is still an evolving area, and no one knows how or when the announced quantum revolution 2.0 will happen. However, we should create a sense of urgency to position the Nordics as a stakeholder that can make a difference in the field. To succeed in making our region a stronghold for quantum, we need to unite around goals for the long term, pool funding, and identify leadership. Furthermore, we need to ensure good integration between research, business applications, and policy.

In the work with this report, interviewees have underlined the importance of a regional approach, and the advantage of working together was highlighted by the Nordic Prime Ministers and Heads of Government in their joint statement on quantum technology in May 2025. This report picks up on the commitment expressed in the joint statement, and we hope it will inspire new partnerships across borders, sectors, and value chains. To emphasize the need for collaboration, we have included both the Nordics and the Baltics in our mapping, believing that there are synergies that should be considered when broadening the regional scope.

The report is an open invitation – a starting point for policymakers to initiate talks on what the region can do together on a specific level. Moreover, the report is intended to raise curiosity amongst Nordic-Baltic businesses and point to opportunities on how quantum technology can be used to gain a competitive edge.

Whether you are a seasoned expert, a policymaker, a business executive, an investor, or someone newly intrigued by the possibilities of quantum, we invite you to explore the findings and to engage in the development of the Nordic-Baltic quantum ecosystem.

Sindre Bornstein

Managing Director

Nordic Innovation



Executive summary

Disruptive potential of quantum technologies

Quantum technologies represent a frontier with game-changing potential, including breakthroughs in areas such as healthcare, climate solutions, and security. However, they remain in the early stages of development, with global competition intensifying and uncertainty over which qubit technologies will dominate.

Smart collaboration for global impact

Governments and industries worldwide are racing to lead in quantum. The Nordic-Baltic countries have limited resources, so combining them strategically and using them smartly is essential. Pooling efforts across borders not only increases efficiency but also creates agility, turning constraints into advantages. The region's strong research base, culture of collaboration, and shared values offer a solid foundation for efforts to achieve a quantum leadership role.

Quantum business development across the Nordic-Baltic

Denmark, Finland, and Sweden lead regional quantum technology development with strong research ecosystems and active commercial initiatives, particularly in quantum computing and sensing. Norway is advancing and focusing on quantum sensing. The Baltic countries, Estonia, Latvia, and Lithuania, are strengthening their positions through research and foundational developments, with a growing emphasis on quantum communication. Iceland contributes primarily through academic research.

Nordic strongholds and emerging opportunities

The Nordic region excels in superconducting quantum computing, quantum photonics and optics, and quantum life sciences, backed by world-class research and growing commercial activity. Promising opportunities in Nordic-Baltic are also emerging in defense, advanced manufacturing, and financial services. These strongholds and growth areas offer a strategic edge and global potential through collaboration and investment.

Three high-impact policy recommendations

The analysis identified key policy gaps and systemic needs shaping the quantum landscape in the Nordic-Baltic area. To address these, three priority actions stand out for their impact and feasibility at this stage. In addition to these targeted steps, a broader set of supporting actions referred to as the *policy toolbox* has been identified to complement national strategies and drive quantum technology development.

1. **Establish a Quantum coordination forum**
   A lightweight coordination forum should be established to align strategies, coordinate cross-border efforts, and identify regional synergies across the Nordic-Baltic quantum ecosystem. Building on existing national and regional structures, the forum would act as a connective layer, avoiding duplication, supporting joint initiatives, and translating political ambition into effective collaboration. Dedicated funding is essential to ensure its long-term impact.
2. **Establish a Nordic-Baltic quantum thought leadership and strategic influence initiative**
   Position the Nordic-Baltic region as a recognized thought leader in quantum technologies by coordinating joint contributions to international policy, standardization, and strategic foresight. This initiative will amplify the region's influence in shaping global quantum agendas by mobilising research, industry, and public sector voices in key international forums.
3. **Launch ambitious cross-country pilot projects**
   Establish collaborative, research-driven pilot projects involving research organizations, technology providers, and end-users. Accelerate technology readiness, engage end-users in development, and elevate the Nordic-Baltic brand as a quantum technology leader. Combine public and private funding to support the pilots.

Positioning the Nordic-Baltic region at the forefront of quantum innovation

Quantum technologies are rapidly evolving and poised to drive breakthroughs across various sectors. Recognizing both the promise and the urgency of coordinated action, the Nordic Prime Ministers and Heads of Government issued a joint statement in May 2025, committing to deeper regional cooperation to strengthen the Nordic position in the global quantum race. The declaration highlights a shared ambition to foster the responsible development of quantum technologies and to position the Nordics as a global hub for quantum innovation.

This report supports that vision by offering a comprehensive, data-driven analysis of the Nordic-Baltic quantum landscape. It maps the region's commercial activity,

identifies key technological strongholds, and outlines policy recommendations to accelerate market formation, attract investment, and promote cross-border collaboration. It emphasizes how shared action-aligned strategies, joint pilots, and a common voice in international forums can multiply the region's impact and secure its leadership in the future quantum economy.

Now is the moment to act decisively. By uniting efforts and pooling resources, the Nordic-Baltic countries can turn scientific excellence into commercial impact and secure a leading role in the global quantum landscape.



Introduction

Quantum technologies are rapidly emerging as transformative forces across multiple domains. While quantum sensing already has tangible applications, most other quantum technologies, especially computing and communication, are still emerging technologies from a business advantage point of view. In this formative phase, research institutions, universities, and industry players are working in close collaboration to push the boundaries of what is possible.

This report offers a comprehensive mapping of the Nordic-Baltic business ecosystem for quantum technologies, focusing on commercial actors, emerging startups, innovation networks, and the business models that are taking shape. While a parallel study will examine the region's academic and research landscape in greater detail, this report places the spotlight on market-facing developments and the growing potential for industrial and societal value creation.

The Nordic and Baltic countries have a long tradition of collaboration and a strong foundation in science, technology, and innovation. Building on this, several national and cross-border initiatives are laying the groundwork for a vibrant quantum ecosystem. Yet differences exist in each country's maturity and strategic focus, from well-established national strategies and funding programs to early-stage initiatives and nascent innovation clusters.

The purpose of this study is to provide policymakers and stakeholders with a data-driven overview of the region's quantum business landscape, identifying areas of current strength, potential growth, and strategic gaps. We examine how Nordic-Baltic quantum startups are emerging, how businesses are beginning to explore use cases, and how innovation ecosystems are forming around different technology domains.

As quantum technologies advance, they hold the potential to enhance regional industrial competitiveness and significantly support long-term societal goals. Applications range from accelerating drug discovery and improving the sustainability of energy systems to enabling secure communications and strengthening national security. With the right policy support and coordinated action, the Nordic-Baltic region can position itself as a globally recognized hub for responsible, high-impact quantum innovation.



Quantum technologies

Three quantum technology areas

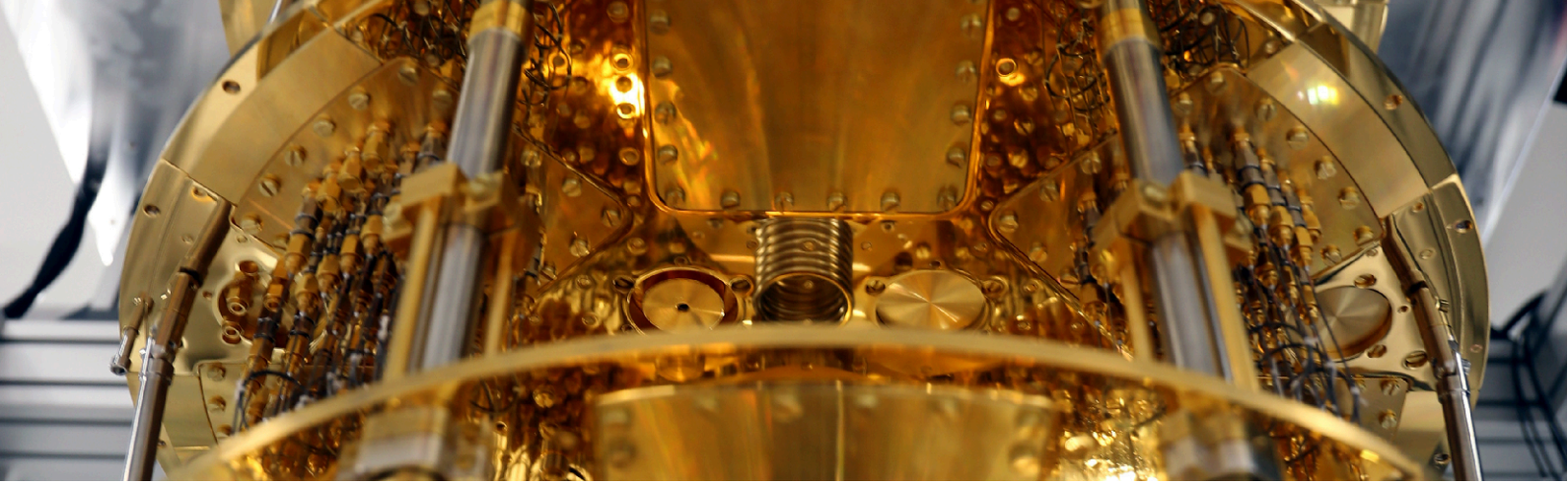
This chapter provides readers with a concise overview of the three primary categories of quantum technologies, quantum computing, quantum sensing, and quantum communication, which are central to shaping future competitiveness and innovation in the Nordic-Baltic region.

Quantum computing, leveraging quantum mechanics to revolutionize data processing capabilities, has the potential to solve problems currently beyond classical computational limits.

Quantum sensing exploits quantum properties to measure physical quantities with unprecedented precision, enabling advances in sectors such as healthcare, navigation, and environmental monitoring.

Quantum communication harnesses quantum mechanics principles to enhance security and efficiency in information exchange, presenting opportunities to redefine cybersecurity and communication infrastructure.

Understanding these technologies is essential for informed decision-making, fostering regional collaboration, and securing a competitive advantage on the global quantum stage.



Quantum computing

What is quantum computing?

Quantum computing is a radically new computing paradigm that leverages the principles of quantum mechanics to process information in ways fundamentally different from classical computers. Instead of bits that are either 0 or 1, quantum computers use quantum bits (qubits), which can exist in a superposition of both states. This feature, combined with entanglement and quantum interference, allows quantum algorithms to explore many computational paths in parallel.

Quantum computing is not only about building advanced hardware—it also involves developing new types of software and algorithms that structure and solve problems in ways uniquely suited to quantum systems. These quantum algorithms aim to unlock advantages for specific classes of problems that are too complex or inefficient for classical machines to solve within reasonable timeframes. Such problems include quantum chemistry and materials simulation, combinatorial optimisation, factoring, machine learning, and solving large systems of equations.

Importantly, quantum computers do not simply "process data faster." Instead, they offer a different way of structuring and solving problems, potentially uncovering solutions that are unreachable by classical methods. Their impact is expected to be highly focused but transformative in domains where classical computation faces fundamental limits.

As with classical computing, quantum computation can be performed either on dedicated, on-premises quantum hardware or accessed remotely via cloud-based platforms. Several providers now offer quantum computing as a service, allowing users to experiment with and develop quantum applications without owning physical quantum processors.

The following table outlines where these breakthroughs are most anticipated across sectors.

Global market development

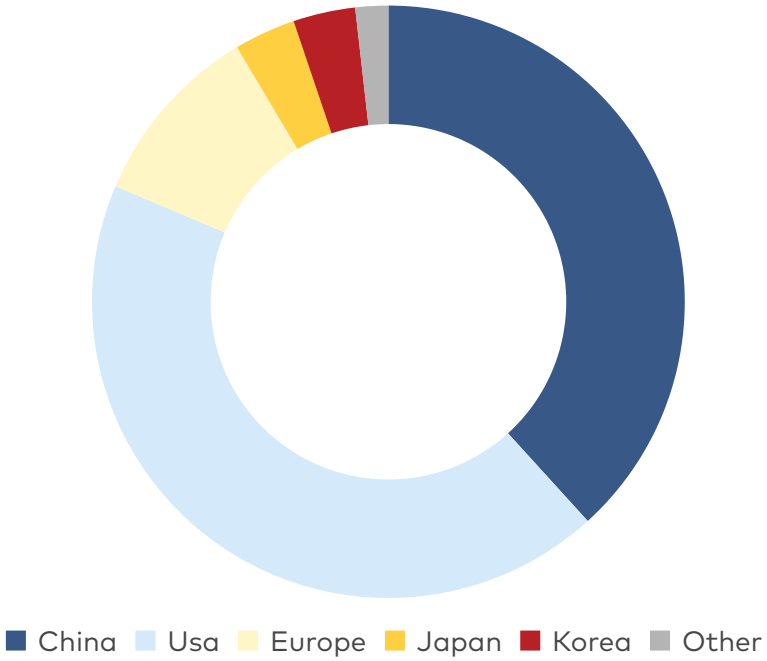
Quantum technology is rapidly becoming a focal point of international and geopolitical competition. Countries and companies that lead in developing and deploying quantum technologies stand to gain substantial economic and security

advantages. This has triggered intense global investment, particularly from governments in China and the United States, as well as major technology firms such as Microsoft, Google, IBM, Rigetti, and IonQ.

Public investment figures in Europe vary significantly by country; for example, Germany has pledged €3 billion, UK €4.2 billion, France €1.8 billion, and the Netherlands €965 million[1]. The overall market potential is substantial: quantum technologies are projected to reach a global market size of approximately €106 billion by 2040[2]. Quantum computing alone could generate an estimated €1 trillion in economic value by 2035, driven by its expected impact on industries such as pharmaceuticals, chemicals, finance, and automotive[3].

In this competitive context, understanding global market dynamics is essential for positioning the Nordic-Baltic region. While the individual countries may be smaller in scale compared to global frontrunners, the region stands out for its world-class research and niche industrial strengths. Denmark, Finland, and Sweden have established vibrant quantum ecosystems supported by growing startup activity. Meanwhile, Norway and the Baltic countries are taking steps to build their capabilities and integrate more actively into the global quantum landscape.

Distribution of quantum computing patent families per country/region



Source: PatSnap 16.5.2025

Potential application areas of quantum computing

Global systems, security and resilience

- Predict and prevent infrastructure failures (e.g., energy, telecom)
- Improve crisis response through faster scenario modeling and resource allocation
- Optimize supply chains under uncertainty
- Detect and mitigate fraud and cyber threats

Scientific discovery

- Simulate new materials at an atomic scale (e.g., for batteries and clean energy)
- Explore complex physical phenomena (e.g., superconductivity)
- Solve currently intractable computational problems

Healthcare and wellbeing

- Accelerate drug discovery through molecular simulation
- Enable personalized medicine using genomic and clinical data
- Speed up vaccine and treatment development for pandemic response
- Model biological processes to understand diseases

Sustainability and climate

- Improve climate forecasting for better policy decision-making
- Design advanced clean tech (e.g., solar panels, EV batteries)
- Optimize resource use in agriculture, energy systems and industry
- Increase computing energy efficiency



Quantum sensing

What is quantum sensing?

Quantum sensing harnesses quantum mechanical effects such as superposition, entanglement, or quantized energy levels to detect and measure physical quantities with extraordinary precision. Its evolution began with pioneering devices like atomic clocks and superconducting quantum interference devices (SQUIDs), which emerged in the mid-20th century. These early quantum sensors revolutionized fields like timekeeping and magnetic field detection by measuring quantities such as frequency, magnetic flux, and electrical resistance, albeit often requiring bulky setups and specialised conditions like cryogenic cooling.

Today, the field is experiencing a transformation with the advent of a new generation of quantum sensors. Advances in nanofabrication, materials science, and quantum control techniques have enabled the development of more compact, efficient, and versatile devices. Modern quantum sensors can now measure a wide range of physical quantities, including:

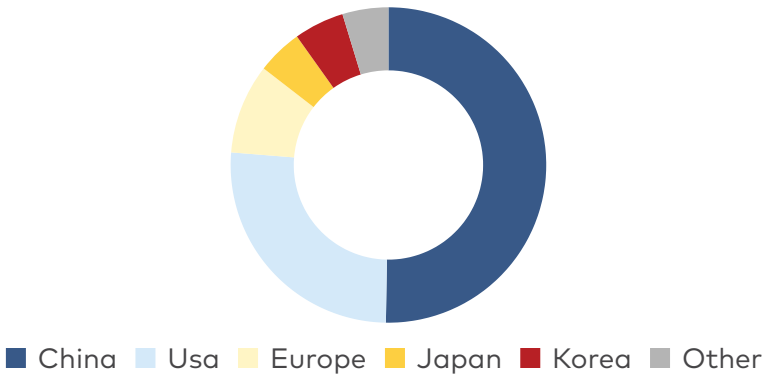
- ***Time and frequency***: Ultra-precise atomic clocks and frequency standards underpin global positioning systems and telecommunications.
- ***Magnetic fields***: Magnetometers based on atomic vapors, NV centers in diamonds, or superconducting circuits are used in applications ranging from biomedical imaging to navigation and geological surveys.
- ***Temperature***: Quantum thermometers and bolometers capable of detecting minute thermal changes are essential for materials research and environmental monitoring.
- ***Acceleration and rotation***: Inertial sensors like cold-atom accelerometers and gyroscopes enable precise navigation, even in GPS-denied environments.
- ***Optical phase and light intensity***: Interferometric and photonic sensors that measure optical phase shifts and intensities with high sensitivity, facilitating breakthroughs in imaging and spectroscopy.
- ***Force and pressure***: Detecting extremely small forces and pressure variations, applicable in fields ranging from biomedical research to industrial quality control.

Worldwide market trends and Nordic-Baltic positioning

The quantum sensing market shows particular near-term promise. Over the next 5–10 years, the global quantum sensor market is expected to grow substantially (10-15% CAGR[4]). Driven by rapid technological advances in nanofabrication, materials science, and quantum control, new generation quantum sensors are transitioning from experimental prototypes to commercially viable products. Key application areas, such as defense, healthcare, and environmental monitoring, are set to benefit from the unparalleled sensitivity and miniaturization of these devices.

Venture funding in the field of quantum sensing has received comparatively less attention due to the dominance of investment in quantum computing firms. According to McKinsey, 80% of all venture capital in quantum sensing has gone to the five most highly funded startups[5]. However, this does not necessarily indicate industry concentration as there are large numbers of recently established small startups in the field. Many sensing companies are drawing on a mix of revenue streams, including government funding, strategic private investments, and sales of both classical and quantum sensors.

Distribution of quantum sensing patent families per country/region



Source: PatSnap 16.5.2025

While global quantum sensing markets are accelerating, the Nordic-Baltic region remains in the early stages of commercialization. As in Europe more broadly, patent activity across the Nordics is still very modest, but this does not fully reflect the region's strong technical foundation. Nordic and Baltic countries host notable expertise in classical sensors and related enabling technologies, which could be redirected toward quantum applications. Emerging startups, particularly in Sweden and Denmark, are now developing next-generation biomedical and navigation sensors, supported by innovation hubs such as WACQT and the Center for Biomedical Quantum Sensing. With targeted investment and better-defined commercial pathways, the region holds the potential to become a strong player in quantum-enabled sensing solutions.

Potential application areas of quantum sensing

Healthcare and wellbeing

- Quantum-enhanced imaging (e.g., MRI, handheld micro-MRI, magnetoencephalography)
- Early and precise disease detection with sensitive biosensors (e.g., cancer, dementia, heart, neurological)

Navigation and positioning (PNT)

- Precision navigation without GPS (e.g., underground, underwater, airborne)

Environmental monitoring

- Gravitational field sensing for geological surveys and resource exploration (oil, gas, minerals)
- Detection of pollutants and environmental changes for climate monitoring

Security and defense

- Advanced surveillance and reconnaissance (e.g., ghost imaging, quantum radar)
- Detection of hidden objects or people (e.g., weapons, disaster areas)
- Enhanced object detection (e.g., submarines, mines) with quantum magnetometers
- Intrusion detection in sensitive areas

Infrastructure and engineering

- Subsurface imaging for inspections and construction safety
- Detection of material defects
- Precision sensing of pressure, temperature, and magnetic fields

Fundamental scientific research

- Quantum metrology for fundamental physics (e.g., gravitational waves, atomic physics, cosmology)



Quantum communication

What is quantum communication?

Quantum communication uses the unique properties of quantum particles to make our data exchanges more secure, not by sending every message bit as a quantum particle, but by creating unbreakable encryption keys. In today's quantum communication systems, two parties send tiny quantum signals (qubits) over a dedicated link to agree on a secret key. If anyone tries to intercept those qubits, their quantum state is disturbed, and both parties immediately know the key has been compromised. That secret key then encrypts all normal data — emails, phone calls or files — over conventional networks.

While researchers are investigating advanced concepts such as "quantum teleportation" for transmitting quantum information itself, current real-world deployments are centered on **quantum key distribution (QKD)**. QKD provides a proven, physics-based layer of security to existing communication systems, ensuring that only intended recipients can access the information and that any attempt at eavesdropping is immediately detectable.

Across Europe, current deployments focus on building test networks that connect key nodes either between countries or within national borders. These pilot infrastructures, often developed under the EuroQCI initiative, aim to demonstrate the technical feasibility and policy relevance of QKD in government, critical infrastructure, and cross-border communication. In these systems, quantum links and classical data channels operate together, offering a hybrid solution for securing today's sensitive information while paving the way for more advanced quantum communication networks.

In parallel, **post-quantum cryptography (PQC)** uses classical cryptographic algorithms specifically designed to resist attacks by future quantum computers. Depending on the source, PQC is either considered a complementary solution or is not categorized under quantum communication, since it does not rely on quantum particles but addresses the same long-term security challenges.

Looking further ahead, quantum communication technologies such as QKD form the building blocks of the **quantum internet** — a global network designed to connect quantum devices and users via entangled quantum states. The following table describes some of the near-term and future opportunities of quantum communications.

Potential application areas of quantum communication

Secure data transmission (QKD)

- Protecting classified government and defense communications
- Securing financial transactions and data exchange between institutions
- Safeguarding energy, transport, and healthcare infrastructure communications
- Ensuring enterprise data privacy and protection of intellectual property
- Enabling global QKD via satellites for long-distance secure links

Quantum Internet

- Enabling distributed quantum computing across remote quantum processors
- Supporting secure, cloud-based quantum computing services
- Enabling fundamental tests of quantum mechanics over global distances

Advanced sensing and metrology networks

- Linking quantum sensors securely across locations
- Enhancing measurement precision through networked quantum systems

Secure voting and identity verification

- Developing tamper-proof electronic voting systems
- Using quantum digital signatures to verify identity and secure transactions

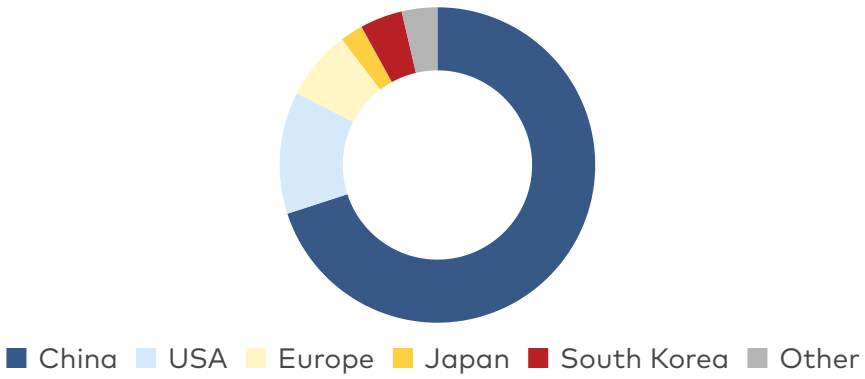
Worldwide market development and Nordic-Baltic positioning

Quantum communication is on a sharp upward trajectory, driven by the urgent need for ultra-secure networks in finance, defense and critical infrastructure. The global market is projected to grow from approximately USD 1.3-1.6 billion in 2025 to USD 10.5-14.9 billion by 2035, representing 23-25% compound annual growth rate (CAGR).[6] Rising cybersecurity threats, from quantum-capable adversaries to conventional hackers, underpin this rapid growth. Significant edge-computing and 6G development efforts integrate quantum-secure links into existing telecom and data-centre architectures.

Increasing importance is evident also in the statistics of academic publications. Fraunhofer ISI study[7] points out a 10-fold increase in publications globally (from 200 in 2020 to nearly 2000 publications in 2022). Out of papers published in 2022, around 33 % originate from China, 29 % from the EU, and 16 % from the USA. Although China leads in volume, European research, often cited more frequently, demonstrates high impact. Nordic-Baltic institutions are increasingly visible within this ecosystem, contributing niche expertise in areas like secure network protocols and satellite-based key distribution that bolster the region's growing academic footprint in the quantum-communication arena.

Patent filings in quantum communication highlight China's dominant role: it accounts for nearly 70 % of global quantum communication patent families, followed far behind by the United States, Europe, Korea and Japan.

Number of quantum communication patent families per country/region



Source: PatSnap 16.5.2025

Footnotes & References:

[1] Qureca (April 25, 2025) Quantum Initiatives Worldwide 2025
[2] Quantum Technology Monitor, McKinsey & Company, April 2023
[3] Quantum insider (2024) The Quantum Insider Projects $1 Trillion in Economic Impact From Quantum Computing by 2035
[4] McKinsey, 2024 estimates 10-15% annual growth by 2030, where as Global Market Insights estimates 15% CAGR between 2024-2032, and IdTechEx forecasts 11.4% CAGR between 2025 and 2045
[5] McKinsey (17.9.2024) Quantum sensing's untapped potential: Insights for leaders - Article
[6] McKinsey (2025) Quantum communication: Trends and outlook.
[7] Fraunhofer ISI & Universität Des Saarlandes. (2024), Monitoring Report 1. Quantum Communication.

- European Quantum Industry Consortium. (2024). A Portrait of the Global Patent Landscape in Quantum Technologies.
- European Quantum Industry Consortium. (2025). QuIC's Recommendations for the EU Quantum Strategy.
- Fraunhofer ISI & Universität Des Saarlandes. (2024), Monitoring Report 1. Quantum Communication.
- IBM Institute for Business Value. (2023). The quantum decade. A playbook for achieving awareness, readiness, and advantage. 4th ed.
- IQM, OpenOcean, & Lakestar. (2024). State of quantum 2024: Understanding the 2023 trends and outlook for 2024.
- MarketsandMarkets. (2024). Quantum Communication Market.
- McKinsey Digital (April 24, 2024) Steady progress in approaching the quantum advantage,
- McKinsey Digital (2024) Quantum Technology Monitor
- McKinsey (2025) Quantum communication: Trends and outlook.
- OECD. (2025). A quantum technologies policy primer. OECD Digital Economy Papers, No. 371, OECD Publishing, Paris.
- QED-C. (2024). Quantum Sensing for Position, Navigation and Timing Use Cases.
- Quantum Flagship. (2024). Strategic Research and Industry Agenda.
- Soller, H. & Mohr, N. (2024). Quantum sensing's untapped potential: Insights for leaders. McKinsey.
- WACQT. (2023). Mid-Term Report Summarising 2018-2023.
- Wallin, A., Apilo, T., Nurmi, O., Nuutinen, M., & Kotovirta, V. (2024). Quantum computing: Practical guide to navigating the future. VTT.


“By aligning policy, funding, and talent across borders, we create an innovation ecosystem that outpaces individual national efforts.”



National quantum ecosystems

This chapter overviews the national quantum technology ecosystems across the Nordic and Baltic countries. It primarily focuses on commercial actors and the policy and funding instruments that support their development. While some countries have a long-standing tradition in quantum technologies and are already advancing commercial activities across computing, communication, and sensing, others are more recently recognizing the strategic importance of building quantum business ecosystems. Across the region, a combination of research-driven innovation, startup formation, and targeted public-private collaboration is shaping the future landscape. This chapter highlights emerging companies, flagship initiatives, and government efforts aimed at fostering commercialization, attracting investment, and integrating national strengths into the broader European and global quantum economy.



Denmark

Denmark's quantum technology business ecosystem is rooted in a long and significant history of world-class scientific research. In addition, Denmark has built targeted infrastructure and fostered a culture of strong public-private partnerships to turn scientific breakthroughs into commercial solutions. The Danish Quantum Community, leading universities such as the University of Copenhagen, Technical University of Denmark, Aarhus University, University of Southern Denmark, and Aalborg University, and industry clusters collaborate closely to promote knowledge exchange, matchmaking, and pilot projects. Initiatives like "express licenses" for academic spin-offs help streamline tech transfer.

Quantum technology development in Denmark

Denmark is highly active in quantum computing research and hardware and algorithm development. The country hosts a vibrant mix of startups like Kvantify and QPurpose, alongside global players like Microsoft Quantum Materials Lab, an IBM Quantum Hub, and Atom Computing. Research spans quantum error correction, quantum simulation, and application-specific algorithms, particularly for life sciences and optimization problems.

A distinctive feature of Denmark's approach is the Novo Nordisk Foundation Quantum Computing Program (NQCP), which adopts a multi-modality strategy. Rather than focusing on a single qubit type, NQCP supports parallel research in superconducting qubits, trapped ions, and photonic qubits. This flexible model aims to identify and scale the most viable platform for a fault-tolerant quantum computer while minimizing early-stage technology lock-in.

On the quantum sensing front, Denmark leverages its strong capabilities in precision measurement, photonics, and atomic physics. A major initiative, the Center for Biomedical Quantum Sensing, targets biomedical applications, aiming to establish a new paradigm of quantum-enabled medicine. It brings together leading research groups to develop highly sensitive sensors for diagnostics, biological imaging, and health monitoring. National efforts also explore sensing applications for energy systems, defense, and navigation, building on Denmark's strengths in photonics and precision engineering.

In quantum communication, Denmark focuses on secure transmission and quantum key distribution (QKD). Research institutions and companies are piloting secure communication solutions for the public sector and critical infrastructure. Parallel

efforts support integration of post-quantum cryptography into existing systems. The forthcoming International Quantum Hub and related security initiatives aim to position Denmark as a trusted provider of quantum-secure technologies, enhancing both domestic resilience and international partnerships.

National actions to advance quantum technology in Denmark

The Danish government has launched a comprehensive National Strategy for Quantum Technology. Initially focused on research leadership, it now expands toward commercialization, security, and global collaboration. More than DKK 1 billion has been allocated to quantum R&D for 2023–2027, with an additional DKK 200 million directed toward market development, internationalization, and strengthening national resilience.

Innovation Fund Denmark has introduced a strategic program with DKK 150 million to support basic and applied research, talent development, interdisciplinary collaboration, testing and demonstration facilities, entrepreneurship, and standards development.

To bridge the gap between research and commercialization, the government is establishing Quantum House Denmark—providing co-working space, prototyping labs, and business development services — and a National Test Center funded by the Novo Nordisk Foundation to offer shared access to precision measurement and fabrication tools. A National Forum for Quantum Technology brings together academia, industry, startups, and funders to align objectives and address ecosystem-level challenges. Demonstration projects led by industry and public-sector actors showcase early-stage quantum applications.

Internationally, the upcoming International Quantum Hub aims to highlight Denmark's strengths, attract global talent, and build new research and business alliances. A dedicated secretariat will coordinate national efforts to detect and mitigate emerging quantum security threats, from post-quantum cryptography deployment to critical infrastructure protection.



Finland

Finland's position as one of Europe's most dynamic hubs for quantum technologies stems from decades of sustained excellence in low-temperature physics, cryogenics, and microsystem engineering. This long-standing scientific and technical foundation has gradually evolved into a robust quantum ecosystem that now spans foundational science, hardware, software, sensing, and communication. Today, Finland combines world-class research, deep industrial expertise, and a growing commercial sector.

Quantum technology development in Finland

Research infrastructures in micro-, nano-, and quantum technologies are at the core of Finland's quantum ecosystem, developed through long-standing collaboration between *Aalto University* and *VTT Technical Research Centre of Finland*. The ecosystem has been supported by consistent public investment, particularly through the Academy of Finland, which has funded Centers of Excellence in quantum research since the mid-1990s. More recently, *InstituteQ* was established to strengthen national coordination and networking among key players in academia, industry, and education, promoting Finland's cohesive and forward-looking approach to quantum development.

On the commercial side, quantum computing is Finland's most visible and internationally competitive segment. Two key companies are *Bluefors* and *IQM Quantum Computers*. Bluefors is the world's leading supplier of dilution refrigerators — essential for operating most quantum computers — while IQM is one of Europe's top hardware companies, developing superconducting quantum processors and full-stack quantum computing systems. VTT spin-off *SemiQon* is also developing silicon-based quantum processors that offer scalability and compatibility with existing industrial manufacturing. Startups such as *Algorithmiq, Quanscient, Arctic Instruments,* and *QMill* have recently secured multi-million-euro investments to accelerate quantum algorithms and simulations growth.

Finland also has a long-standing tradition in superconducting sensor technologies, which build on the same low-temperature expertise underpinning its quantum computing sector. In quantum sensing, Finland hosts a complete commercial value chain, especially in SQUID (Superconducting Quantum Interference Device) technologies. This chain ranges from sensor development at VTT, through companies like *Aivon Oy* and *Megin Oy,* to delivery of advanced brain imaging systems used in hospitals worldwide. While Finland has been less prominent in photonic quantum

technologies, interest in this area is growing. Photonics Finland, the national photonics association, supports both industrial development and scientific collaboration in photonic and quantum-enabled sensing applications.

Quantum communication is another growing field. Finnish research institutions actively participate in European initiatives such as EuroQCI, and national projects are underway to develop secure quantum links. While these technologies are not yet commercialized, they lay the groundwork for future quantum networks aligned with EU strategic objectives.

National actions to advance quantum technology in Finland

Finland's policy framework is guided by the Quantum Technology Strategy 2025–2035, published by the Ministry of Economic Affairs and Employment in 2025. The strategy sets out an ambitious vision: to make Finland globally competitive, attract international investment, and apply quantum technologies to drive business and societal value by 2035.

Key goals include achieving €3 billion in quantum industry turnover and supporting 10,000 jobs, with Finland positioned as a globally trusted partner. Measures outlined in the strategy include the development of world-class quantum computing infrastructure (targeting a 1,000 logical qubit system), integrating high-performance computing and AI, globally leading quantum software development, and targeted support for component manufacturing. The strategy also emphasizes long-term funding for research, education, and innovation, and aims to strengthen the industrial ecosystem by aligning academia, business, and investors.

Internationally, Finland plays an active role in the EU Quantum Flagship and Nordic Quantum collaboration, supporting cross-border research, infrastructure development, and talent exchange. With a strong research base, a rapidly growing startup community, and a clear national policy, Finland is well-positioned to become a key European player in the commercialization and application of quantum technologies.



Sweden

Sweden has emerged as a significant player in the Nordic quantum landscape, supported by strong academic research, active international collaboration, and targeted private investment. While the country currently lacks a unified national quantum strategy, key institutions and initiatives — most notably *the Wallenberg Centre for Quantum Technology (WACQT)* — have positioned Sweden at the forefront of several quantum technology domains, including quantum computing, communication, and sensing.

Quantum technology development in Sweden

Quantum computing research in Sweden is centered around *Chalmers University of Technology*, which leads the WACQT initiative. Launched in 2018 with SEK 1.4 billion in funding from the Knut and Alice Wallenberg Foundation, WACQT's flagship goal is to build a 100-qubit superconducting quantum computer by 2029. The program supports full-stack development — from hardware to software and algorithms — making Sweden one of the few countries globally pursuing such an integrated approach. In parallel, the Quantum Sweden platform, funded by the national innovation agency Vinnova, seeks to accelerate research translation into industrial applications and to strengthen collaboration between academia, startups, and large enterprises.

Quantum sensing is another promising area, particularly at *Lund University*, which hosts WACQT's sensing research node. Sweden's strengths in photonics, cryogenic electronics, and materials science underpin efforts to develop quantum sensors for precision measurement, navigation, and materials characterization. While still in the early stages of commercialization, several Swedish startups — such as *AdamantQ, DeepLight Vision,* and *SpectraCure* — are developing components relevant to sensing. Industrial interest is growing, particularly in telecommunications, defense, and life sciences. However, translating research into market-ready products remains a key challenge.

Sweden is also advancing quantum communication. KTH Royal Institute of Technology leads quantum key distribution (QKD) and quantum networks research. A significant milestone was when KTH inaugurated a pilot quantum communication facility in Stockholm to serve as Sweden's national hub within the broader European

Quantum Communication Infrastructure (EuroQCI). The project reflects strong collaboration between research excellence and industrial engagement. Major players such as Ericsson and innovative Swedish startups are actively involved in this dynamic innovation ecosystem.

Sweden's quantum ecosystem is built on a foundation of technical expertise, world-class research institutions, and active collaboration between academia, industry, and private foundations. Initiatives like WACQT and Quantum Sweden demonstrate national capacity for innovation, while a growing number of startups, such as Scalinq and Con-Science, are beginning to translate scientific advances into commercial applications.

National actions to advance quantum technology in Sweden

In 2023, the Swedish Quantum Agenda was published, calling for a more cohesive national approach to quantum technologies. It identified key priorities, including increased public investment, targeted funding instruments, and better alignment between research, education, and industry. The agenda also noted structural challenges such as fragmented funding and limited access to venture capital.

In response, the Swedish government tasked the Swedish Research Council (Vetenskapsrådet) in 2024 with developing a national quantum strategy for 2025–2030. This forthcoming strategy is expected to provide a coordinated framework for guiding research priorities, infrastructure investments, education, and innovation policy, marking a key step toward long-term national planning in quantum technologies.

As quantum technologies move toward real-world deployment, Sweden is well-positioned to lead in several niche areas, supported by academic excellence and growing industrial engagement. Realizing this potential will require continued investment in talent, stronger policy coordination, and deeper international collaboration to ensure Sweden remains competitive in the rapidly evolving global quantum landscape.



Norway

Norway's quantum technology business ecosystem is currently less developed compared to its Nordic neighbors. Commercially oriented activities remain limited, but recent developments indicate increasing momentum in both research and policy.

Research strengths and collaborative efforts

Norwegian quantum research has traditionally been strong in theory, with institutions such as the University of Oslo, Oslo Metropolitan University, NTNU, and the University of Bergen playing key roles. These universities work on various topics, including quantum materials, condensed matter physics, quantum software engineering, and algorithm development. Although Norway has more limited experimental capacity than some of its peers, its researchers actively collaborate with international partners.

Emerging initiatives such as the Gemini Center on Quantum Computing and the OsloMet Quantum Hub are fostering a more coordinated research environment. Oslo Science City, Norway's first innovation district, has also identified quantum technology as one of its focus areas to attract talent and encourage collaboration between academia and industry.

Policy developments

In response to the growing importance of quantum technologies, the Norwegian government has announced plans to develop a national quantum strategy, aiming for release in 2026. This initiative seeks to address the current lack of strategic direction and limited funding, which have constrained progress to date. Additionally, the Long-Term Plan for Research and Higher Education (2023–2032) designates quantum technology as a national priority, alongside artificial intelligence and biotechnology. This marks a significant step toward recognizing quantum as a strategic research area.

Industrial potential and the path forward

Quantum sensing is one of Norway's most promising areas, with potential applications aligned with national strengths in the defense and maritime sectors. Kongsberg Gruppen, a leading Norwegian industrial player, is well-positioned to explore quantum sensing technologies for use in high-precision navigation, underwater detection, and secure communications. While these developments indicate strong future potential, most activity remains at the research and prototyping stage, and commercial applications are still limited. Nevertheless, the sector is viewed as a strategic opportunity for industrial innovation and differentiation.

Looking ahead, Norway is laying the groundwork for long-term success in quantum technologies. The forthcoming national quantum strategy is expected to offer clear direction and coordinated support for the ecosystem. However, a strategy alone will not be enough to position Norway among the global leaders. To secure its place in the quantum future, the country will also need to significantly increase investment, cultivate domestic talent, and deepen international partnerships.



Iceland

Iceland's quantum technology ecosystem is still in its early stages, but there is growing interest, particularly through high-performance computing (HPC) and international collaboration. The Icelandic High-Performance Computing (IHPC) Center, which also serves as the National Competence Center for HPC and AI, has begun exploring quantum computing in the context of advanced simulation and research infrastructure. Although Iceland does not yet have a dedicated national quantum strategy, large-scale funding, or major quantum initiatives, it is actively involved in regional and European collaborations that support long-term quantum development.

The University of Iceland is central to the country's emerging quantum activities. Notably, it maintains strong research ties with Forschungszentrum Jülich in Germany, one of Europe's leading quantum computing and simulation institutions. These partnerships provide Icelandic researchers access to cutting-edge expertise and infrastructure, helping build capacity despite Iceland's limited experimental facilities.

Iceland also participates in the Nordic Quantum network, the Nordic academic community for quantum science and technology (QST). While the national quantum workforce and commercial activity remain very limited, early educational initiatives and international collaboration suggest that Iceland is laying the groundwork for a more active role in the quantum future.



Estonia

Estonia's quantum technology ecosystem is in the early stages of development but shows increasing commercial potential. While the national community remains small and there is no dedicated quantum strategy in place, Estonia benefits from an agile tech environment and strong capabilities in software engineering, an area of growing relevance for quantum algorithms and application development. The country's global reputation in digital innovation and secure e-government services positions it well to explore quantum-secure infrastructure and post-quantum cryptography solutions.

Emerging commercial activity in sensing and cybersecurity

Commercial interest is most visible in areas adjacent to quantum sensing and secure communications. Startups such as GScan are advancing classical detector technologies that align with future quantum sensing capabilities. Several Estonian electronics manufacturers are designing low-noise components compatible with quantum devices, and some firms are beginning to explore how quantum sensors could be integrated into advanced industrial and defense applications. There is also early activity in post-quantum cryptography, with Estonian companies investigating data protection solutions for the quantum era.

Estonia participates actively in several international quantum initiatives, gaining important commercial exposure and building partnerships. Estonia is part of the EuroQCI initiative and is currently developing a national quantum communication infrastructure (EstQCI) led by the Ministry of Economic Affairs and Metrosert. The platform Kvant, operated by Metrosert, serves as a national coordination point, connecting stakeholders across research, government, and industry and promoting awareness and collaboration in the quantum domain.

Software-led quantum potential

Estonia is also a partner in NordIQuEst, a Nordic-Estonian infrastructure project integrating high-performance computing and quantum technologies. Combined with existing collaborations with more mature ecosystems, such as Finland's and Estonia's strong software-driven innovation culture, these developments suggest that with the right policy signals and investment, Estonia could carve out a competitive role in the emerging quantum economy, particularly in software, cryptography, and sensing-related technologies.



Latvia

Latvia's quantum technology ecosystem is gaining traction through a combination of public investment, strong academic foundations, and increasing industry engagement. While the commercial landscape is still emerging, Latvia is aiming to position itself as a proactive regional player, particularly in quantum computing, quantum communication, and photonic technologies. A central coordinating effort, the Latvian Quantum Initiative (2023–2026), is helping to unify research institutions, industry, and policymakers to foster innovation and support commercialization.

Quantum technology development in Latvia

Latvian companies are exploring practical applications in quantum computing in collaboration with research institutions. Accenture Baltics has piloted the use of quantum algorithms for medical image analysis and continues to investigate their utility in other sectors. Tilde, a leading language technology company, is contributing to EU-funded projects exploring the use of quantum algorithms in computational linguistics as an industry partner for data preparation and performance evaluation. These activities indicate a growing interest in quantum algorithms and applications among Latvian firms.

Quantum communication is another area of strategic focus. Telecom operators LMT and Tet, working with Mikrotik and research institutions like IMCS UL, are developing next-generation quantum-encrypted networks. Notably, Latvia is deploying an experimental national Quantum Key Distribution (QKD) network, co-funded by the EU with a total budget of €8.06 million. Latvia State Radio and Television Centre leads the infrastructure and will support secure data transmission in healthcare, finance, and defense sectors. Use cases include 5G and satellite-based encryption.

Towards a quantum testbed for applied innovation

Substantial policy and funding instruments, including €17 million from the EU Recovery and Resilience Facility, dedicated to quantum technology development, support Latvia's efforts. Latvia's participation in the EuroQCI initiative further reinforces the ecosystem, positioning the country as an important contributor to Europe's future quantum communication infrastructure. Combined with active industrial pilots and public-private collaboration, these initiatives aim to transform Latvia into a testbed for applied quantum technologies, with long-term ambitions in quantum device development, secure communication, and small-scale component manufacturing.



Lithuania

Lithuania's quantum technology ecosystem is grounded in a strong academic tradition, particularly in photonics, quantum optics, and theoretical physics. Institutions nationwide have significantly contributed to quantum science, supported by decades of foundational research. However, the commercial side of quantum technologies is still emerging, with limited industry engagement and early-stage startup activity. Recent national and European initiatives are now laying the groundwork for a more robust innovation and commercialization landscape.

Quantum technology development in Lithuania

Lithuania's internationally recognized laser and photonics industry forms a critical foundation for many quantum applications. The country produces key components — such as laser systems, semiconductor devices, and advanced materials including graphene, diamond, and hexagonal boron nitride — essential for quantum hardware. These enabling technologies support both domestic research and international collaborations across quantum computing, sensing, and communication.

Quantum sensing is one of Lithuania's most advanced and commercially active quantum domains. Research focuses on compact, high-sensitivity sensors, including techniques such as electron spin resonance, diamond-based sensing, and quantum imaging for detecting weak signals in noisy environments. Work on atomic spin squeezing and entanglement further positions Lithuania at the forefront of sensor innovation, with commercial products already reaching the market through various technology platforms.

Lithuania views quantum communication as a strategic focus area, partly driven by geopolitical considerations. Research includes the development of defect-based single-photon sources, quantum cryptography, and quantum key distribution (QKD) for secure telecommunications. Both theoretical and experimental work is underway, with a long-term goal of establishing secure quantum communication infrastructure for terrestrial and free-space environments.

Emerging quantum business ecosystem in Lithuania

A key milestone in national coordination was the establishment of the Lithuanian Quantum Technologies Association (LQTA) in late 2023. This organization is a central hub connecting stakeholders from academia, industry, and government to promote quantum technology research, education, and commercialization. Although the commercial ecosystem is still taking shape, Lithuania's participation in European initiatives, such as the 2024 signing of the European Declaration on Quantum Technologies, demonstrates a growing ambition to position the country as an emerging contributor in quantum computing, sensing, and communication.

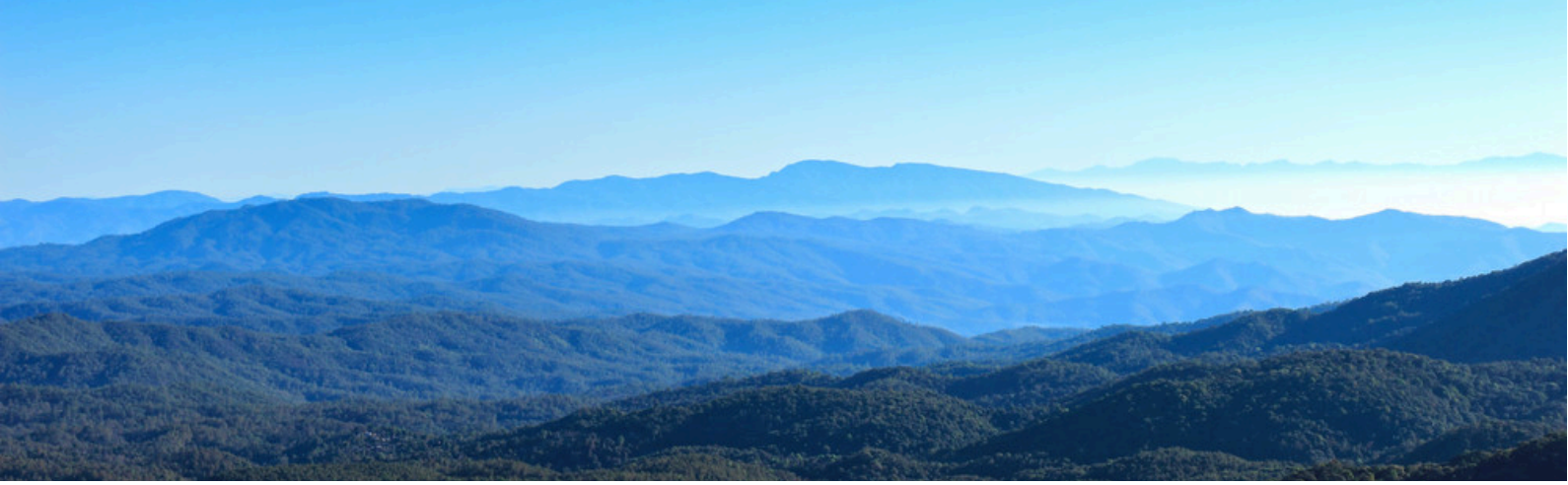
Summary of Nordic-Baltic quantum business activities

Before turning to the cross-country analysis, the following summary highlights the distinct strengths and emerging focus areas of each Nordic and Baltic country, providing a concise snapshot of how individual nations are contributing to the region's evolving quantum technology landscape.

- **Denmark** combines strong research leadership in quantum optics and electronics with rapidly growing commercial activity, anchored by major national investments—most notably from the Novo Nordisk Foundation, which drives long-term ecosystem development through its quantum computing programme and broader funding for infrastructure, talent, and interdisciplinary applications.
- **Finland** is a European frontrunner in superconducting quantum computing, anchored by IQM and Bluefors and supported by a vertically integrated ecosystem with world-class research and infrastructure.
- **Sweden** excels in quantum sensing and superconducting computing through the WACQT program and is fostering a dynamic ecosystem of deep-tech startups and strong academic collaboration.
- **Norway** is building momentum in quantum sensing and quantum software, with national strategy development underway and established industrial actors, such as Kongsberg, engaging in quantum exploration.
- **Iceland** contributes to the Nordic-Baltic quantum landscape through international academic collaborations and foundational research in quantum physics.
- **Estonia** is strengthening its role in quantum communication and post-quantum cryptography, supported by solid software expertise and active participation in initiatives like EuroQCI and NordIQuEst.
- **Latvia** is developing academic excellence in quantum photonics and optics, laying the groundwork for future commercialisation and regional collaboration.
- **Lithuania** leverages its strong photonics and laser industries to develop quantum communication and sensing technologies, supported by active research groups and growing strategic interest.

References

- Bruaset, A. M. Ali, S., Brodtkorb, A., Bøe, G., Denysov, S., Eide, H., & Selstø, S. (2023). Bidrag til ein norsk strategi for kvanterekning. QCNorway. Simula, OsloMet, Sigma.
- Business Finland. (2024). Quantum computing from Finland.
- The Danish Government. (2023). National Quantum Strategy. Part 2 - Commercialisation, Security and International Cooperation.
- Danish Quantum Community
- Erhvervsministeriet. (2024) Kvantenindustrien i Denmark.
- Erhversstyrelsen. (2022). Kortlægning af økosystemet for kvanteteknologi i dansk erhvervsliv
- European Quantum Flagship
- FInland's Quantum Technology Strategy 2025-2035. A new engine of growth and builder for a sustainable future. (2025). Publications of the Ministry of Economic Affairs and Employment Enterprises. 2025:18.
- Forskningsradet. (2024). Investeringsplan.
- Forskningsrådet. (2024). Rapport til Kunnskapsdepartementet fra Norges Forskningsråd. Behov for tungregnekraft for forskning og kunstig intelligens.
- Gemini Center on Quantum Technology
- InstituteQ. (2025) The quantum science and technology workforce in Finland 2035.
- KPMG. (2020). Quantum technology in Denmark. The case for Danish investment in quantum technology.
- Krågebakk, V. (2025). Report: The Ecosystem Surrounding Quantum Technology: Important Considerations and Key Takeaways. Kongsberg.
- Kunnskapsdepartementet. (2025). Nå starter arbeidet med nasjonal strategi for kvanteteknologi.
- Labs of Latvia (2023) Article series of 6 blog posts/articles.
- LMT Quantum innovations
- Marzo, S.D. (2023). Helsinki-based quantum scaleup Algorithmiq raises €13.7 million to dramatically reduce time and cost of drug discovery. EU-Startups.
- Meld. St. 5 ENG (2022–2023) Long-term plan for research and higher education 2023-2032
- Nordita. (2024). Nordic Quantum. White Paper.
- Norway announces quantum catch-up strategy - Research Professional News
- The OsloMet Quantum Hub
- Quantum Lithuania. (2025). Lithuanian quantum technologies agenda.
- Regjeringen. (2025). Nå starter arbeidet med nasjonal strategi for kvanteteknologi. Pressemelding.
- RISE, Swelife, The Swedish Research Council, Vinnova & WACQT. (2023) Swedish Quantum Agenda. Vinnova.
- Rodríguez, A. G. (2024). Finland in the race for quantum advantage. Policy Recommendations for a National Quantum Strategy. Sitra.
- SemiQon. (2025). EUR 17.5 million in EIC Financing Propels SemiQon's Growth from Startup to Scaleup.
- Swayne, M. (2024). Finland-based QMill Raises $4.5 Million in Seed Funding. The Quantum Insider.
- Swayne, M. (2024). Quantum Algorithm Company Quanscient Secures €5.2 Million in Growth Funding. The Quantum Insider.
- Teknologisk Institut. (2023). Kvanteteknologi i Danmark. Framtiden er kvanteteknologi - hvordan kommer Danmark med?. Teknologisk udsyn. Nr. 2.
- Uddannelses - og Forskningsstyrelsen. (2022). Forskning på kvanteområdet. Herunder samspillet mellan universiteter og virksomheder.
- Vinnova (2025) National Quantum Communication Infrastructure in Sweden
- VTT. (2025). IQM Quantum Computers to supply Finland with a world-leading superconducting 300-qubit quantum computer. Press Release.
- VTT. (2024). Arctic Instruments raises EUR 2.35 million for developing next-generation amplifiers for quantum computers. Press Release.



Mapping of Nordic-Baltic quantum business ecosystems

The Nordic–Baltic quantum technologies business ecosystem map provides a clear, at-a-glance overview of the region's rapidly evolving quantum sector. By visualizing the whole constellation of quantum technology "makers" [1][2] — from pioneering startups and established technology firms — this map makes it easy to identify existing clusters, emerging hubs, and potential points of collaboration across Denmark, Finland, Iceland, Norway, Sweden, Estonia, Latvia, and Lithuania.

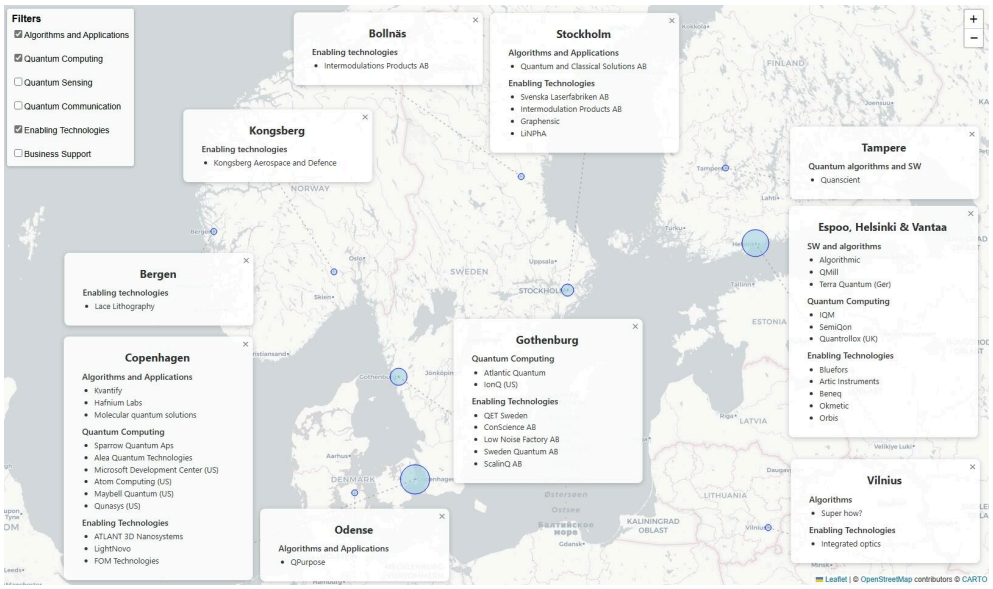
Understanding the geographic distribution of these key players is essential for policymakers, investors, and corporate strategists alike. It highlights strengths to build on and gaps to address, guides targeted partnership development, and supports informed decision-making in a field where proximity and network effects are critical. This ecosystem map, therefore, serves as both a strategic planning tool and a catalyst for deeper Nordic–Baltic cooperation in quantum innovation.

Quantum computing

Hardware excellence fueling broader innovation and global reach

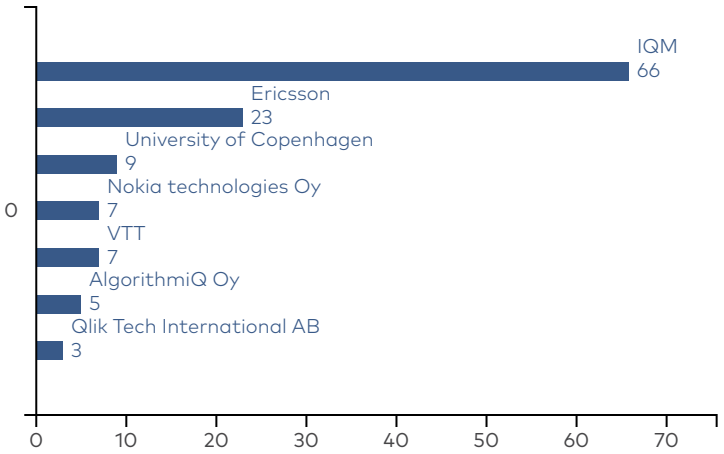
Across the Nordic-Baltic region, three principal hardware hubs drive quantum computing development: the Copenhagen area, Espoo in Greater Helsinki, and Gothenburg. Each hub is anchored by leading universities and public research institutes, which remain the region's primary sources of foundational innovation.

Quantum computing HW & SW firms and enabling technologies



The patent landscape (see figure below) reflects both these deep academic roots and growing industrial ambition. IQM leads with a large portfolio focused on superconducting and planar qubit architectures. Global telecom giants Ericsson (with 23 patents) and Nokia (with 7 patents) follow closely, staking early claims in quantum-enabled communications and error-correction methods. However, how actively they participate in the Nordic-Baltic ecosystem remains unclear beyond their broader operations.

Quantum computing patents (Nordic and Baltic countries)



The figure includes patent holders with three or more patent families. In addition, there are 2 patent families by WACQT IP AB, EpinovaTech AB, Artic Instruments, Molecular Quantum Solutions APS, Aarhus University, Microsoft Technology Licensing LLC, QET Sweden AB, QDevil APS, and Quanscient Oy. Also, 33 single patent-family holders exist, which are not displayed in the figure.

Public research organizations also contribute critical patents that seed later spin-out companies. For example, the University of Copenhagen and VTT Technical Research Centre of Finland bridge theoretical advances in quantum control with practical demonstrators, ensuring that Scandinavian academic excellence continues feeding into commercial pipelines.

On the software and algorithms front, the ecosystem is less mature but rapidly evolving. Fast-growing firms like Algorithmiq, specializing in quantum-accelerated chemistry simulations, already hold multiple patent families, signaling a clear IP strategy for niche leadership. Other quantum software players such as Denmark's Kvantify and Finland's Quanscient and QMill have also secured multi-million-euro funding rounds, demonstrating rising market interest.

Beyond core qubit technologies and applications, a flourishing ecosystem of enabling hardware and control-software developers, including areas outside the main hubs, is taking shape. Over thirty additional entities hold single patent families, ranging from specialist labs to emerging startups. This long tail covers innovations from photonic-qubit components to novel error-mitigation protocols. The fact that many small teams or individual inventors own one or two patent families highlights a vibrant grassroots ecosystem of experimentation that complements the work of larger players.

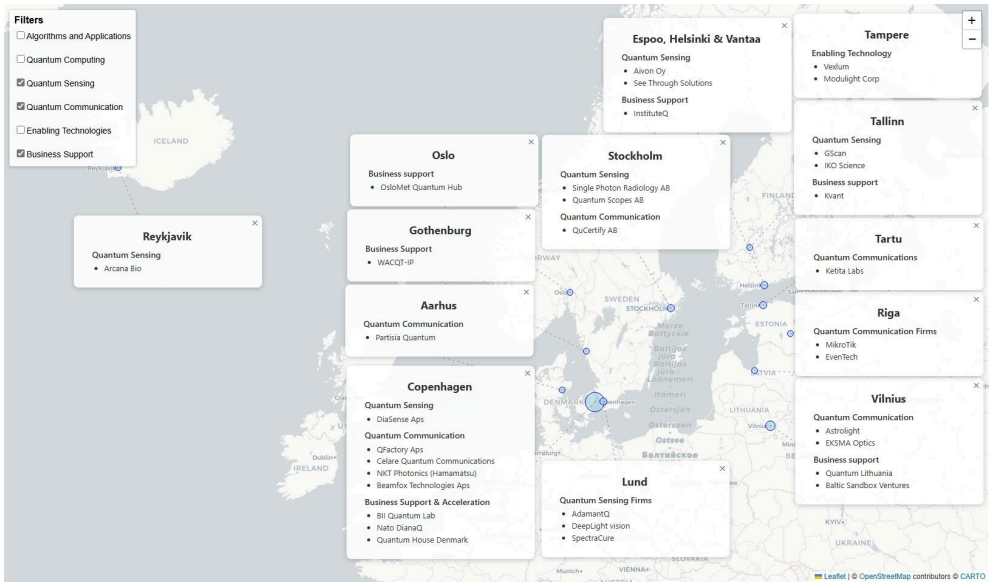
Taken together, this distribution of patent activity demonstrates a maturing Nordic-Baltic quantum ecosystem. Leading organizations build depth and scale, while agile newcomers explore high-value niches. Academic institutions continue to seed the field with breakthrough ideas and strategic alliances—whether through licensing or joint ventures—and promise to convert these patents into the next generation of quantum hardware, software, and services.

Quantum sensing

An emerging frontier with untapped industrial potential

Quantum sensing is a rapidly evolving field that promises transformative improvements in measurement precision, particularly in biomedical imaging, navigation, materials characterization, and defense. However, current patenting activity in the Nordic-Baltic region suggests the field is still in a nascent phase commercially. Only 46 patent families related to quantum sensing have been identified in the region, with a handful of organizations — IQM, Nokia, VTT, and Algorithmiq — holding more than one patent family. This modest IP footprint, however, does not reflect the broader industrial potential embedded in the region.

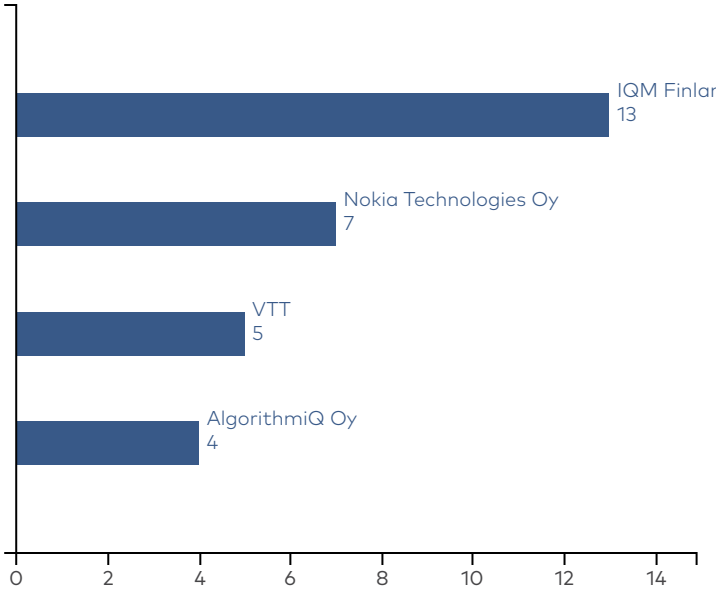
Quantum sensing, communication and business support



Several Nordic institutions and companies have longstanding industrial and research experience in classical sensing domains that are highly relevant to quantum applications. Finland's VTT stands out with its decades-long work in superconducting quantum interference devices (SQUIDs), which it also manufactures commercially. These superconducting sensors form a foundational technology for many quantum sensing applications, especially in areas like biomagnetism and magnetoencephalography (MEG).

Beyond this, the Nordic region hosts a broad base of companies specializing in classical sensing, low-noise electronics, optics, and photonics, all providing essential enabling technologies for future quantum sensors. Despite this alignment, many of these firms have not moved strategically into quantum sensing. Significant investment in research, retooling, and market development is required to transition existing expertise toward quantum-enabled products — efforts that currently remain largely invisible in public IP filings or commercial announcements.

Quantum sensing patents (Nordic and Baltic countries)



Note. Figure excludes 17 patent family holders with only one patent family.

Meanwhile, a new generation of startups is beginning to emerge, many building on academic advances in Sweden and Denmark. Notably, sensing nodes within the Wallenberg Centre for Quantum Technology (WACQT) in Lund and the Center for Biomedical Quantum Sensing in Copenhagen are spawning ventures focused on developing commercially viable quantum sensors. These startups are targeting applications in healthcare, neuroscience, and precision navigation, aiming to bring quantum-enabled products to market within the next few years. However, their commercial footprint is still at an early stage and not yet strongly reflected in IP portfolios or major venture capital activity.

While the Nordic-Baltic region has a strong foundational ecosystem in measurement and sensing, the leap into quantum sensing will require concerted policy, funding, and industrial engagement to capitalize on existing strengths fully. The region stands at a promising inflection point, with a visible research-to-commercialization pipeline beginning to take shape.

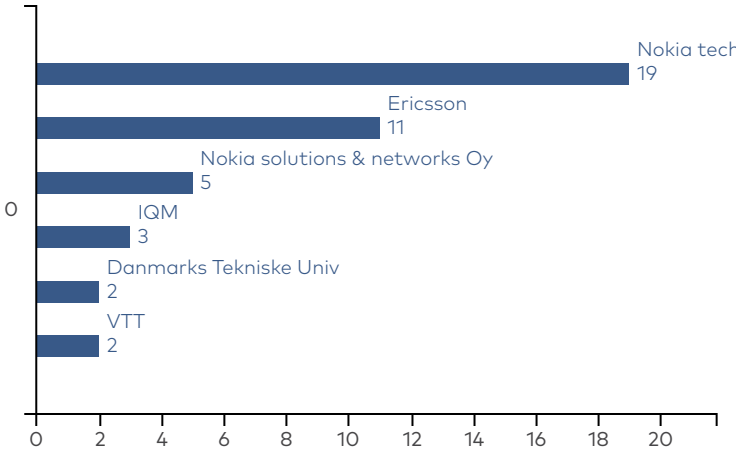
Quantum communication

A nascent but strategically positioned field

Quantum communication in the Nordic-Baltic region remains in an early commercialization phase, particularly when benchmarked against global frontrunners. Patent data illustrates this clearly: across seven countries, only 58 patent families have been identified in the field of quantum communication—a small figure given the strategic importance of secure communication in the quantum era.

A handful of players currently dominate commercial and research patenting activity. The top three patent holders are *Nokia Technologies Oy (*19 patent families), *Telefon AB LM Ericsson* (11), and *Nokia Solutions & Networks Oy* (5), together accounting for nearly two-thirds of all regional patents. These figures reflect strong Finnish and Swedish industrial foundations in telecommunications, particularly in classical network infrastructure, which are now being extended into quantum-secure applications.

Quantum communication patents (Nordic and Baltic countries)[3]



Note. Figure excludes 14 patent family holders with only one patent family.

Startups and SMEs focused exclusively on quantum networking or novel photonic quantum communication platforms are still rare and invisible in the patent survey. However, there appear to be emerging startup activities in some of the key quantum hubs in the Nordics. Denmark emerges as the leading country in the number of firms primarily focusing on quantum communications[1]. Much of the activity in Denmark and the Nordic-Baltic region is linked to the European EuroQCI initiative, which aims to establish cross-border quantum key distribution links between key national nodes. This includes government-backed efforts to secure digital infrastructure and strengthen sovereignty in critical communications.

In summary, the Nordic-Baltic region has essential technological capabilities and

research depth in quantum communication but lags in commercial maturity and patent output compared to global leaders. With focused investments, clearer national strategies, and stronger industry-academia partnerships, the region could begin translating its latent strengths into a competitive quantum communication ecosystem.

[1] Data excludes companies that are categorised as end-users, consultants or educators. Although research organisation are highly important for competitiveness, they are excluded in this study, since they are evaluated in complementary study of quantum research in Nordics.
[2]Categorising companies exclusively under "quantum computing", "quantum sensing" and "quantum communication" is challenging due to overlapping technologies; the same hardware and software innovation may support use cases in different quantum technologies. Each company is listed only once (to avoid overcrowding the figure), based on an estimation what is the most relevant category for the company.
[3] Post-Quantum Cryptography is an active research area across the region, but it was not included in the patent analysis, as PQC solutions, while highly relevant to securing data against future quantum threats, do not involve quantum physical phenomena directly.

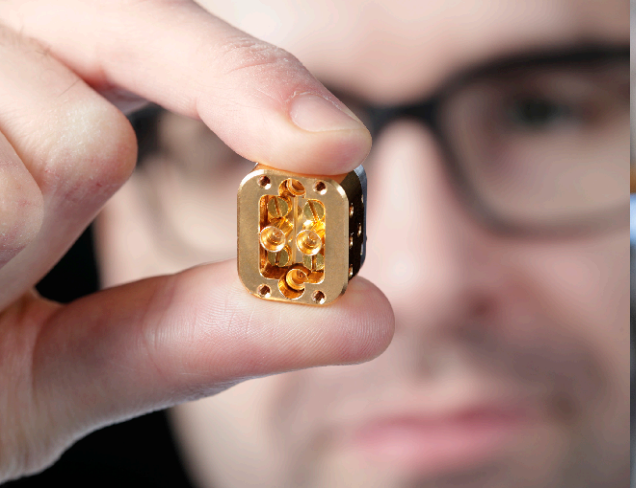


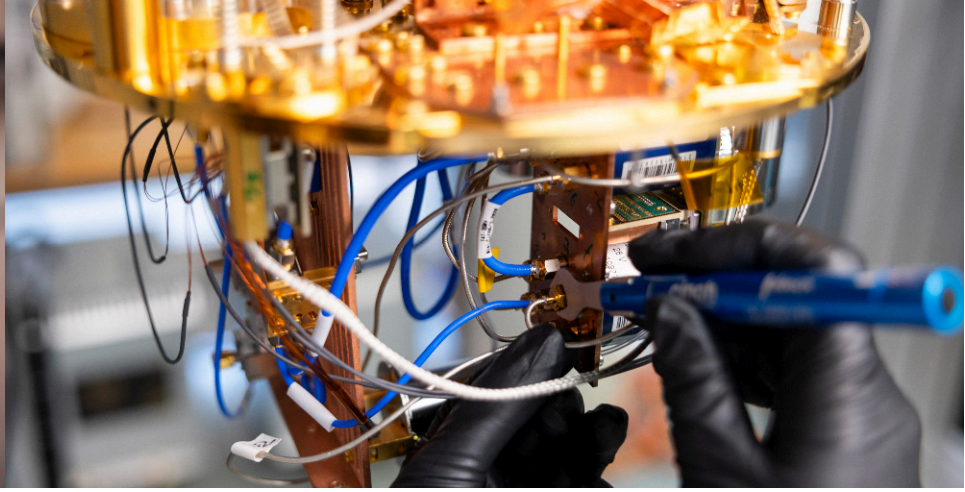
Nordic-Baltic quantum strongholds

This chapter presents six domains in which the Nordic-Baltic region shows distinct potential to lead in the development and application of quantum technologies. Based on ecosystem analysis, three have been identified as *strongholds* — areas where the region already combines world-class research, specialized infrastructure, and growing commercial activity. These include **superconducting quantum computing**, **quantum photonics and optics**, and **quantum life sciences**.

Alongside them, three additional domains — **defense**, **advanced manufacturing**, and **finance** — demonstrate strong industrial and academic capabilities and are emerging as promising candidates for future regional leadership. While current quantum activity in these sectors remains limited, they offer clear opportunities for strategic growth through cross-border collaboration and targeted investment.

Strongholds are key areas of innovation and business where regional collaboration creates added value, representing a strategic domain in which the Nordic countries possess a competitive edge. They can lead internationally through innovation, collaboration, and sustainable growth.





Superconducting quantum computing

The Nordic-Baltic region has emerged as a global stronghold in superconducting quantum computing, combining deep academic expertise, industrial leadership, and robust infrastructure to advance this pivotal technology.

IQM and Bluefors - Driving the Nordic-Baltic superconducting landscape

Finland stands at the forefront in commercial systems with a vertically integrated ecosystem. IQM Quantum Computers, a spin-out from Aalto University and VTT, has deployed Europe's first 50-qubit superconducting quantum computer, located at VTT's Micronova facility in Espoo. This system is accessible to researchers and companies via the VTT QX quantum computing service, facilitating application development in areas like material modeling, optimization, and artificial intelligence.

Recently, IQM and VTT signed a contract for a joint development project and delivery of a 150-qubit computer by mid-2026 and a 300-qubit computer in late 2027. IQM computers are operating within the cryogenic infrastructure created by Bluefors, a Helsinki-based company that is the world leader in cryogenic systems essential for superconducting qubit operations. Their KIDE cryogenic platform is designed to house over 1,000 qubits, supporting the scalability of quantum processors.

Growing ecosystem of superconducting quantum technologies

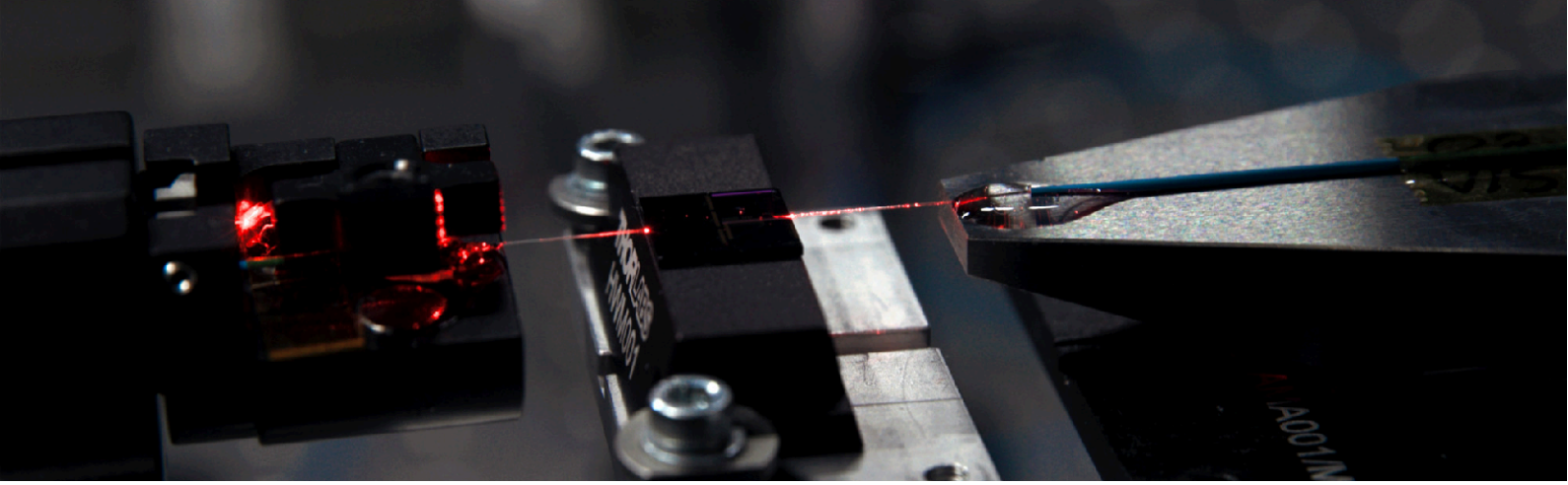
In addition to these internationally recognized leaders, the Nordic superconducting quantum ecosystem is increasingly supported by a dynamic group of promising startups. Companies like Arctic Instruments, Low Noise Factory AB, ScalinQ AB, QET Sweden AB, and Sweden Quantum AB are emerging as key players delivering components and enabling technologies critical to the performance and scalability of superconducting quantum computers.

This wave of innovation is closely tied to strategic investments, particularly Sweden's *Wallenberg Centre for Quantum Technology programme (WACQT).* WACQT's long-term funding and focus on building a high-fidelity superconducting quantum computer have advanced academic research at institutions like Chalmers University of Technology and stimulated the growth of a supporting innovation ecosystem. The program has created a fertile environment for spin-offs, deep-tech ventures, and commercial collaborations that extend Sweden's role beyond research

into hardware components, measurement systems, and control infrastructure for superconducting qubit systems.

Denmark, while initially having taken a broader, qubit-agnostic approach through the *Novo Nordisk Foundation Quantum Computing Programme (NQCP)*, also plays a vital role in the regional superconducting landscape. One key modality under active development in Denmark is superconducting qubits, with research led by the Niels Bohr Institute at the University of Copenhagen. Danish teams are focusing, for example, on overcoming coherence and control challenges and developing scalable architectures, including integrating superconducting qubits with hybrid quantum systems. With its strong expertise in quantum electronics, shared infrastructure, and global industrial partnerships, Denmark is well-positioned to support and complement the growing Nordic superconducting ecosystem, especially as different qubit platforms converge toward more advanced and interoperable architectures.

Collectively, these initiatives position the Nordic-Baltic region as a leader in superconducting quantum computing, fostering advancements from fundamental research to industrial applications.



Quantum photonics and optics

Photonics and optics form a critical foundation for quantum technologies, playing essential roles across multiple domains—including the manipulation and readout of qubits, quantum communication, and advanced sensing applications. In the Nordic-Baltic region, this field benefits from decades of excellence in classical photonics, particularly in areas such as lasers, optical communications, and sensor technologies. This longstanding expertise provides a robust platform for advancing quantum photonics research and nurturing early-stage innovation. While scientific capabilities are strong, the commercial landscape remains in a formative phase. Most companies are still focused on conventional photonics markets, with quantum-related initiatives typically positioned as exploratory efforts or technology demonstrators rather than mature revenue streams.

In Denmark, leading institutions such as the Niels Bohr Institute and the Technical University of Denmark (*DTU Fotonik* and *DTU Physics*) have long-standing photonics and quantum optics research programs. These research hubs are developing technologies like integrated photonic chips and single-photon sources to enable quantum communication, computing, and sensing. While this research is internationally competitive and technologically promising, commercial offshoots remain limited in scale. Nevertheless, these institutions act as critical enablers, offering a knowledge base and talent pipeline that may support future spinouts. Among the emerging commercial actors, Sparrow Quantum, a spinout from the Niels Bohr Institute, plays a key role by developing on-chip single-photon sources for quantum networks and computing. Additionally, NKT Photonics, a long-established photonics company recently acquired by global leader Hamamatsu, brings significant industrial capacity in laser and photonic technologies relevant to quantum applications. These companies exemplify how Denmark's photonics ecosystem is beginning to bridge fundamental research with applied quantum technologies.

Across the Baltic region, Lithuania and Latvia are expanding their quantum optics and photonics capabilities, building on strong foundations in classical optics, lasers, and space photonics. In Lithuania, institutions like Vilnius University and FTMC lead research in areas such as squeezed light, single-photon sources, and integrated photonics, supported by an established laser and nanophotonics industry. Notably,

Lithuanian firm Astrolight — specializing in space-grade optical communication — was selected for the NATO *DIANAQ* accelerator, highlighting emerging commercial potential. In Latvia, collaborative efforts between the University of Latvia and Riga Technical University aim to establish a center of excellence in quantum photonics, focusing on materials, optical systems, and device development. While quantum-specific commercial activities remain early-stage, both countries actively build academic and industrial capacity to position themselves for future breakthroughs.

Finland and Sweden both possess strong foundations in classical photonics, which serve as a springboard for quantum photonics development, although most commercial applications remain at an early stage. In Sweden, the emerging quantum photonics and optics hub around KTH Royal Institute of Technology in Stockholm is driving localized ecosystem growth. A cluster of startups — including Svenska Laserfabriken, Single Photon Quantum Radiology AB, and Quantum Scopes — is exploring applications ranging from laser-based technologies to single-photon imaging. While these companies remain early-stage, they reflect growing commercial interest building upon Sweden's strong academic foundation in photonics and quantum optics. Similarly, in Finland, the national *PREIN* flagship links academic research with industry, with the country's commercial photonics cluster concentrated around Tampere, where Tampere University leads in photonics research. Companies like Modulight and Vexlum, specializing in laser systems, are exploring quantum-adjacent technologies while maintaining a primary focus on conventional markets.

In summary, the Nordic-Baltic region possesses deep capabilities in photonics and optics that are critical for quantum technology. While a few pioneering firms and research groups are laying the groundwork for commercial applications, the field is not yet mature enough to provide stable commercial returns. As a result, many players continue to develop versatile photonic technologies that serve both quantum and broader technology markets, positioning the region well for future growth as quantum demand increases.





Quantum life science

While the Nordic-Baltic region is home to globally recognized expertise in foundational quantum technologies, it is also emerging as a leader in specific application domains where quantum technologies are expected to have a transformative impact. Among these, quantum life sciences currently stand out as the most mature stronghold, with active research and early commercial initiatives already underway.

Quantum life science is an emerging interdisciplinary field that applies quantum technologies to address complex challenges in biology, medicine, and healthcare. The Nordic-Baltic region, particularly Sweden and Denmark, has established itself as a stronghold in this domain through coordinated national initiatives, significant public and private investments, and a robust collaborative ecosystem spanning academia, healthcare, and industry.

Denmark is advancing quantum life science through initiatives like the *Novo Nordisk Foundation Quantum Computing Programme (NQCP)*, which has committed $200 million to develop quantum computing hardware and algorithms to solve critical life sciences problems. Additionally, the Copenhagen Center for Biomedical Quantum Sensing, a collaboration between the University of Copenhagen, the Technical University of Denmark (DTU), and the University of Texas at Austin, is working to develop quantum sensing and imaging technologies for medical diagnostics and healthcare applications.

USE CASE	Quantum capacity building for life sciences
Application area Quantum computing, biomedical simulation & drug discovery **End-users** Pharmaceutical companies, life sciences researchers **Tech developers** NQCP, University of Copenhagen, Niels Bohr Institute (Denmark), MIT(USA) **Further reading**	Novo Nordisk Foundation's Quantum Computing Programme (NQCP) is driving Denmark's ambition to develop a globally competitive quantum ecosystem, focusing on innovation in life sciences. The programme combines cutting-edge hardware development with targeted pharmaceutical, genomic, and neurobiology applications. NQCP is building critical capabilities through partnerships with institutions such as the Niels Bohr Institute, the Technical University of Denmark, Nordita, and industrial players. It advances superconducting, photonic, and trapped-ion qubit platforms to identify the most promising technology for fault-tolerant quantum computing. On the application side, NQCP is developing quantum algorithms to tackle life sciences challenges, including complex molecular simulations for drug discovery and precision medicine. The programme also invests in Quantum Foundry Copenhagen, a facility for producing high-quality quantum processors and materials, and collaborates internationally, for example, with MIT, to accelerate research and ecosystem-building. • NQCP

Sweden's leadership in quantum life science is anchored by the national Quantum Life Science Centre (QLSC), hosted at Karolinska Institutet's Department of Clinical Neuroscience. The QLSC aims to accelerate the development of quantum applications in precision health by fostering interdisciplinary collaboration among quantum physicists, AI researchers, clinicians, and biotech companies. Key partners include the Wallenberg Centre for Quantum Technology (WACQT), AstraZeneca, IBM, Elekta, and startups such as Deep Light Vision, Quantum Scopes, and SPQR. The centre focuses on developing quantum-enhanced tools for bioimaging, diagnostics, and drug discovery, with the goal of positioning Sweden as a global leader in quantum-enabled precision medicine.

USE CASE	Quantum sensors for next-generation brain imaging
Application area Quantum sensing, MEG **End-users** NatMEG lab (open to researchers and clinicians in Sweden) **Tech developers** Swedish technical universities and Karolinska Institutet (Sweden) **Further reading**	At Karolinska Institutet in Sweden, the NatMEG lab is pioneering the clinical use of quantum sensors for brain diagnostics. NatMEG has implemented an advanced on-scalp MEG system that utilizes optically pumped magnetometers (OPMs), a new highly sensitive, quantum-enhanced sensor type. Unlike traditional MEG systems, these sensors can be placed directly on the scalp, which offers significantly improved spatial resolution and sensitivity. The system is already used to diagnose and plan surgery for epilepsy patients. It enables detailed brain activity mapping without invasive procedures. The facility supports clinical use and research nationwide and collaborates with academic and healthcare partners, including Chalmers University of Technology, to further develop the technology. The system primarily benefits pediatric patients, offering a more adaptable and comfortable setup for children and adolescents during brain examinations. • Nat.MEG research laboratory • Karolinska Institutet news about NatMEG' grant

The Nordic-Baltic region is nurturing a dynamic ecosystem of companies developing quantum algorithms for life sciences and chemistry. In Denmark, firms such as *QunaSys, Kvantify*, and *Hafnium Labs* are advancing quantum simulation methods to model complex molecular interactions and chemical processes relevant to drug discovery and biochemical research. Finland's *Algorithmiq* is at the forefront of applying quantum computing in healthcare and life sciences, driving innovation in molecular simulation, drug discovery, and advanced medical treatments. A prime example of the transformative potential of Nordic companies is the computational drug discovery pipeline Algorithmiq is developing to integrate quantum computing into real-world pharmaceutical workflows.

USE CASE	**Quantum computing for photodynamic cancer therapy**
Application area Quantum computing, photodynamic cancer therapy **End-user** Cleveland Clinic (USA) **Tech provider** Algorithmiq (Finland), IBM (USA) **Further reading**	In collaboration with IBM Quantum and Cleveland Clinic and as part of Wellcome Leap's Quantum for Bio Challenge, Algorithmiq is leading efforts to advance cancer treatment by accurately simulating the complex properties critical to the efficacy of photodynamic therapy (PDT), a method in which light-activated drugs (photosensitizers) selectively target and destroy cancer cells. Algorithmiq's hybrid quantum-AI pipeline enables the prediction of drug behavior prior to synthesis, reducing experimental demands and accelerating the discovery of photoactivated compounds. This project is among the first to apply quantum simulation across a complete biomedical pipeline. As quantum hardware advances, the pipeline seamlessly integrates quantum-derived data to enhance AI performance further, surpassing the limitations of classical modeling alone. The goal is to improve drug efficacy and selectivity while minimizing side effects, paving the way for quantum-assisted drug discovery and more effective cancer therapies. • Algorithmiq Aurora Platform • Cleveland Clinic News Release • Q4Bio

These concerted efforts in Sweden, Denmark, and Finland highlight the Nordic-Baltic region's emerging strength in quantum life sciences. The region is positioning itself at the frontier of applying quantum technologies to healthcare and biomedical research by combining world-class research infrastructure, active clinical partnerships, and pioneering industrial initiatives. While the field remains at an early stage globally, the Nordic focus on quantum sensing and simulation for diagnostics and drug discovery illustrates a unique commitment to translating quantum research into potentially transformative healthcare solutions.

USE CASE	**Quantum center for drug discovery**
Application area Pharmaceutical R&D (drug discovery, molecular design) **Industrial partner:** AstraZeneca (Sweden), IonQ (USA) **Research partner**: BioVentureHub (AstraZeneca, Sweden) **Further reading**	AstraZeneca and IonQ have initiated a collaboration by establishing a Quantum Computational Chemistry Center of Excellence within AstraZeneca's BioVentureHub in Gothenburg, Sweden. The initiative focuses on applying quantum computing to early-stage drug discovery and molecular design. By leveraging IonQ's quantum expertise, the goal is to understand molecular interactions better and develop more efficient, targeted, and cost-effective therapies. IonQ intends to assemble a dedicated team in Gothenburg, consisting of computational chemists, engineers, and entrepreneurs, to develop quantum applications for pharmaceutical research and development. The center reflects AstraZeneca's broader strategy to promote sustainable chemistry and underscores growing regional interest in integrating quantum technologies into life sciences. This collaboration positions the Nordic-Baltic region as a potential leader in quantum-assisted drug development. • IonQ joins AstraZeneca BioVentureHub



Potential strongholds

In addition to life sciences, several sectors show strong potential to evolve into regional quantum strongholds, including defense and security, energy, advanced manufacturing, and finance. These opportunities reflect the region's unique combination of scientific excellence, industrial capability, and societal priorities. This section explores where the Nordic-Baltic ecosystem is best positioned to shape and lead the next wave of quantum-enabled applications.

Defense

The Nordic-Baltic region recognizes quantum technologies as strategically critical for national security, defense capabilities, and technological sovereignty. The region has positioned itself as a committed participant in NATO and EU defense technology programs, with quantum technologies at the center of emerging dual-use strategies. Establishing *NATO Centre for Quantum Technologies in Denmark* under NATO's Defence Innovation Accelerator for the North Atlantic (*DIANA*) reflects strong institutional support. Additionally, accelerators and test sites exist across Finland, Norway, Estonia, Latvia, and Lithuania, further demonstrating the region's collective commitment to fostering dual-use innovations in defense and security contexts.

Quantum sensing stands out as the region's most promising area for defense applications. Research activities focus on developing highly sensitive quantum sensors for navigation, detection, imaging, and positioning, which could offer significant tactical advantages. While these applications remain largely in the research phase, the Nordic-Baltic region's expertise in precision measurement and materials research positions it well for leadership as defense applications mature. Major defense industry players like *Saab* (Sweden) and *Kongsberg* (Norway) are actively exploring the potential of quantum technologies for defense and aerospace use, particularly in sensing and secure communication.

USE CASE	Quantum sensing for next-gen radar
Application area Quantum sensors, quantum noise radar **Industrial partner:** Saab (Sweden) **Research partner:** WACQT (Sweden) **Further reading**	Saab, a leading Swedish defense and security company, is actively collaborating with the Wallenberg Centre for Quantum Technology (WACQT) to explore the potential of quantum technologies in defense applications. As part of this partnership, Saab is involved in two PhD research projects on developing a novel radar concept known as *quantum noise radar*. These projects investigate whether entanglement between generated photons can enhance radar system performance, potentially improving detection capabilities and resilience against electronic countermeasures. This collaboration reflects Saab's strategic commitment to integrating cutting-edge quantum research into real-world defense systems and aligns with Sweden's broader ambitions to lead in quantum technology development.measures. • WACQT

Quantum communication and cybersecurity are also areas of growing focus, although capabilities remain at an early stage. Most Nordic and Baltic countries participate actively in the EU's *EuroQCI initiative*, which aims to establish quantum-secure communication infrastructure across Europe. National-level pilots and research activities are underway in cooperation with telecom operators and critical infrastructure providers. The urgent need to prepare communication networks against future quantum threats is widely acknowledged across the region.

Overall, the Nordic-Baltic region's defense-related quantum efforts are characterized by early participation in NATO and EU programs, strong academic and industrial research bases, and increasing public-private collaboration. The dual-use nature of enabling technologies, such as photonics and lasers, offers additional potential to bridge civilian and defense quantum applications as the ecosystem evolves.





Manufacturing industry

The Nordic-Baltic region has strong industrial roots, particularly in heavy manufacturing sectors in Sweden and Finland. Leading companies with significant R&D capacity offer fertile ground for the emergence of quantum-enhanced industrial applications. Around these, a broader quantum ecosystem could develop, extending beyond heavy industry to include engineering service providers, logistics optimization firms, and industrial software developers across the region.

USE CASE	Quantum-assisted chemistry for next-gen batteries
Application area: Quantum computing, battery materials simulation **Industrial partner:** Volkswagen Group (GER) **Tech provider**: IQM (FIN) **Academic partners:** University of Munich (GER) **Further reading**	Volkswagen and IQM partnered to explore how quantum computing can advance battery chemistry for electric vehicles. The project successfully simulated lithium-ion battery reactions with high chemical accuracy, achieving these results using only 13 qubits, demonstrating a significant reduction in hardware requirements. The approach combined classical and quantum computing to model complex chemical interactions efficiently. This hybrid method reduced the number of required qubits and showed resilience to quantum noise, making it compatible with today's quantum hardware. By enabling accurate simulations with fewer resources, the collaboration marks a major step toward practical quantum computing applications in designing more efficient and longer-lasting EV batteries. • IQM Technical White Paper (2024) • Quantum Insider Coverage • Research article about Quantum Monte Carlo

Early efforts in the region have demonstrated how quantum computing can support materials science, process modeling, and resource optimization. In Sweden, the WACQT programme brings together companies such as *Volvo Group, Sandvik, Scania, Saab, and ABB* to explore quantum applications in manufacturing, logistics, and systems control. Finnish company *Quanscient* is also advancing quantum-powered simulations for engineering, with early work focusing on fluid dynamics and multi-physics modeling. Furthermore, Finland's *IQM* and Volkswagen developed a hybrid quantum-classical approach to simulate battery reactions with high accuracy and minimal qubit requirements (see use case).

USE CASE	Hybrid quantum optimization in industry
Application area: Quantum computing, scheduling, route planning, optimization, fraud detection **Academic & research partners:** University of Oslo & SINTEF Energy (NO), Fraunhofer-Gesellschaft (GER), University of Tartu (EST) **Industrial partners**: Equinor, Statkraft, Statnett, DNB, and Kongsberg (NOR)	The NeQst project, led by SINTEF Digital and funded by the Research Council of Norway, explores how near-term quantum computers can solve complex industrial optimization problems. From 2022 to 2026, the project brings together academic and industry partners from Norway, Estonia, and Germany. NeQst focuses on real-world applications such as hydropower scheduling, route planning for autonomous ships, financial fraud detection, portfolio management, and supply chain optimization. The consortium develops hybrid quantum-classical algorithms tailored to these use cases, addressing practical challenges like hardware noise and benchmarking against classical approaches. By targeting diverse sectors, NeQst aims to demonstrate the real-world value of quantum computing in industrial contexts.
Further reading	NeQst - Quantum Computing Applied to Industrial Optimization Problems - SINTEF

In the future, quantum computing may become a key enabler for industrial AI. The growing demand for predictive systems, automated quality control, and generative design pressures classical machine learning. Quantum machine learning could unlock new possibilities, offering faster convergence, higher accuracy, or better generalization with limited training data. This would be especially valuable in industrial settings where data can be sparse or noisy. At the same time, quantum optimization may help industries make better decisions under uncertainty: from production planning to supply chain logistics and dynamic scheduling. These capabilities could support more agile, efficient, and resilient operations, benefiting

large manufacturers and specialized logistics service providers.

Looking ahead, quantum technologies may also accelerate the industry's green transition. They offer new tools for materials discovery, enabling the design of lighter, stronger, and recyclable compounds. In a circular economy context, this could mean optimizing reuse strategies, extending product life cycles, and reducing raw material dependence. Quantum computing's potential to simulate molecular and atomic behavior more accurately than classical methods may open new paths to cleaner, more sustainable industrial processes.

USE CASE	**Quantum simulation for fluid dynamics and engineering**
Application area Quantum computing, multiphysics simulation (fluid dynamics, electromagnetics) **End-user segment** : Engineering and product development (e.g. aerospace, energy, HVAC) **Tech provider:** Quanscient (FIN) **Research partner:** VTT (FIN) **Further reading**	Quanscient, in collaboration with VTT, has demonstrated how quantum computing can be used to simulate fluid dynamics across multiple time steps —an essential part of modeling airflow, heat transfer, and particle transport. The simulation achieved high accuracy using only 12 qubits, showing how quantum methods can solve complex engineering problems with minimal hardware. Instead of adapting traditional models, the team used a quantum-native approach designed specifically for quantum computing's strengths. This allows for more compact and scalable simulations that could, in the future, outperform classical methods in speed and efficiency. Potential applications include building ventilation, cooling systems, and aerodynamic design. This work also highlights how aligning algorithms with current hardware capabilities can improve performance in real-world quantum simulations. While still in early stages, the project marks progress toward using quantum computing in advanced engineering and product development. • News: Quanscient achieves a world-first in quantum computational fluid dynamics simulation • Quanscient • VTT Q50 Use case video: Solving fluid dynamics



Financial services

The financial services sector in the Nordic-Baltic region has begun to explore quantum computing. Still, engagement remains limited compared to more active developments in the USA and other parts of Europe. In particular, financial institutions in Spain and Italy have launched early experiments with quantum algorithms, addressing complex challenges such as risk modeling, pricing strategies, and ESG-related finance.

Several promising cases demonstrate emerging interest within the Nordic-Baltic region. Denmark's *Jyske Bank* has deployed quantum-inspired algorithms in live trading operations, while Finland's *OP Financial Group* has piloted credit risk modeling tools in collaboration with domestic quantum researchers. DATEV's cooperation with Finland's *IQM* highlights the region's contribution to quantum-enhanced financial software. In addition, *the Bank of Finland* and other financial actors took part in the VTT-led *FutureQ* foresight project, which examined how quantum computing could reshape financial infrastructure, competition, and regulation.

Still, broader engagement from the sector is needed. Some regional stakeholders express concern that quantum research prioritizes other application areas, such as health and materials science, while overlooking finance. Stronger collaboration between financial institutions and the research community is essential to build strategic capabilities in quantum finance. This includes addressing near-term challenges such as data availability, algorithmic maturity, and practical use-case validation.

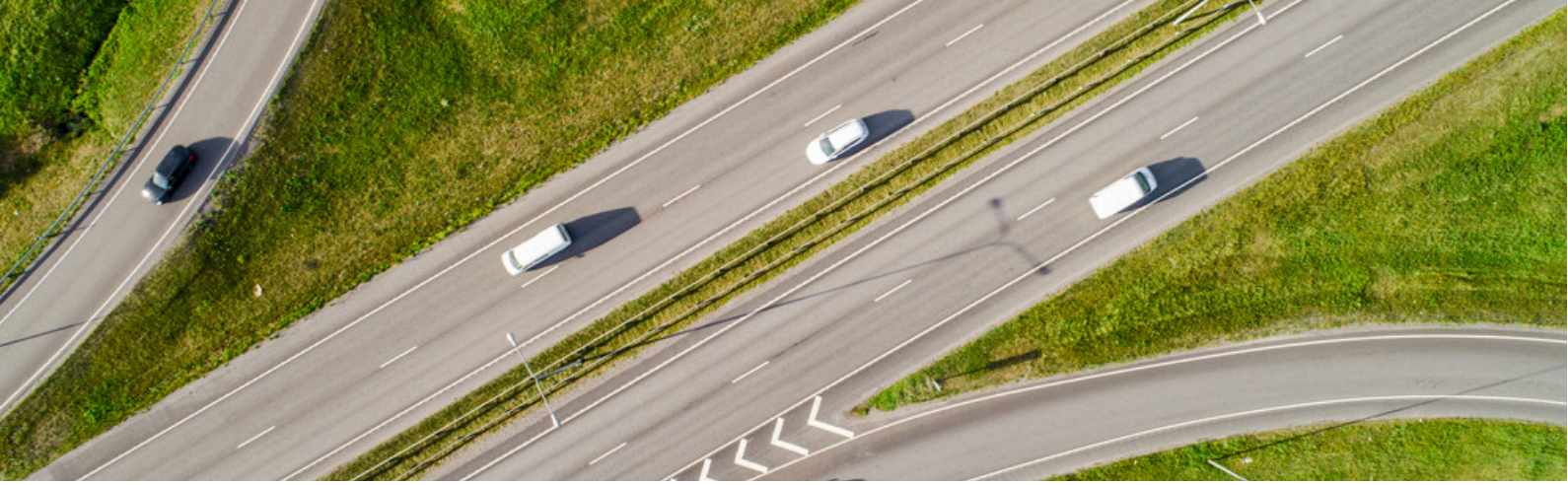
USE CASE	Quantum-optimised real-time trading
Application area Quantum computing, algorithmic trading, financial risk management **End-user:** Jyske Bank (DEN) **Tech providers:** Qpurpose & Centre for Quantum Mathematics (DEN) **Academic partner:** University of Southern Denmark (DEN) **Further reading**	Jyske Bank, in partnership with Qpurpose and the Centre for Quantum Mathematics, has deployed a quantum-enhanced real-time trading system into live daily operations. The system uses quantum techniques to model complex market behaviors more efficiently than traditional methods. This allows for more accurate short-term forecasts, improved pricing and hedging strategies, and better capital allocation. The solution has increased trading revenues and leaner hedging practices, helping the bank reduce its regulatory capital requirements. Actively used in daily trading, the system will be extended to cover additional asset classes, marking one of the first real-world applications of quantum software in financial markets. This case illustrates how quantum computing is starting to deliver measurable value, even before fault-tolerant systems are fully available. • 16 Danish Quantum Use Cases

Looking forward, quantum computing could profoundly impact the financial sector. Global tech giants may use quantum advantage to offer more advanced, data-driven financial services, potentially displacing traditional players or capturing the customer interface. Conversely, quantum-enhanced modeling could support more personalized financial products, smarter risk segmentation, and new tools for evaluating climate and systemic financial risks. These capabilities could also help governments and regulators design more robust, transparent, and equitable financial systems.

USE CASE	Piloting quantum applications in financial services
Application area Financial services (Credit risk, forecasting, portfolio optimisation) **Industrial partner:** OP Financial Group (FIN) **Research Partners:** University of Jyväskylä, University of Oulu, other Finnish academic partners	OP Financial Group's innovation unit, OP Lab, has been actively exploring the potential of quantum computing across various financial applications. The aim has been to understand better where and when quantum technologies may offer advantages, and how current maturity levels align with real-world financial needs. As part of this learning journey, OP has piloted quantum approaches in three distinct areas: • **Credit risk modeling:** In collaboration with academic partners, OP explored using quantum annealing to support feature selection in credit scoring. The goal was to identify the most predictive variables in a large dataset. Although current hardware presented limitations, the study provided valuable insight into how quantum algorithms could enhance financial modeling in the future. • **Forecasting housing prices:** Quantum-enhanced models were tested to predict housing price trends. This pilot assessed whether quantum machine learning could outperform classical methods in pattern detection and uncertainty estimation. • **Loan portfolio optimization:** OP evaluated how quantum algorithms might improve the efficiency of loan portfolio management by solving complex optimization problems more effectively. OP Lab's approach centers on building future readiness and identifying strategic entry points for realizing quantum advantage as the technology matures.
Further reading	• Credit scoring use case • Exploring quantum computing at OP (In Finnish) • Forecasting housing price trends with quantum algorithms (In Finnish) • Optimising credit risk models with future methods (In Finnish)

References

- Algorithmiq
- Bluefors. (2023). We Made 1000 qubits for quantum computing possible. Newsletter story.
- Börjes, R. (2024). IonQ joins AstraZeneca BioVentureHub. AstraZeneca BioVentureHub News.
- Chalmers. (2023). New Swedish quantum computer to be made available to industry. News article.
- Chalmers University of Technology. Wallenberg Centre for Quantum Technology. WACQT
- Cleveland Clinic. (2023). Cleveland Clinic selected by Wellcome Leap for Two Quantum Computing Research Projects.
- Choucair, C. (2024). Volkswagen and IQM Collaborate to Scale Quantum Simulations with Fewer Qubits. The Quantum Insider.
- Danish Business Authority & Danish Quantum Community. (2024). 16 Danish Quantum Use Cases. Practical Insights into Applications of Quantum Technologies Across Industries.
- DCD. (2025). IQM launches Europe's first 50-qubit quantum computer at VTT, Finland.
- European Union. (2019). Developing quantum optics and photonics at the Universtity of Latvia. Kohesio.
- IQM. (2025). IQM and DATEV advance quantum solutions for portfolio optimisation. Press Release.
- IQM. (2025). IQM Radiance. Products.
- IQM. (2025). Study on Battery Simulation. Technical Whitepaper.
- IQM. (2025). VTT and IQM launch first 50-qubit quantum computer developed in Europe - IQM Quantum Computers. Press release.
- Karolinska Institutet. (2025). New grant from the Swedish Research Council makes KI's brain-imaging lab NatMEG world-class.
- Kiser, M., Beuerle, M., & Simkovic IV, F. (2024). Contextual Subspace Auxiliary-Field Quantum Monte Carlo: Improved bias with reduced quantum resources. ArXiv.
- Liimatta, P. (2021). Voidaanko asuntojen hintakehitystä ennakoida kvanttialgoritmien avulla? OP Media.
- Liimatta, P. (2024) OP kvanttilaskennan pyörteissä. OP Media.
- Liimatta, P., Taipale, P., Halunen, K., Heinosaari, T., Mikkonen, T., & Stirbu, V. (2024). Research Versus Practice in Quantum Software Engineering: Experiences from Credit Scoring Use Case. In IEEE Software, 41 (6), 9–16). IEEE.
- Lund University. Lund Laser Center
  NatMEG - The swedish national laboratory for Magnetoencephalography
- Nordic Investment Bank. (2025). Next up: building a more resilient Nordic–Baltic region.
- O'Dwyer, G. (2023). Sweden, Finland eye quantum tech leap amid call for official strategy. Defense News.
- PREIN - Finnish Flagship on Photonics Research and Innovation. (2023). Quantum Technologies (WP5)
- Quanscient
- Quanscient. (2025). Quanscient achieves a world-first in quantum Computational Fluid Dynamics (CFD) simulation at VTT/IQM 50-Qubit launch event.
- SINTEF. (2023). NeQst - Quantum Computing Applied to Industrial Optimization Problems.
- Swedish Centre for Quantum Life Science
- Taipale, P. (2023). Käytännön kvanttilaskentaa: Luottoriskimallien optimointia tulevaisuuden menetelmillä. OP Media.
- University of Copenhagen. Copenhagen Center for Biomedical Quantum Sensing.
- University of Copenhagen. The Novo Nordisk Foundation Quantum Computing Programme. Superconducting qubit pilot line.
- Vinnova. (2024). Development of the Swedish Quantum Life Science Centre (QLSC).
- VTT (2025). VTT Q50 use case: Solving fluid dynamics. YouTube.
- Wellcome Leap. (2024). Q4Bio.



Policy recommendations

Designing effective quantum policy

Emerging technologies like quantum introduce unique challenges for policy design, including deep uncertainty, long development timelines, and cross-sector impacts. To identify effective measures, it is essential to consider these complexities and assess the appropriate scale of national, Nordic-Baltic, or European for coordinated action.

The following summary provides an overview of the key considerations for designing effective quantum policies for the Nordic-Baltic level before delving into a more detailed examination of those.

Key considerations

1. Scientific uncertainty and slow path to market
2. Intensifying global competition for strategic technologies
3. Potential for transformative societal impact across sectors
4. Uneven development pace and varying impact across technologies
5. Lack of clear adoption roadmaps in industries
6. Need for a balance between supply-side and demand-side policies
7. Importance of targeted actions at the cross-country level for maximum impact

Designing effective policy for quantum technologies is uniquely challenging. Unlike mature sectors, quantum innovation unfolds amid deep scientific uncertainty, long and unpredictable development timelines, dual-use sensitivities, and shifting geopolitical dynamics.

Several features set quantum technologies apart as a policy domain. Key applications, especially in computing, may take 5 to 15 years to mature. Most industries still lack clear adoption roadmaps, further slowing market formation and practical impact. At the same time, rising concerns over security, technological sovereignty, and dual-use governance are intensifying as quantum intersects with critical infrastructure and defense systems.

Conventional policy tools, such as isolated R&D funding or market incentives, are insufficient in this context. Forward-looking quantum policy requires strategic foresight, systemic thinking, and adaptability. It should enable experimentation, support long-term capability building, and foster collaboration across sectors and borders while recognizing that quantum technologies offer competitive advantages and the potential to transform key societal systems for the better.

Greater impact through Nordic-Baltic collaboration

Cross-country efforts can help better leverage the opportunities presented by quantum technologies. Fragmented strategies, short-term funding cycles, and isolated pilot efforts limit the ability to compete globally, scale innovations, and build the necessary depth. By aligning national priorities, developing shared infrastructure, and amplifying joint strengths, Northern European countries can play a more influential role in shaping the global quantum future in specific domains.

When designing collaborative efforts, assessing which policy challenges and opportunities call for joint responses at this scale is critical. Some issues may be more effectively addressed through national programmes or European-level instruments, while others benefit from cross-country coordination, particularly where complementary strengths or shared needs exist.

In a globally competitive landscape, policies must also reflect the operating realities of quantum firms, which scale internationally from day one. Cross-border collaboration can create the right conditions for innovation, resilience, and visibility, supporting trusted partnerships and technological sovereignty without duplicating national efforts.

Need for balanced policy instruments

A balanced mix of supply—and demand-side policy instruments is essential to effectively developing and applying quantum technologies.

Supply-side instruments aim to strengthen the foundational ecosystem by investing in quantum research, funding PhD programs, establishing national quantum laboratories and testbeds, and supporting start-ups. These initiatives help build the necessary scientific expertise and technical infrastructure for developing quantum hardware, algorithms, and software.

Demand-side instruments are equally crucial but often underused in deep tech fields like quantum. Key measures include public procurement of quantum-safe encryption solutions, integrating quantum capabilities into national security and space programs, and setting standards for post-quantum cryptography. Innovation subsidies and pilot programs can also help various industries explore quantum applications.

Both sides are vital for a robust quantum ecosystem. Supply-side policies ensure the development of quantum solutions, but without concurrent demand-side initiatives, these technologies may lack real-world applications and market feedback. Conversely, demand-side policies without domestic capabilities can lead to dependency on foreign suppliers and missed strategic opportunities.

To foster the growth of quantum technologies, policymakers should create coordinated strategies that invest in research and development while stimulating early markets, guiding standards, and mitigating risks in key sectors.



Policy gaps at the Nordic-Baltic level

Although the Nordic-Baltic region has a strong scientific foundation and burgeoning commercial activity, its quantum ecosystem encounters several significant policy gaps that must be addressed to ensure global competitiveness, strategic coordination, and sustainable growth. These gaps underscore the need for a more strategic, coordinated, and well-funded regional policy approach that aligns national efforts, enables shared infrastructure, fosters demand-side uptake, and secures the Nordic-Baltic region's place in the global quantum landscape.

Key policy caps

1. Fragmented national strategies and coordination
2. Insufficient long-term and strategic funding
3. Limited access to and participation in international programs
4. Low industry awareness and uptake
5. Lack of strategic differentiation and prioritization
6. Gaps in experimental infrastructure and hardware access
7. Talent and education gaps

Fragmented national strategies and coordination

Denmark and Finland have established an active national quantum strategy, providing a clear vision and structure for investments, talent development, and international collaboration. Norway and Sweden are preparing to launch their national quantum strategy shortly, signalling progress toward stronger national coordination. However, other countries in the region still lack a comprehensive national quantum strategy. This uneven landscape creates asymmetries in investment prioritization, limits alignment across stakeholders, and hampers regional coordination. The Nordic quantum community has broadly identified the lack of national coordination and coherent strategies as a critical weakness holding back the region's collective potential.

Insufficient long-term and strategic funding

Many countries in the region report inadequate quantum-specific funding, particularly for long-term R&D, infrastructure, and talent pipelines. Lithuania and Norway note gaps in public funding and limited success in attracting EU project financing. A region-wide shortage of long-term investment mechanisms is a barrier to scaling deep-tech ventures and sustaining innovation.

Limited access to and participation in international programs

Countries like Lithuania highlight insufficient participation in international quantum programs and networks, resulting in slower progress and fewer collaboration opportunities. Non-EU countries like Norway face structural disadvantages in EU-wide initiatives like EuroQCI and DIGITAL Europe due to their status and funding rules, limiting their engagement and integration into broader European efforts.

Low industry awareness and uptake

Across the Nordic-Baltic region, there is low awareness of quantum technologies among industry players, particularly SMEs. End-users often lack the competence to evaluate or integrate quantum solutions, resulting in weak early demand. This slows down commercialization and prevents the formation of domestic lead markets.

Lack of strategic differentiation and prioritization

In smaller countries, with limited funding opportunities, the need for focused strategic prioritization is especially pressing. Without clear national choices on niche areas of strength, limited resources risk being spread too thinly. Strategic differentiation is essential for becoming a credible global partner in selected domains.

Gaps in experimental infrastructure and hardware access

Some countries report limited access to quantum hardware and experimental testbeds, constraining research, validation, and skill development. Norway, for instance, notes weak experimental activity as a significant obstacle to building a robust quantum R&D environment.

Talent and education gaps

A strong and future-ready talent base is essential for sustaining quantum innovation, yet countries across the region report significant challenges in education and workforce development. For example, Sweden identifies a shortage of skilled professionals, particularly postdoctoral researchers, and faces intense international competition for top talent. While quantum physics is typically included in university curricula, there is a notable lack of dedicated education in quantum engineering and applied technologies. Norway highlights the need for tailored education pathways, including study programs on quantum science and technology. Finland emphasizes the importance of cross-border coordination in education and the development of workforce retraining programs to help existing professionals transition into quantum-relevant roles. Without targeted and collaborative action, the region risks falling behind in the global race for quantum talent.



Operationalizing strategic goals

Designing effective quantum policy requires addressing both global competitive pressures and the unique challenges of emerging technologies. Six strategic objectives have been identified based on policy gaps and systemic needs analysis. *These objectives reflect the areas where combining efforts and resources across the Nordic and Baltic countries can deliver a greater impact.* They focus on strengthening capabilities and infrastructure, stimulating demand and ecosystem growth, and ensuring the Nordic's collective voice is heard on European and global stages.

Beyond impact and economic value creation, these objectives also draw on the shared values of the Nordic and Baltic countries. Collaboration is underpinned by a common commitment to openness, inclusivity, sustainability, and responsible innovation principles that are increasingly important in a world of geopolitical tension and technological competition. Like in the European AI policy space, the Nordic-Baltic countries can act as trusted and values-driven players in the development of quantum technologies.

Strategic objectives

1. Strengthen the competitiveness in quantum tech
2. Stimulate demand and activate the ecosystem
3. Enhance global positioning and influence
4. Create a vibrant quantum talent and job market
5. Improve security, strategic autonomy, and resilience
6. Drive ethical and sustainable quantum innovation

This framework offers a coherent approach to advancing the region's position in the global quantum technology landscape by identifying the most impactful policy actions under each objective. Policymakers can use these actions to select and implement measures that align with their strategic priorities, thereby turning these shared goals into practical steps for quantum innovation and societal benefit.

By identifying the most impactful policy actions under each objective, a comprehensive framework emerges to guide the development of targeted, practical measures. These measures provide a pathway to turn strategic goals into actionable steps that advance the Nordic-Baltic position in the global quantum technology landscape.

Strengthen competitiveness in quantum tech

The first set of policy actions focuses on reinforcing *the supply side* of the quantum ecosystem by supporting researchers, startups, and scale-ups through targeted Nordic-Baltic-level initiatives. These measures aim to translate scientific excellence into sustainable economic growth and long-term technological leadership.

Policy action	Implementation	Key stakeholders
Nordic-Baltic quantum infrastructure access program	Provide cross-border access to testbeds, processors, and simulators via a virtual portal and federated infrastructure with shared scheduling.	Research labs, HPC centers, digital infrastructure providers, funding agencies.
Quantum export acceleration	Promote internationalization through joint export services, pitch events, delegations, and market entry support.	Trade promotion agencies, chambers of commerce, national export offices, quantum firms.
Startup and scale-up support program	Support growth through access to incubators, accelerators, mentoring, and early-stage funding across the region.	Startup hubs, tech parks, venture capital firms, regional economic development offices.

Stimulate demand and activate the ecosystem

Creating early demand is essential for transforming Nordic-Baltic quantum research excellence into real-world impact and commercial success. While the region has a strong scientific foundation, the market for quantum technologies remains nascent and fragmented.

To bridge this gap, policy efforts should focus on de-risking early adoption, raising awareness among industry and public sector users, and enabling practical experimentation. By stimulating demand through targeted procurement, use-case challenges, and adoption incentives, the region can help build lead markets, validate business models, and accelerate the growth of a robust quantum economy.

The following policy actions outline concrete steps to drive demand and position the Nordic-Baltic region as both a testbed and an early adopter of quantum innovation.

Policy action	Implementation	Key stakeholders
Quantum industry awareness program	Raise understanding and readiness through sector-specific workshops, use case handbooks, readiness tools, and targeted outreach campaigns.	Industry associations, chambers of commerce, innovation agencies, quantum startups.
Quantum use case roadmaps by sector	Co-develop sectoral roadmaps and impact assessments via consultation and foresight exercises with industry and research stakeholders.	Sector-specific stakeholders (energy, logistics, health), policy think tanks, research groups.
Quantum use case fund and adoption vouchers	Launch open innovation challenges with funding, mentoring, and testing support. Offer micro-grants (€10k–€50k) for feasibility studies and prototype development.	Universities, research institutes, startups, large corporates, funding bodies.

Enhance global positioning and influence

Individually, the Nordic and Baltic countries are relatively small players in the global quantum landscape. However, they can significantly amplify their influence by acting together as a coordinated regional bloc. Aligning national strategies, presenting a unified voice in European and international forums, and showcasing regional excellence in research and innovation enables the region to shape global standards, funding priorities, and technology governance. Joint action strengthens the region's visibility, credibility, and ability to form strategic partnerships, positioning the area as a respected and influential actor in the future of quantum technologies.

Policy action	Implementation	Key stakeholders
Nordic-Baltic quantum brand and visibility campaign	Strengthen international visibility through digital storytelling, brand toolkit, showcase events, and targeted media engagement.	Trade promotion agencies, communication strategists, scientific publishers, tech ambassadors.
Convene a Quantum foresight network	Bring together key research, industry, and government actors to form agile *Quantum foresight network*. The goal is to inform strategic decisions, guide policy adjustments and help prioritize investments.	Research leaders, industry experts, ethics councils, innovation agencies.
Multilateral quantum tech diplomacy dialogues	Advance trust-based global partnerships through regular high-level dialogues with EU, US, Japan, Korea, and other quantum-active regions.	Foreign ministries, R&D diplomacy networks, think tanks, multilateral cooperation bodies.

Create a vibrant quantum talent and job market

A strong quantum workforce is the foundation of a globally competitive innovation ecosystem. For the Nordic-Baltic region to lead in quantum technologies, it must develop a deep and diverse pool of talent and ensure that talent can find meaningful, well-aligned employment across research, industry, and government. This requires investing in education and skills and supporting career mobility, job creation, and workforce adaptation. The following policy actions aim to match the growing supply of quantum-competent professionals with emerging demand across sectors and borders, building a dynamic and attractive job market.

Policy action	Implementation	Key stakeholders
Nordic-Baltic joint quantum education program	Launch joint MSc/PhD programs, shared modules, and credit recognition to support harmonized quantum education across borders.	Universities, national education ministries, academic consortia, accreditation bodies.
Quantum career mobility and fellowship scheme	Offer postdoc fellowships, industry internships, and mobility grants to promote regional knowledge exchange and talent circulation.	Research institutes, funding agencies, industry partners, talent mobility organizations.
Quantum workforce upskilling and retraining initiative	Deliver modular online courses, bootcamps, and certifications in collaboration with industry to retrain and upskill the existing workforce.	Vocational institutions, training providers, chambers of commerce, innovation agencies.

Improve security, strategic autonomy and resilience

As quantum technologies advance, urgent challenges emerge in cybersecurity, defense, and industrial sovereignty. The Nordic-Baltic region must prepare for post-quantum threats and reduce reliance on fragile or foreign-controlled supply chains, especially in hardware. Strengthening secure infrastructure, export controls, dual-use governance, and strategic foresight is essential for long-term resilience. The policy actions below aim to build sovereign and trusted capabilities aligned with shared values and interests.

Policy action	Implementation	Key stakeholders
Strategic materials and hardware supply chain strategy	Map supply chains, assess risks, and strengthen resilience through stockpiling and strategic industry partnerships.	Quantum hardware companies, industry alliances, supply chain analysts, trade ministries.
Sovereign capability development for critical applications	Fund long-term R&D and build regional capabilities for defense-relevant quantum sensing and encryption solutions.	Defense ministries, national labs, dual-use research centers, strategic innovation funds.
Secure quantum communication infrastructure initiative	Leverage EuroQCI to build secure, sovereign Nordic–Baltic quantum networks	Telecom operators, national security agencies, EuroQCI coordinators, digital ministries, innovation funds.

Drive ethical and sustainable quantum innovation

As quantum technologies advance, their development must align with the Nordic-Baltic region's responsibility, inclusivity, and sustainability values. The proactive policy can ensure that quantum innovation serves technological and economic goals and addresses broader societal and environmental implications. This section outlines selected policy actions integrating ethical foresight, public engagement, education, and governance into the region's quantum agenda, positioning the Nordic-Baltic countries as global leaders in responsible quantum development.

Policy action	Implementation	Key stakeholders
Position paper on responsible quantum development	Develop a shared Nordic-Baltic voice on ethical, sustainable, and human-centered quantum innovation through joint drafting, consultation, and publication.	Ministries, ethics councils, quantum researchers, innovation agencies.
Ethics and society modules in quantum education	Integrate ethical, legal, and sustainability aspects into quantum education via curriculum development and joint MSc/PhD initiatives.	Universities, education ministries, academic networks, quantum industry advisors.
Ethical guidelines for quantum innovation	Establish ethical guidelines for quantum R&D by benchmarking global practices and engaging expert working groups for voluntary adoption.	Research institutions, funding bodies, legal and ethics experts, industry representatives.

High-priority policy recommendations

In this final section, we focus on identifying and presenting a set of easily communicable and practical policy recommendations that align with the strategic objectives outlined earlier in this chapter. While the preceding sections have mapped out the key challenges, policy gaps, and a rich toolbox of policy measures, this section highlights a focused set of high-impact measures designed to be both highly implementable and influential at the cross-country level.

The aim is to leverage shared capabilities, foster collaboration, and amplify the region's role in shaping the future of quantum technologies. These recommendations also emphasize the need to align national and cross-country actions, ensure efficient resource use, proactive adaptation to evolving technologies and markets, and strengthen positioning on the global stage.

Prioritized high-impact policy recommendations

Establish a Quantum coordination forum

Establish a Nordic-Baltic quantum thought leadership and strategic influence initiative

Launch ambitious cross-country quantum pilot projects

To turn strategic ambitions into tangible results, three high-priority actions have been identified for their strong potential impact and practical feasibility. Two of these actions focus on improving regional coordination and projecting a unified Nordic-Baltic voice in global quantum discussions, which are crucial in a fast-moving landscape marked by technological disruption, fragmented investments, and increasing geopolitical complexity. These efforts are designed to align national strategies, coordinate input, and ensure that the region plays an influential role in shaping international quantum agendas. The third action, launching joint pilot projects, demonstrates how cross-border collaboration can translate shared goals into real-world outcomes. The following sections explore each of these priority actions in more detail.

Establish a Quantum coordination forum

To ensure strategic alignment and efficient use of resources, we propose the establishment of a lightweight Nordic-Baltic Quantum Coordination Forum. This forum would convene representatives from national innovation agencies, research networks, and quantum industry clusters to coordinate cross-border efforts and provide a shared platform for strategic dialogue, joint planning, and the identification of regional synergies.

The forum should build on and leverage established cross-country coordination structures (e.g. Nordic Quantum). Moreover, existing organisations already active in orchestrating national-level quantum activities must play a central role in this initiative. The forum would act as a connective layer, enhancing coherence, aligning timelines, and enabling mutual learning across the region. This approach will also help avoid fragmentation and ensure complementarity with national strategies and programmes.

While the exact institutional structure should remain flexible, a suitable host could be identified from among existing Nordic-level organisations with a track record in coordinating innovation, research, or industrial collaboration. Crucially, dedicated funding must be secured to support the forum's coordination activities, stakeholder engagement, and facilitation of cross-country initiatives.

This forum would serve as a foundational mechanism for achieving the broader vision outlined by the Nordic Prime Ministers' Joint Statement on Quantum Technologies, helping translate political ambition into sustained collaboration and long-term impact.

Establish a Nordic-Baltic Quantum Thought Leadership and Strategic Influence Initiative

Position the Nordic-Baltic region as a globally recognised thought leader in quantum technologies by coordinating joint contributions to international discourse, policy development, and standards setting. This initiative would support the publication of white papers, participation in expert panels, and representation in key global forums, such as ISO, ETSI, and relevant EU or OECD groups, on topics including interoperability, ethical frameworks, governance models, and strategic technology foresight. By mobilising research leaders, industry experts, and innovation agencies, the region can shape emerging global agendas, promote responsible quantum development, and ensure that its values and priorities are embedded in future international frameworks.

Launch ambitious cross-country quantum pilot projects

Establish a coordinated program of bold, research-driven quantum pilot projects involving research organizations, technology providers, and end-user companies across Nordic and Baltic countries. These pilots actively engage end-users in development, accelerating technology readiness and market entry while elevating the Nordic-Baltic brand as a global quantum technology leader. The projects will attract a diverse funding mix, combining public investment with contributions from major foundations, and will strengthen collaboration across the entire quantum technology value chain.



Concluding remarks

This report has provided a comprehensive, data-driven overview of the Nordic-Baltic quantum technology ecosystem, mapping commercial activity, highlighting regional strengths, and identifying concrete policy actions to enhance competitiveness.

Quantum innovation is not only a scientific pursuit but also a foundation for future industrial leadership, economic growth, and societal resilience. Denmark, Finland, and Sweden have built dynamic ecosystems, anchored by strong public-private partnerships and active commercial players. While Norway, Latvia, Lithuania, and Estonia currently have less developed commercial ecosystems, they possess a solid scientific base and growing national ambition, creating strong potential for rapid advancement.

Cross-country collaboration is essential to unlocking quantum technologies' full potential. This means aligning national strategies, investing in shared infrastructure, and fostering continuous dialogue and coordination across sectors and borders. The recommendations in this report, including the Quantum Coordination Forum, the Thought leadership and strategic influence initiative, and ambitious cross-country pilot projects, provide a focused starting point for impactful action.

Importantly, quantum policy must not be seen in isolation. Its role in advancing societal well-being, enhancing resilience, and promoting sustainability underpins the broader potential impact of this emerging technology. It is about technological progress and how quantum can serve societal needs while upholding shared values such as openness, responsibility, and sustainability.

The recent Joint Statement by the Nordic Prime Ministers and Heads of Government on Quantum Technologies (May 2025) underscores this shared commitment. By pledging to deepen collaboration, strengthen commercialisation efforts, and position the Nordics as a global hub for responsible quantum innovation, the region's leaders have sent a clear message: quantum is a strategic priority. This political momentum creates a unique window of opportunity to align national efforts and scale regional impact.

Now is the time to act. With bold, coordinated action, inclusive governance, and a long-term perspective, the Nordic-Baltic countries can shape the future of quantum technologies and create lasting economic and societal value.

Methodology

This study supports policymakers by providing a clear overview of strengthening the Nordic and Baltic region's position in quantum technologies. To build that understanding, the work began with a country-level analysis, followed by a regional synthesis and a comparison to global developments.

The project started with a review of national strategies, funding instruments, policy initiatives, and prior reports. This background research helped identify each country's state of quantum technology development and guided the overall structure of the analysis. Furthermore, the study used databases and company websites to identify key business players in each country.

A total of 28 stakeholder theme interviews were conducted across the region. Interviewees included representatives from startups, established firms, public organizations, universities, and funding bodies. The interviews provided practical insights into the national quantum ecosystems, key actors, dynamics, technology readiness, and collaboration opportunities at the Nordic-Baltic level.

In Denmark, Finland, and Sweden, the focus was on commercial activity, startup formation, and public-private innovation partnerships, reflecting more advanced quantum-technology landscapes. In Norway, Iceland, and the Baltic states, where quantum business activity is still emerging, the analysis emphasized academic strengths, early-stage testbeds, infrastructure investments, and policy frameworks that provide the foundation for future growth.

A comprehensive map of the Nordic-Baltic quantum ecosystem was developed based on this analysis, highlighting commercial activities in quantum computing, communication, and sensing.

The patent analysis consisted of two parts. First, it examined the number of European patent families in all three quantum domains and benchmarked the region against the most patent-active countries globally. Second, it analyzed the number of patent families held by Nordic-Baltic companies, offering insight into innovation activity in the area. The patent search queries used in the analysis are listed in the appendix.

Workshops played a central role in validating and shaping the policy recommendations. Participants used a regional SWOT analysis in the first workshop to identify and align key actions with strategic policy objectives. The second workshop focused on assessing the relevance of different policy instruments for supporting six strategic goals and refining potential policy measures. After the workshops, participants evaluated the proposed measures using a structured framework based on impact and feasibility through inquiries.



Authors and contributors

Corresponding authors

Dr. **Arto Wallin**, Senior Scientist at VTT, specialises in corporate foresight and guiding companies in leveraging emerging technologies for renewal.

Dr. **Tiina Apilo** is a Senior Scientist at VTT, with expertise in corporate foresight, innovation ecosystems, and leveraging emerging technologies to create business opportunities.

Contributors - VTT

We thank our VTT colleagues listed below for bringing their specialized expertise to this project.

- Matti Palomäki
- Eveliina Jutila
- Eija Tuominen
- Katri Valkokari
- Piia Konstari
- Pekka Pursula
- Arho Suominen

Acknowledgements

We thank the following individuals at **Nordic Innovation and Nordforsk** for their guidance and constructive collaboration throughout the course of this study.

- Olivia Rekman
- Ville Mäkinen
- Stian Bergeland
- Gudmund Høst

Interviewees an workshop participants

We gratefully acknowledge the contributions of the following interviewees and workshop participants, whose insights informed the analysis.

- Andris Ambainis, University of Latvia
- Morten Bache, Novo Nordisk Foundation
- Are Magnus Bruaset, Simula Research Laboratory
- Ebba Carbonnier, Quantum Life Science Centre, Karolinska Institut
- Nataly Dubbelman, Kvant
- Jeannette Dypbunkt, Vinnova
- Kristine Helen Falgren, Danish Quantum Community
- Mikael Johansson, CSC
- Johan Felix, QSIP
- Minna Günes, Algorithmiq
- Ulrich Hoff, Kvantify
- Camilla Johansson, QSIP
- Göran I Johansson, WACQT
- Milja Kalliosaari, IQM
- Outi Keski-Äijö, Business Finland
- Sofie Lindskov Hansen, Ministry of Foreign Affairs, Denmark
- Mika Lintilä, FInnish Parliament
- Louise Lund Henneberg, Ministry of Foreign Affairs, Denmark
- Ilona Lundström, Aalto University
- Cathal Mahon, BioInnovation Institute
- Vita Markeviciute, Quantum Lithuania
- Terje Nilsen, Kongsberg Discovery
- Jukka Pekola, Aalto University
- Arto Pussinen, Business Finland
- Morris Riedel, University of Iceland
- Vibeke Schrøder, Innofund
- Susanne Friederike Viefers, University of Oslo
- Ulf Öhlander, Vinnova

Appendices



Patent data search queries

Patent searches were performed with PatSnap Analytics 16.5.2025 by Eveliina Jutila.

Search	Search query	Filter	Other refinements
Quantum computing - Nordic and Baltic patents	CPC:(G06N10) AND (AN_ADD:((DK OR Denmark OR FI OR Finland OR IS OR Iceland OR NO OR Norway OR SE OR Sweden OR FO OR Faroe Islands OR GL OR Greenland OR AX OR Åland Islands OR EE OR Estonia OR LV OR Latvia OR LT OR Lithuania) NOT "No.") OR ANC_ADD:((DK OR Denmark OR FI OR Finland OR IS OR Iceland OR NO OR Norway OR SE OR Sweden OR FO OR Faroe Islands OR GL OR Greenland OR AX OR Åland Islands OR EE OR Estonia OR LV OR Latvia OR LT OR Lithuania) NOT "No."))	NOT Simple Legal Status: Inactive, PCT designates stage expired, Undetermined	All irrelevant results which are not from the selected countries were removed
Quantum communication - Nordic and Baltic patents	(CPC:(H04L9/0852 OR H04L9/0855 OR H04L9/0858 OR H04B10/70) OR TAC_ALL:("quantum communication" OR "quantum key distribution" OR QKD OR "BB84 protocol" OR "E91 protocol" OR "BBM92 protocol" OR "measurement-device-independent QKD" OR "continuous-variable QKD" OR "discrete-variable QKD" OR "quantum secure direct communication" OR "Differential phase shift" OR "Coherent one-way protocol" OR "entanglement swapping" OR "Bell-state measurement" OR "time-bin encoding" OR "single-photon source" OR "single-photon detector" OR "superconducting nanowire detector" OR "quantum repeater" OR "entangled photon pair source" OR "quantum memory for QKD" OR "photonic quantum memory" OR "quantum router" OR "quantum switch" OR "optical quantum bus" OR "photonic integrated circuit" OR "waveguide coupler" OR "quantum network" OR "quantum mesh" OR "QKD node" OR "satellite-based QKD" OR "ground-to-satellite QKD" OR "free-space optical quantum link" OR "wavelength-division multiplexing for quantum signals" OR "privacy amplification in QKD" OR "quantum privacy amplification" OR "photon number splitting attack" OR "decoy-state QKD" OR "QKD information reconciliation with LDPC" OR "Cascade protocol in QKD" OR "authentication in quantum networks" OR "quantum network authentication protocol" OR "quantum-classical interface controller" OR "hybrid classical/quantum network orchestrator" OR "quantum-secure VPN gateway" OR "middleware for QKD control" OR "quantum random number generator" OR QRNG OR "long-haul secure quantum trunk" OR "quantum-secured data center interconnect")) AND (AN_ADD:((DK OR Denmark OR FI OR Finland OR IS OR Iceland OR NO OR Norway OR SE OR Sweden OR FO OR Faroe Islands OR GL OR Greenland OR AX OR Åland Islands OR EE OR Estonia OR LV OR Latvia OR LT OR Lithuania) NOT "No.") OR ANC_ADD:((DK OR Denmark OR FI OR Finland OR IS OR Iceland OR NO OR Norway OR SE OR Sweden OR FO OR Faroe Islands OR GL OR Greenland OR AX OR Åland Islands OR EE OR Estonia OR LV OR Latvia OR LT OR Lithuania) NOT "No.")) AND TAC_ALL:(quantum or qubit)	NOT Simple Legal Status: Inactive, PCT designates stage expired, Undetermined	All irrelevant results which are not from the selected countries were removed
Quantum computing - All countries	CPC:(G06N10)	NOT Simple Legal Status: Inactive, PCT designates stage expired, Undetermined	

Quantum communication 2 - All countries	(CPC:(H04L9/0852 OR H04L9/0855 OR H04L9/0858 OR H04B10/70) OR TAC_ALL:("quantum communication" OR "quantum key distribution" OR QKD OR "BB84 protocol" OR "E91 protocol" OR "BBM92 protocol" OR "measurement-device-independent QKD" OR "continuous-variable QKD" OR "discrete-variable QKD" OR "quantum secure direct communication" OR "Differential phase shift" OR "Coherent one-way protocol" OR "entanglement swapping" OR "Bell-state measurement" OR "time-bin encoding" OR "single-photon source" OR "single-photon detector" OR "superconducting nanowire detector" OR "quantum repeater" OR "entangled photon pair source" OR "quantum memory for QKD" OR "photonic quantum memory" OR "quantum router" OR "quantum switch" OR "optical quantum bus" OR "photonic integrated circuit" OR "waveguide coupler" OR "quantum network" OR "quantum mesh" OR "QKD node" OR "satellite-based QKD" OR "ground-to-satellite QKD" OR "free-space optical quantum link" OR "wavelength-division multiplexing for quantum signals" OR "privacy amplification in QKD" OR "quantum privacy amplification" OR "photon number splitting attack" OR "decoy-state QKD" OR "QKD information reconciliation with LDPC" OR "Cascade protocol in QKD" OR "authentication in quantum networks" OR "quantum network authentication protocol" OR "quantum-classical interface controller" OR "hybrid classical/quantum network orchestrator" OR "quantum-secure VPN gateway" OR "middleware for QKD control" OR "quantum random number generator" OR QRNG OR "long-haul secure quantum trunk" OR "quantum-secured data center interconnect")) AND TAC_ALL:(quantum OR qubit)	NOT Simple Legal Status: Inactive, PCT designates stage expired, Undetermined	
Quantum sensing 2 - Nordic and Baltic countries	(CPC:(G01R33/035* OR G01R33/326 OR G01V7/00 OR G01C OR G01P OR G04F5/14 OR G01J OR G01S OR A61B) OR TAC_ALL: ("quantum sensor" OR "quantum measurement" OR "cold atom" OR "NV center" OR "quantum metrology" OR SQUID OR "superconducting quantum interference device" OR "superconducting quantum interference" OR "quantum magnetometer" OR "diamond magnetometer" OR "atomic magnetometer" OR "cold atom interferometer" OR "quantum gravimeter" OR "atomic gravity sensor" OR "atom interferometry" OR "quantum gyroscope" OR "atom interferometer gyro" OR "cold atom gyro" OR "spin precession sensor" OR "atomic clock" OR "quantum clock" OR "optical clock" OR "frequency standard" OR "time reference" OR "quantum lidar" OR "quantum radar" OR "entangled photon imaging" OR "ghost imaging" OR "quantum spectroscopy" OR "quantum sensing")) AND (AN_ADD:((DK OR Denmark OR FI OR Finland OR IS OR Iceland OR NO OR Norway OR SE OR Sweden OR FO OR Faroe Islands OR GL OR Greenland OR AX OR Åland Islands OR EE OR Estonia OR LV OR Latvia OR LT OR Lithuania) NOT "No.") OR ANC_ADD:((DK OR Denmark OR FI OR Finland OR IS OR Iceland OR NO OR Norway OR SE OR Sweden OR FO OR Faroe Islands OR GL OR Greenland OR AX OR Åland Islands OR EE OR Estonia OR LV OR Latvia OR LT OR Lithuania) NOT "No.")) AND TAC_ALL:(quantum OR qubit)	NOT Simple Legal Status: Inactive, PCT designates stage expired, Undetermined	All irrelevant results which are not from the selected countries were removed
Quantum sensing 2 - All countries	(CPC:(G01R33/035* OR G01R33/326 OR G01V7/00 OR G01C OR G01P OR G04F5/14 OR G01J OR G01S OR A61B) OR TAC_ALL: ("quantum sensor" OR "quantum measurement" OR "cold atom" OR "NV center" OR "quantum metrology" OR SQUID OR "superconducting quantum interference device" OR "superconducting quantum interference" OR "quantum magnetometer" OR "diamond magnetometer" OR "atomic magnetometer" OR "cold atom interferometer" OR "quantum gravimeter" OR "atomic gravity sensor" OR "atom interferometry" OR "quantum gyroscope" OR "atom interferometer gyro" OR "cold atom gyro" OR "spin precession sensor" OR "atomic clock" OR "quantum clock" OR "optical clock" OR "frequency standard" OR "time reference" OR "quantum lidar" OR "quantum radar" OR "entangled photon imaging" OR "ghost imaging" OR "quantum spectroscopy" OR "quantum sensing")) AND TAC_ALL:(quantum OR qubit)	NOT Simple Legal Status: Inactive, PCT designates stage expired, Undetermined	

Search	Results	Active or pending results
Quantum computing - Nordic and Baltic patents	183 simple patent families	**153 simple patent families**
Quantum computing - All countries	9365 simple patent families	**8305 simple patent families**
Quantum communication 2 - Nordic and Baltic patents	62 simple patent families	**50 simple patent families**
Quantum communication 2 - All countries	13122 simple patent families	**8669 simple patent families**
Quantum sensing 2 - Nordic and Baltic countries	146 simple patent families	**49 simple families**
Quantum sensing 2 - All countries	9057 simple patent families	**4893 simple families**

CPC Code	Title & Use
G06N10	Quantum computing; umbrella class for quantum information processing
H04L9/0852	Quantum cryptography, especially quantum key distribution (QKD)
H04L9/0855	Quantum networks with intermediate nodes (e.g., repeaters)
H04L9/0858	Key distillation, error correction, and privacy amplification for QKD
H04B10/70	Photonic quantum communication; transmission of quantum information optically
G01R33/035*	SQUID-based magnetometers; superconducting quantum interference devices
G01R33/326	Magnetic variable measurement using SQUIDs
G01V7/00	Measuring gravitational fields; general gravimeters, including quantum types
G01C	Measuring linear/angular displacement or acceleration; includes gyroscopes
G01P	Measuring speed or acceleration; inertial sensors
G04F5/14	Atomic clocks and time standards based on quantum principles
G01J	Measurement of radiation intensity; includes quantum spectrometry
G01S	Radar, sonar, lidar; includes quantum lidar and radar

A61B	Diagnostic instruments; relevant for quantum NMR, MRI, and biosensing

Readers can access the patSnap workspace by following public link below:

- Workspace: Nordic and baltian quantum patents
- https://workspace.patsnap.com/share/fromShareLink?code=56d42a05bb9842aaa110359e8006bdfe&channel_source=WSPLG&created_from=WS&dataType=patent&viewType=table
- Shared by: eveliina.jutila@vtt.fi

List of abbrevisitions

AI – Artificial Intelligence

ETSI – European Telecommunications Standards Institute

EuroQCI – European Quantum Communication Infrastructure

HPC – High-Performance Computing

IP – Intellectual Property

ISO – International Organization for Standardization

KPI – Key Performance Indicator

MEG – Magnetoencephalography

MRI – Magnetic Resonance Imaging

NISQ – Noisy Intermediate-Scale Quantum

NQCP – Novo Nordisk Foundation Quantum Computing Programme

SQUID – Superconducting QUantum Interference Devices

QEC – Quantum Error Correction

QKD – Quantum Key Distribution

QLSC – Quantum Life Science Centre

QPU – Quantum Processing Unit

SME – Small and Medium-sized Enterprise

TRL – Technology Readiness Level

WACQT – Wallenberg Centre for Quantum Technology

List of picture sources

Cover "50-qubit quantum computer": VTT

Contents: Kuvatoimisto Kuvio - VTT

Executive summary: Anders Vestergaard Jensen - Norden.org

Introduction: Eyþór Árnason - Norden.org

Quantum technologies: VTT; Getty Images - VTT

Quantum computing: VTT

Quantum sensing: Vesa Kippola - VTT

Quantum communication, Getty Images - VTT

Quote page, Tiina Apilo

National quantum ecosystem: Tiina Apilo; Nikolaj Bock – Norden.org; Zoe Ansari - Unplash; Eirik Skarstein - Unplash; Silje Bergum Kinsten - Norden.org; Karson – Unsplash; Darya Tryfanava – Unsplash; Julai Karnavusha – Unsplash

Mapping of Nordic-Baltic quantum business ecosystems: VTT

Nordic-Baltic quantum strongholds: Edward Jenner – Pexels; Monty Rakusen/ Getty Images – VTT

Superconducting quantum computing: Timo Kauppila/Fotariamo – VTT; VTT

Quantum photonics and optics: Tuomas Kiukas – VTT

Quantum life science: Darko Stojanovic, Pixabay; Helena Jankovičová Kováčová - Pixabay; Mart Production – Pexels

Potential strongholds: Johannes Jansson – Norden.org

Manufacturing industry: Pexels

Financial services: Kuvatoimisto Kuvio – VTT

Policy recommendations: Kuvatoimisto Kuvio – VTT

Policy gaps at the Nordic-Baltic level: Anita Miruškina – Norden.lv

Operationalizing strategic goals: Tiina Apilo

Concluding remarks: Tiina Apilo

Authors and contibutors: Unsplash

Appendices: Tiina Nykänen - VTT

Disclaimer

This publication is part of the "Nordic Forward: Resilience and competitiveness for 2050" program by Nordic Innovation. VTT authors Arto Wallin and Tiina Apilo are responsible for the content of this report. The report represents a synthesis of insights gathered through a combination of desktop research, background material analysis, expert interviews, and stakeholder workshops. While numerous individuals and organizations contributed valuable perspectives, the views and recommendations expressed are those of the authors and do not necessarily reflect the positions of all contributors.

About VTT

VTT is a visionary research, development and innovation partner for companies and the society. We bring together people, business, science and technology to solve the biggest challenges of our time. We advance the utilisation and commercialisation of research and technology in commerce and society. This is how we create sustainable growth, jobs and wellbeing and bring exponential hope.

VTT is one of the leading technical research organisations in Europe, and we have over 80 years of experience in cutting-edge research and science-based results. Our more than 2,000 professionals work to develop systemic and technological solutions that can bring about fundamental transformation.

We promise to always think beyond the obvious.

About Nordic Innovation

Nordic Innovation is an organisation under the Nordic Council of Ministers. Nordic Innovation aims to make the Nordics a pioneering region for sustainable growth and works to promote entrepreneurship, innovation and competitiveness in Nordic business.