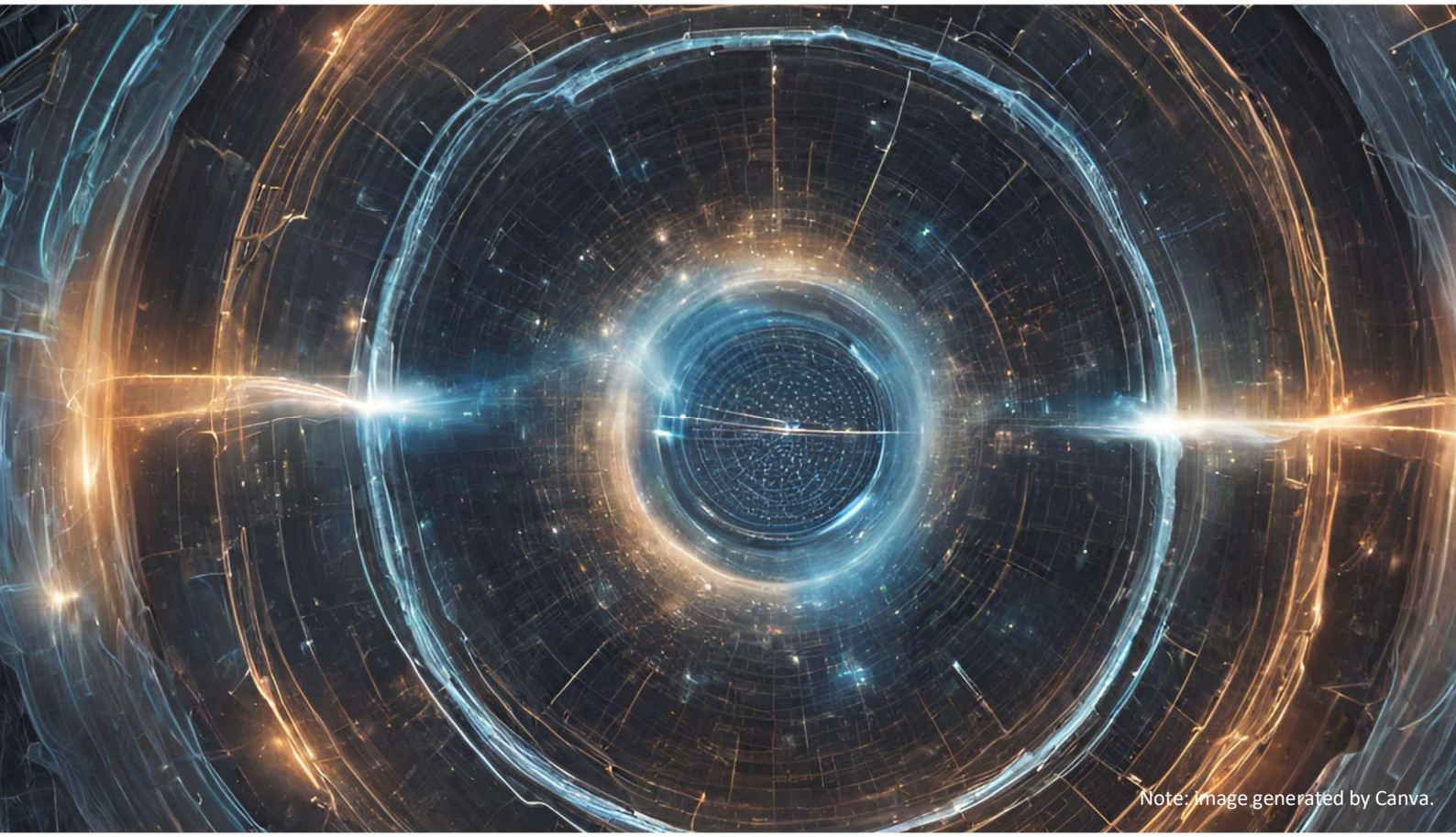

Note: Image generated by Canva.

QUANTUM TECHNOLOGY IN SOUTH KOREA – OUTLOOK FOR DANISH KOREAN COLLABORATION

INNOVATION CENTRE DENMARK

DANISH IDEAS. GLOBAL SOLUTIONS.

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FOREWORD

Denmark and South Korea are like-minded nations and are committed to collaborate in fields of science and technology of strategic importance to both countries. In February 2024 Denmark and Korea will sign an agreement to collaborate specifically in the field of research and commercialization of quantum technologies, this report seeks to shed light on the following:

- The approaches of major South Korean stakeholders in the realms of research, industry, and the political sphere towards quantum technology.
- A comparison of the quantum ecosystems in Denmark and Korea, highlighting potential collaborative opportunities.
- Examples to illustrate potential future collaborations and applications of quantum technology, leveraging South Korea's strengths in this field.

The report is a first step in support of increased collaboration between Denmark and South Korea. Questions to the report or inquiries about collaborative activities can be directed to Innovation Centre Denmark Seoul.

Innovation Centre Denmark, Seoul

February 2024

EXECUTIVE SUMMARY

Quantum technology stands at the forefront of global innovation promising transformative changes across industries. As nations seek to assert their global influence, strategic alliances become instrumental in unlocking the vast potential of quantum technologies.

This report focuses on the collaborative opportunities in this field between Denmark and South Korea. It serves as a catalyst for fostering meaningful collaborations that may lead to advancement and growth in the field of quantum technology.

Recently published national strategies for quantum technology in both Denmark and South Korea contain overlapping interests and political goals, which offer opportunities for collaboration.
The report shows that collaboration between Denmark and South Korea on advancing and fostering a quantum workforce is an overt opportunity.

The Danish academic environment offers top-class insights on fundamental research in quantum, while South Korea maintains a strong focus on advancing the technology for specific applications. This complementary expertise provides an excellent opportunity for collaboration with potential to advance each country's workforce competencies through talent development programmes, summer schools, etc.

Furthermore, South Korea presents an interesting market for Danish stakeholders involved in the commercialisation of quantum technology. The unique market structures and industrial strengths of South Korea in telecommunication and semiconductors makes it an interesting country for Danish quantum stakeholders.

The report also provides a comprehensive overview of the current state of the South Korean ecosystem for quantum technology. The ecosystem comprises numerous RTOs and universities engaged in quantum-related activities. However, relatively few private companies work with the technology. Among these, however, several are large and renowned and could present compelling partnership opportunities for Danish stakeholders.

The report is prepared by Innovation Centre Denmark, Seoul, in collaboration with the Danish Technological Institute. It is based on desk research and review of key policy documents, interviews with South Korean experts in the field, and mapping of innovation activities based on patent data from global databases. The aim is to explore collaborative opportunities for Danish quantum stakeholders in South Korea.

INTRODUCTION

The field of quantum technology holds prosperous perspectives for many industries. The technology harnesses the principles of quantum mechanics to develop novel solutions. Quantum technology utilises the unique and often counterintuitive properties of quantum mechanics to create powerful tools and technologies that can solve problems more efficiently than existing conventional solutions.

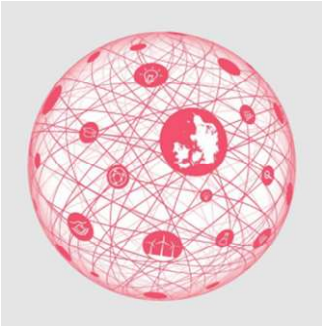
As we currently understand quantum technology, we generally divide it into three subfields: quantum computing (including simulators), quantum communications and quantum sensors.[1] Quantum computing refers to computing that harnesses the principles of quantum mechanics to process information, which enables exponentially faster calculations compared to conventional computers. Quantum communications use quantum principles to securely transmit information, and finally, quantum sensing utilises the principles of quantum mechanics to achieve highly sensitive and accurate measurements.

While applications of quantum technology are still at an early stage, global momentum for the technology is rapidly increasing. This offers great opportunities for international collaboration, which is a crucial factor in furthering the development of real applications of the technology. International collaboration allows different countries to pool their talents and knowledge to create a richer and more comprehensive understanding of the field. This will enable the technology to live up to its promises and be applied commercially at a larger scale.[2]

This report explores the landscape of quantum technology in South Korea, offering insights into key developments, national initiatives, and the national ecosystem. It also highlights potential collaboration opportunities between South Korea and Denmark and identifies synergies that could catalyse meaningful cooperation between the two nations in the quantum domain.

The report starts by outlining the Danish ambitions and political priorities for quantum technology followed by a review of the South Korean strategy for the technology. Then follows an in-depth analysis of the current state of the South Korean quantum ecosystem and its strengths leading to the highlighting of three potentially prosperous avenues of collaboration between Denmark and South Korea.

DANISH AND KOREAN VISIONS FOR QUANTUM TECHNOLOGY AND CURRENT STATE OF THEIR ECOSYSTEMS



The Danish ambitions and the current Danish quantum ecosystem make South Korea a potential valuable strategic partner, both on a national scale, but also for individual research organisations and companies. South Korea's ambitious focus on developing research infrastructure and

[1] E.g. McKinsey & Company (April 2023) Quantum Technology Monitor.

[2] Observer Research Foundation (September 2023) Global initiatives in quantum computing: The role of international collaboration.

quantum technology, combined with a significant financial commitment made by the government, holds great potential for Danish stakeholders. This is further supported by the South Korean government's expression of the importance of international cooperation.

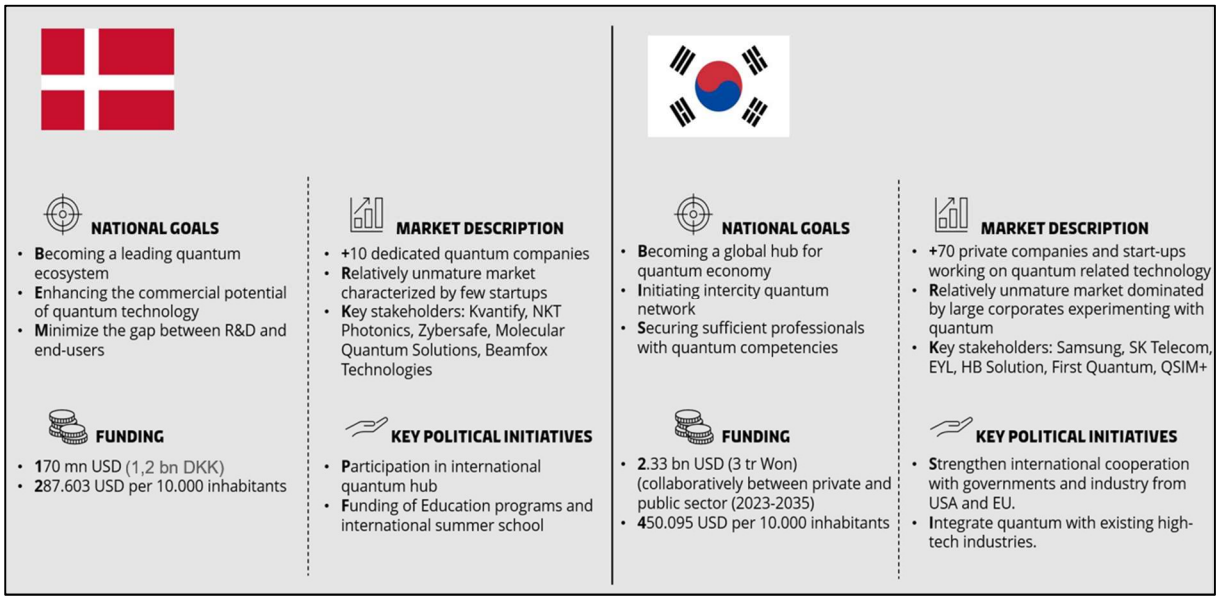
The national goals, investments and initiatives of Denmark and South Korea respectively have been summarized in figure 1 with more detailed descriptions in the following sections.

Both countries have committed large financial resources. South Korea is planning to allocate a significantly larger amount than Denmark, as the South Korean financial commitment to quantum technology stands at USD 450,095 per 10,000 inhabitants against USD 287,603 in Denmark.

The figure also indicates that both the Danish and South Korean markets are relatively immature, currently consisting of only a few dedicated companies.

Furthermore, both countries actively seek international engagement and partnerships and consider it a necessary means for furthering the technological development. Both countries have made direct financial commitments to support international collaboration.

FIGURE 1: QUANTUM PROFILE COMPARISON OF DENMARK AND SOUTH KOREA



Note: based on desk research carried out by DTI.

STRATEGIC AND POLITICAL FOCUS ON QUANTUM TECHNOLOGY IN DENMARK

The national strategy for quantum technology in Denmark was published in two parts; the first with a focus on research and innovation[3], and the second with a focus on commercialisation, security, and international

[3] Ministry of Higher Education and Science (2023) Strategy for Quantum Technology: Part 1 – World Class Research and Innovation.

collaboration.[4] The strategy is expansive with the government budgeting approximately 170 million USD in the period 2023 to 2027 for R&D activities and for strengthening of the Danish quantum ecosystem.

The first part aims to position Denmark as a globally leading research environment that can effectively convert research to new, applicable technology. The strategy focuses on international research- and innovation cooperation, long-term strategic investments, and better access to digital research infrastructure. The second part aims to exploit the commercial potential of quantum technology for the benefit of national security and Danish commercial interests. As shown in figure 2, the collective national strategy is divided into three main areas with subsequent support initiatives. The initiatives include concrete programs, designed to foster international research and innovation cooperation. The Quantum Summer School is a notable initiative under this part, aimed at cultivating talent and expertise in the field.

FIGURE 2: STRATEGIC FOCUS OF DANISH QUANTUM EFFORTS

Source: Ministry of Higher Education and Science (2023) Strategy for Quantum Technology: Part 1 – World Class Research and Innovation and Ministry of Industry, Business and Financial Affairs (2023) National Strategy for Quantum Technology: Part 2 – commercialization, security, and international collaboration
Note: Visualization by DTI.

The Danish ecosystem is in its start-up phase but has a strong foundation. The Technical University of Denmark (DTU) and the University of Copenhagen are frontrunners within R&D and have already produced significant results. There is an aspiring quantum start-up environment in Denmark with companies like SparrowQuantum, Kvantify and QDevil, which are all funded by venture capital. Internationally, Denmark has also gained recognition as a significant player with IBM and Microsoft investing in projects for the development of quantum computers. NATO, the strategic military alliance, opened the new DIANA Centre at the University of Copenhagen with the mission of commercialising dual-use quantum technologies.[5]

[4] Ministry of Industry, Business and Financial Affairs (2023) National Strategy for Quantum Technology: Part 2 – commercialization, security and international collaboration.
[5] IT Branchen (2023) Quantum Technology.

STRATEGIC AND POLITICAL FOCUS ON QUANTUM TECHNOLOGY IN SOUTH KOREA

Although South Korea entered the quantum race later than many of the current leading quantum technology nations[6], the South Korean government recently announced ambitious visions for the development of a strong ecosystem for quantum technology and a strong global position designating quantum science and technology as one of the nation's 12 strategic technologies.[7]

The strategic focus is broad and encompasses technological development within different subfields, but also greatly emphasises strengthening the political framework to support scientific and academic research on quantum, which fosters a strong ecosystem and secures the necessary workforce to build and maintain visionary momentum.

In June 2023, South Korea put forward a mid- and long-term strategy for their efforts within quantum technology.[8] The strategy presents the South Korean preconditions for developing a strong quantum ecosystem and obtaining a predominant market position by 2035 through a SWOT-analysis. The SWOT leaves the impression of a nation that can utilise their advanced high-tech industries, strong ICT infrastructure and workforce, which contains a large number of technical workers, to position themselves as a global quantum leader. However, also an impression of a country that has challenges that must be overcome. Among the highlighted threats is the possible outflow of labour due to the global demand for quantum competencies. The current shortage of quantum specialists is also considered a weakness for the South Korean quantum ecosystem.

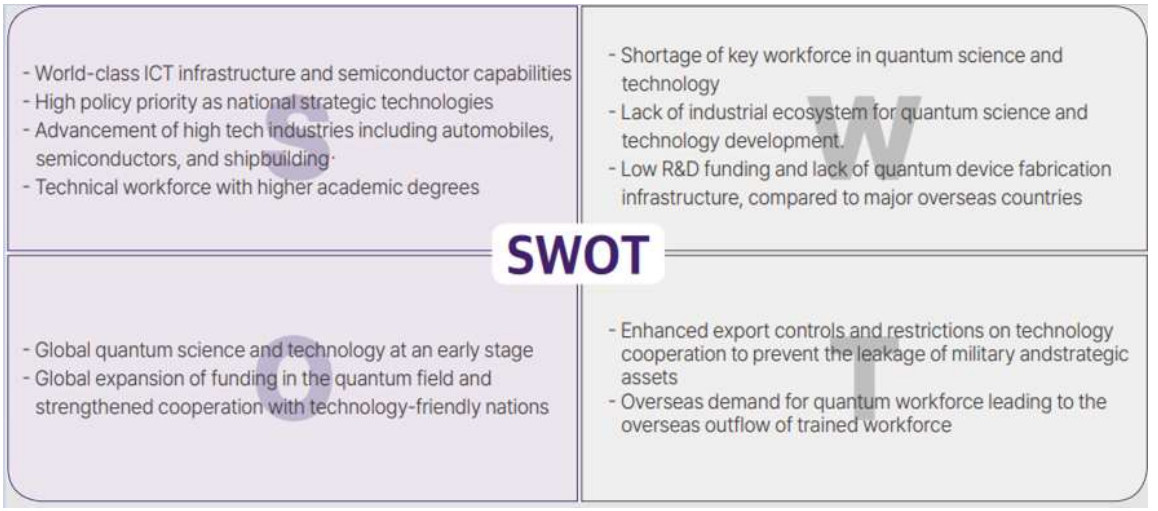
The analysis pinpoints international collaboration as a strong opportunity, which is underpinned by the shortage of an adapted quantum workforce.

[6] The Quantum Insider (July 2023) A Brief Overview of Quantum Computing in South Korea in 2023.

[7] Korean Cultural Centre: New Growth 4.0, 15 Projects for Korea's Big Leap.

[8] Ministry of Science and ICT (2023) Korea's National Quantum Strategy.

FIGURE 3: SWOT OF SOUTH KOREA'S QUANTUM DEVELOPMENT



Source: Ministry of Science and ICT (2023) Korea's National Quantum Strategy

The South Korean visions and political objectives are ambitious. The South Korean government has committed to substantial investments to develop the quantum ecosystem and advance the technological development in the years to come. In total, the government has committed KRW 3 trillion (USD 2,33 billion equivalent) collaboratively between the public and private sector between 2023 and 2035, which makes the South Korean strategy one of the largest publicly disclosed commitments to the development of quantum technology, globally.

The strategy contains political objectives for both advancing the current technology level[9], developing a sufficient workforce, fostering a larger market, achieving a larger market share, and securing more investments and international collaborations. The specific objectives are illustrated by the strategy's key indicators (shown in figure 4). The focus on building international relations within quantum supports the possibilities for Danish stakeholders to tap into the South Korean strengths and opportunities.

Figure 4 also shows the ambitious goals for fostering a quantum workforce. In terms of quantum Key personnel, South Korea aims to increase the key quantum workforce from 384 to 2,500 individuals by 2035, simultaneously expanding the general quantum workforce from 1,000 to 10,000 individuals.

This is further emphasised by the commitment to international collaboration in the form of international joint research and workforce exchange in government quantum-specific projects indicating the financial commitment to explore international partnerships with research institutions from abroad.

FIGURE 4: KEY INDICATORS FOR ADVANCING SOUTH KOREA'S QUANTUM POSITION

Source: Ministry of Science and ICT (2023) Korea's National Quantum Strategy.
Note: the footnotes can be found in the original document, p. 25.

THE MAIN PHASES OF QUANTUM TECHNOLOGY DEVELOPMENT IN SOUTH KOREA

The South Korean strategy is broken down into three phases with milestones for the advancement of (1) the workforce, (2) infrastructure, (3) R&D on quantum computing, (4) communications and (5) sensing.

Phase 1 spans from 2023 to 2027 and focuses on creating a basic quantum ecosystem and on accelerating the development of quantum sensors and quantum cryptography for secure communication. In this phase, it is also the intention to establish open quantum fabrication facilities for researchers and to expand quantum graduate schools and academic research centres to further advance the key workforce within quantum. During this phase, it is also the objective to work with the commercialisation of quantum sensing technologies.

In Phase 2 (spanning from 2028-2031), the focus will be on the industrialisation of materials, components, and equipment that constitute quantum systems. This phase also marks the domestication of quantum computing systems and services for South Korea, adapting the technology to fit the needs, values, and practices of the intended users.

Phase 3, from 2032 to 2035, marks the period in which South Korea will strive to reach status as a global quantum powerhouse. Besides developing the workforce and infrastructure even more, the focus is on expanding the ecosystem and making it more robust through commercialisation of quantum science and technology.

The pathway to fulfilling this ambitious vision is paved with seven policy orientations that the government seeks to achieve. The orientations are presented in figure 5.

KEY QUANTUM TECHNOLOGY POLICIES IN SOUTH KOREA

FIGURE 5: SEVEN POLICY ORIENTATIONS FOR QUANTUM IN SOUTH KOREA

Source: Ministry of Science and ICT (2023) Korea's National Quantum Strategy.
Note: Visualisation by DTI.

This overview of key policy orientations provides interesting avenues in relation to international collaboration. A number of the policy orientations also aligns with the Danish national objectives on quantum technology.

The first policy orientation focuses on the quantum workforce. The strategy mentions the establishment of a global quantum talent circulation system as a part of the South Korean efforts. Specifically, South Korea wants to increase support for PhDs and postdoctoral researchers to expand their possibilities for overseas collaborative research and exchanges.[10] In addition, South Korea intends to support joint research with leading countries within quantum technology and offer opportunities for novice researchers to study abroad and engage in joint research, which again underlines the commitments to international collaboration in the strategy.

The intentions align closely with the Danish national strategy. It also promotes international collaborations to further quantum development. Both Denmark and South Korea take part in the international commitment to facilitate exchange of students, researchers, and professionals in the field of quantum technology through the Entanglement Exchange program.[11]

The common interest of Denmark and South Korea in fostering personal relations and facilitating international exchanges of students and researchers represents an interesting opportunity for international collaboration that can assist research and development of quantum technology for the benefits of both nations.

The South Korean strategy also emphasises the importance of fostering a quantum industry and intends to support advantaged exploration and empirical research. The provision of quantum computer cloud services to support the development of quantum computer algorithms and software along with the commitment to large investments in emerging companies offer interesting perspectives for international stakeholders to become part of research projects that can benefit from South Korea's advantages in other technical fields.

Finally, South Korea intends to promote strategic international alliances between governments and industry partners of major quantum countries. One of the highlighted partners for South Korea is the EU. Through joint international research, the South Korean government intends to improve their technological competitiveness. Moreover, South Korea plans to support international cooperation with 210 billion Won by 2035[12], and South Korea will actively engage in exchanges with international partners.

THE SOUTH KOREAN QUANTUM ECOSYSTEM IN NUMBERS

The academic quantum environment in South Korea has seen a significant blossoming in recent years, especially within the area of quantum computing. Scientific publications can be considered a proxy for the scientific interest and activity within a given technological field.

[10] Ministry of Science and ICT (2023) Korea's National Quantum Strategy.

[11] Entanglement Exchange.

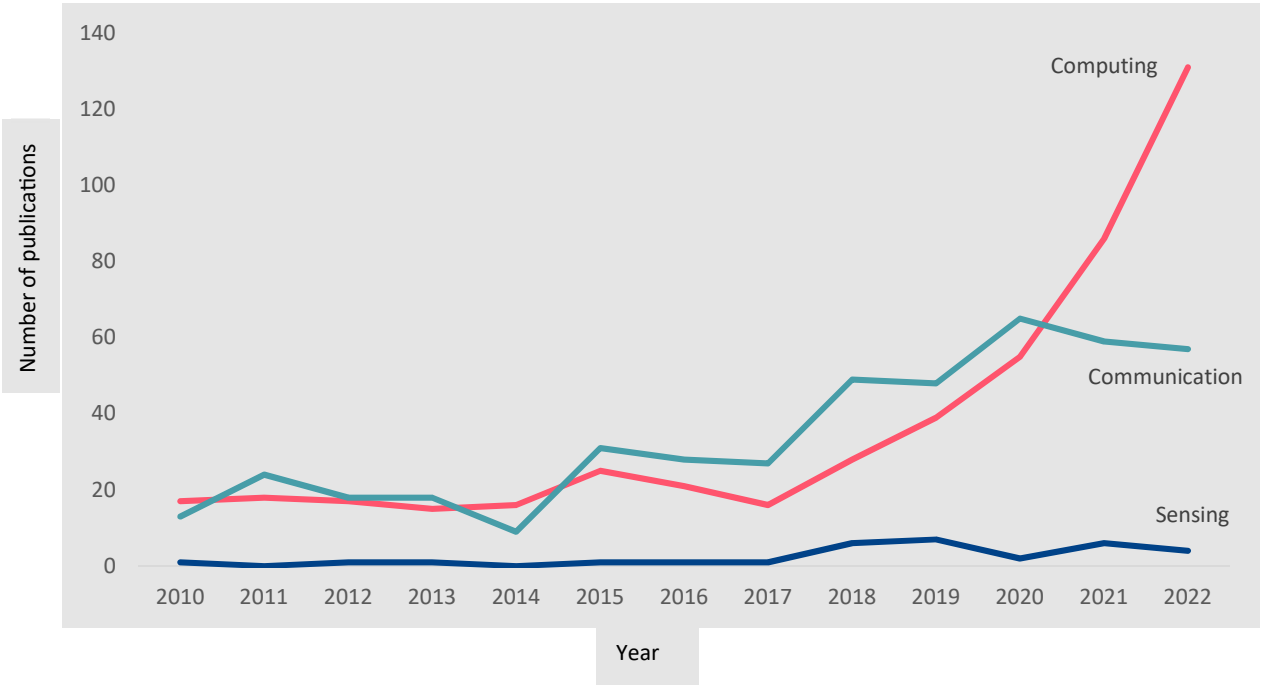
[12] Equivalent to approximately 162 million USD.

QUANTUM TECHNOLOGY TRENDS IN SOUTH KOREA

Figure 6 below demonstrates that the yearly number of scientific publications in the field of quantum computing has increased significantly since 2010, while publications on quantum sensing have not seen a similar increase. For quantum communication, there has been a slight increase in interest over the past 12 years with a minor decline from 2020 to 2022.

These trends express emerging academic interest in the field and holds great promise for the future of South Korean quantum development. Significant interest from the scientific communities creates opportunities for international scholars to contribute to current and planned academic activities.

FIGURE 6: TRENDS IN SOUTH KOREAN PUBLICATIONS ON QUANTUM TECHNOLOGY



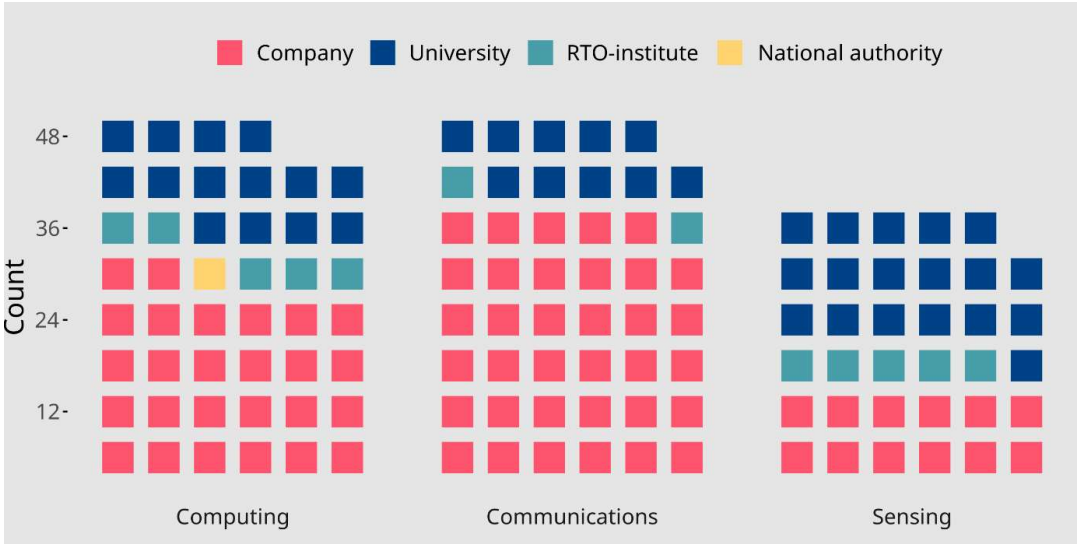
Note: based on calculations carried out by DTI on data from Scopus.

Publications are one way of examining the technological interest in a field. Another proxy is patenting activities. Based on information on the assignees of patents related to quantum technology, figure 7 illustrates the distribution of the quantum technological focus of patents taken out by South Korean stakeholders segmented by organisational type (private company, Research and Technology Organisation (RTO), university, or national authority).

Many of the larger stakeholders (both major universities and large private companies) have patenting activity in the three main areas of quantum technology.The figure confirms that computing and communication are the areas attracting the most interest in South Korea with 46 and 47 patents respectively across all types of stakeholders. The figure also shows more patenting activity in quantum communication within the private sector

compared to the fields of computing and sensing. This might indicate that technology related to quantum communications is a technologically more mature area. This is most likely driven by the South Korean advanced telecommunications industry, including several large and well renowned companies such as Samsung, LG and SK Telecom.

FIGURE 7: DISTRIBUTION OF STAKEHOLDERS WORKING WITHIN THE THREE MAIN TECHNOLOGY AREAS



Note: based on data from Crunchbase, Patsnap and desk research carried out by DTI. The figure does not include all stakeholders; those for whom DTI could not ascertain the quantum focus of the patent are left out.

Zooming in on the patenting activity of universities and RTOs, it becomes evident that these types of organisations are more active in quantum sensing and computing than in quantum communications. Interestingly, although the number of scientific publications on quantum sensing from Korean stakeholders is relatively low, as depicted in figure 6, there is still a substantial patenting activity in the area.

Diving deeper into the South Korean activity on quantum communication shows that South Korea has a particular strength within quantum cryptography and development of Quantum Key Distribution (QKD). QKD is a promising technology, which allows for secure communication through implementation of a cryptographic protocol involving components of quantum mechanics. Among the private companies working with quantum communication is SK Telecom. Relying on existing expertise in wireless communication, the company is exploring quantum cryptography with two of their technologies already approved as the standard for quantum cryptography communication[13]. Recently, the company also announced the development of a quantum key distribution (QKD) technology-based VPN[14]

[13] Quantum Zeitgeist: A Brief Look at Quantum Technology In Korea, how one of the world's most technologically advanced nations is tackling Quantum Technology.

[14] The Korea Economic Daily: SK Telecom develops quantum cryptography-based VPN.

Zooming in on the South Korean efforts within quantum computing, there is a strong focus on algorithm enhancement, error correction, and quantum simulation. Moreover, South Korean enterprises are at the forefront of exploring various application areas, including fine-tuning of financial portfolio strategies, acceleration of pharmaceutical discovery processes, and measures enhancing identity security.[15]

THE WORLD'S FIRST QUANTUM TECHNOLOGY MOBILE PHONE

South Korea is a global leader in telecommunications due to their prevalence of strong private actors such as Samsung, LG and SK Telecom. This makes quantum communication a natural starting point for their journey into quantum technology.

According to an analysis from KAIST, South Korea is globally competitive in the field of quantum cryptography, which is one of the main technologies within quantum communication.

SK Telecom, one of South Korea's leading telecommunications providers, has made a groundbreaking contribution to the field of quantum communication that exemplifies the South Korean position on quantum communication and cryptography by introducing the world's first commercially available quantum mobile phone in 2020.[16] The purpose of the phone is to provide users with an extremely safe mobile communication device.

The 2nd version of the phone, released in 2021, sold more than 300,000 units in the first six months following its release, which SK Telecom describes as their highest sales volume in South Korea for a Galaxy phone that year.[17] The 4th version of the phone, launched this year, differentiates itself by showing a quantum indicator to users, which indicates a quantum security service.

It is the company ID Quantique, a world leader in quantum-safe security solutions, that has designed the QRNG chipset in collaboration with Samsung.[18] ID Quantique is a Swiss company under ownership of SK Telecom.

This case underlines the large and relevant interest from private companies in South Korea actively working on applications of quantum technology, while highlighting the increased potential from international partnerships—also in the private market.

QUANTUM TECHNOLOGY STAKEHOLDERS IN SOUTH KOREA

To get a better understanding of the current South Korean quantum ecosystem, it is relevant to explore the geographical and industrial distribution of the different stakeholders. Danish Technological Institute has

[15] Sam Howell (2023) Why the US, Japan and South Korea should take the quantum leap together. The Hill.

[16] KAIST Electrical Engineering (2020) Professor June-Koo Rhee's (Director of KAIST AI Quantum Computing ITRC Center) interview was reported in Korea IT newspaper.

[17] Leprince-Ringuet, D. (2021) Samsung's new Galaxy Quantum 2 uses quantum cryptography to secure apps.

[18] ID Quantique (2023) SK Telecom and Samsung unveil the Galaxy Quantum 4, providing more safety and performance with IDQ's QRNG Chip.

gathered information on relevant stakeholders involved in the development of South Korean quantum technology. The list of stakeholders covers universities, RTOs, private companies, national authorities, and industry alliances.

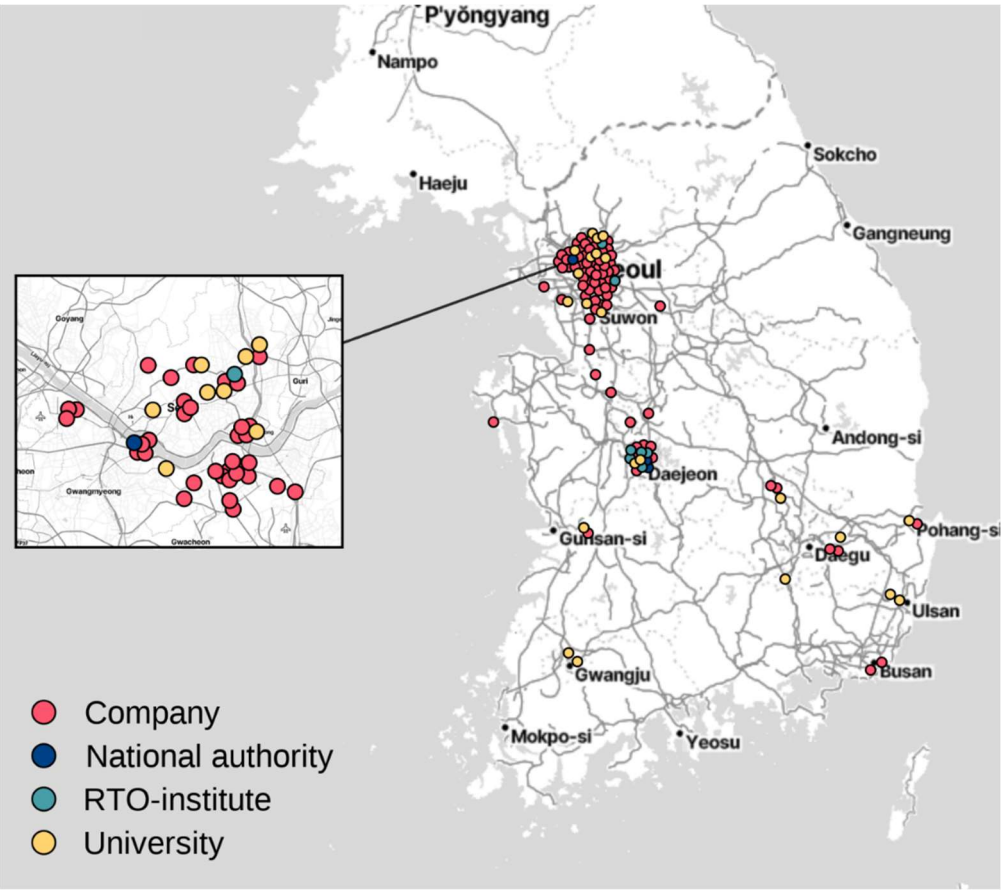
In total, 109 stakeholders were identified in the current South Korean ecosystem. The stakeholders were identified using industry codes from Crunchbase and assignees on patents related to quantum technology. They were further supplemented by stakeholders identified through desk research. The stakeholders have been categorised as working within quantum computing, communications, and/or sensing, based on patent classes and company descriptions, and with additional information obtained through desk research. The full list of identified stakeholders can be found in Appendix A.

In general terms, the South Korean ecosystem is quite similar to the ecosystem of Denmark and most other countries at this early stage of the technology. The South Korean quantum technology ecosystem is characterised by the presence of a large share of universities and research institutes and relatively few private companies compared to other more mature technology fields.

Geographically, many stakeholders are centered in and around Seoul, which has the highest density of universities and companies working with quantum technology. Figure 8 illustrates the geographical landscape of the South Korean quantum ecosystem.

The city Daejeon also hosts a notable number of stakeholders including the Korea Advanced Institute of Science Technology (KAIST), which is one of the frontrunners of R&D on quantum technology in South Korea. In addition to KAIST, there are also 4 RTOs in Daejeon along with a few private companies. The rest of the country sees little concentration of stakeholders with only a few located in other large cities such as Busan, Gwanju and Ulsan.

FIGURE 8: MAPPING OF STAKEHOLDERS IN QUANTUM TECHNOLOGY IN SOUTH KOREA

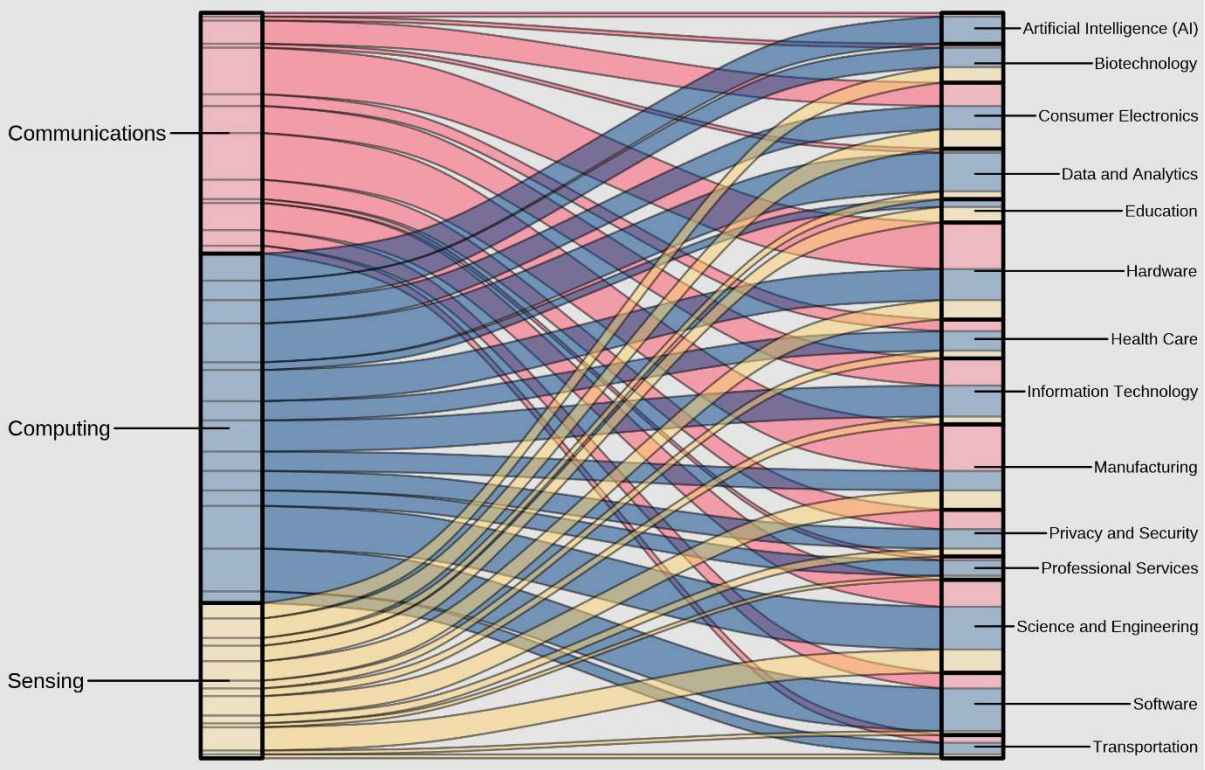


Note: based on data from Crunchbase, Patsnap and desk research carried out by DTI.

Figure 9 illustrates which sub-industries in South Korea utilise quantum technology within the main subfields.[19] The figure shows that manufacturing, hardware, software, and science & engineering are the industries with the biggest quantum focus. However, it also becomes clear that a broad range of industries is exploring the potential of quantum technology. For quantum communication, the dominant industries are hardware, manufacturing, information technology, consumer electronics, and privacy and security. Quantum sensing is prominent within biotechnology, consumer electronics and education. Finally, quantum computing evidently has applications in all sub-industries and makes up a significant part of each industry.

[19] The graph is based on data on the industry codes of the 55 private companies working with quantum technology in South Korea.

FIGURE 9: DISTRIBUTION OF TOP APPLIED INDUSTRIES WITHIN THE THREE MAIN TECHNOLOGY AREAS

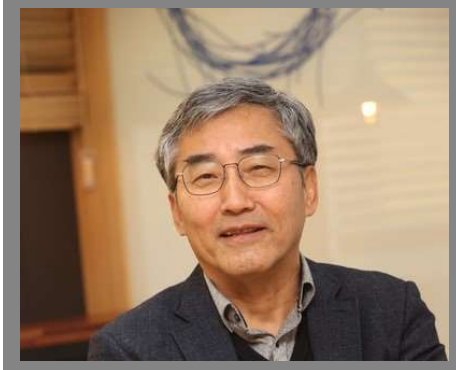


Note: based on data from Crunchbase, Patsnap and desk research carried out by DTI. The plot shows the top industries of South Korean companies working with quantum technology. It is based on 55 companies for which Crunchbase has data.

The figure highlights the broad range of possibilities of quantum technology. Most interestingly, it highlights that quantum technology has applications in a wide range of industries underlining the technologies' potential throughout modern society. Moreover, it opens avenues for international collaboration within multiple subfields.

SOUTH KOREA'S QUANTUM ADVANTAGE: AMPLIFYING POTENTIAL THROUGH SEMICONDUCTORS

As a result of its strong telecommunications industry, South Korea is a frontrunner within semiconductor technology. The nation's strategy is to harness the strength of its semiconductor industry in the future, as semiconductors play an important role in creating and controlling the building blocks of quantum computers – the so-called Qbits – as well as in building the hardware needed for quantum processors.[20]



Professor Soonchil Lee, a physics expert with an extensive background in quantum computing and one of the early South Korean researchers in the field, also points to the semiconductor industry as holding significant potential for South Korea.

"Quantum communication in Korea is at the top level. But I think one of the biggest merits we have is our semiconductor industry where we already have technological benefits, and for commercialisation in the future, we will have some advantages."

Professor Soonchil Lee now works for the national authority, the National Research Foundation, in their division for quantum technology, which provides funding for R&D projects in the field.

Among the key stakeholders in the semiconductor industry, who are simultaneously active in quantum technology, are Samsung and SK Hynix that produce top tier semiconductor process technology. Other companies within the industry include DongWoo Fine-Chem, Global Zeus, HB Solution and Hexa Solution.

The EU has also recognised South Korea's expertise on semiconductors, and in June 2023, the EU and South Korea held the first Digital Partnership council where it was agreed to establish a ROK-EU Forum for Semiconductor Researchers[21]. This seeks to promote research in complementary areas and develop applications within High Performance Computing. A quantum technology expert group will also be established as a part of this partnership.

Existing international partnerships and venues for collaboration

The South Korean quantum strategy greatly emphasises the importance of international collaboration. The National Research Foundation of Korea (NRF) is the main government entity responsible for international collaborative efforts within emerging technologies.

South Korea has already established several strategic partnerships with other countries with the purpose of furthering the development of quantum technology. Among these are partnerships with American universities

[20] Hivelr: Quantum Computing: How Semiconductors Powering the Future of Computing.

[21] European Commission (2023). Republic of Korea - EU Joint Statement.

and research institutes (including Harvard University, MIT and the Korean Advanced Institute of Science and Technology (KAIST))[22]. KAIST has also entered into a commercial partnership with the Canadian company Xanadu to develop training materials for South Korea's quantum workforce through PennyLane, Xanadu's open-source software for quantum machine learning.[23]

For European stakeholders, including Danish actors, there are existing partnerships with South Korea that can be utilised for reaping the benefits of international collaboration. South Korea is already cooperating with a range of actors in Europe and considers the EU one of the most important strategic partners in the advancement of quantum technology.[24] South Korea's association to the European innovation platform, Horizon Europe, is pending clarification during 2024 which may bring more opportunities in the near future.

Both South Korea and Denmark participate in the multilateral EUREKA program which has launched an open call for quantum in February 2024 with opportunity to pursue joint innovation projects[25] between two or more countries collaborating on international R&D projects in the field of applied quantum technology.

The existing partnership between KAIST and the Technical University of Denmark (DTU) is also worth mentioning. The two universities are already collaborating on joint research- and education projects within science and technology. Although not directly focused on quantum technology, the framework for a potential R&D partnership in this area is already there and could be utilised for talent exchange, joint research projects, etc.

[22] Korean Advanced Institute of Science and Technology.

[23] Xanadu (2023) Xanadu and the Korea Advanced Institute of Science and Technology (KAIST) partner to develop South Korea's future quantum workforce.

[24] Ministry of Science and ICT (2023) Korea's National Quantum Strategy.

[25] For more information about the open call see the following link: Eureka | network-projects-quantum-call-2024 (eurekanetwork.org)

KOREA-EUROPE QUANTUM SCIENCE TECHNOLOGY COOPERATION CENTER

Earlier in 2023, the Korea-Europe Quantum Science Technology Cooperation Center was established. The centre is based in Brussels at the pre-existing Korea-EU Research Centre (KERC)[26].

The purpose of the centre is to identify quantum science and technology cooperation initiatives and research partners and to assist in joint projects. Research topics are centred around quantum computing, e.g., scalable semiconductors and superconductive qubits[27].

Although not focusing explicitly on Denmark, the intergovernmental relations established through the centre may be a venue for future joint international efforts between Danish and South Korean stakeholders.

COLLABORATIVE OPPORTUNITIES BETWEEN SOUTH KOREA AND DENMARK

Developing a functional quantum computer requires many supporting techniques, knowledge, and expertise. It is a complex technology, and countries need to collaborate to leverage comparative advantages across the fields.

Both the South Korean and the Danish governments are actively seeking international collaboration and partnerships in order to achieve the goals for developing a market for quantum technology. As established in earlier chapters, various opportunities for international collaboration are present within the realm of quantum technology. Three key areas for collaboration with common political agendas for Denmark and South Korea are identified and outlined below.

1. TALENT DEVELOPMENT: FROM RESEARCH TO WORKFORCE

For all countries entering the quantum race these years, securing enough personnel with the right competencies to advance a national market and ecosystem for quantum technology is a priority. This also goes for both South Korea and Denmark and it opens collaborative opportunities.

[26] KERC (2023) New Korea-Europe Quantum S&T Cooperation Center held its opening ceremony in Brussels.

[27] Ministry of Science and ICT (2023) Korea opens Quantum Science Technology Cooperation Center in Brussels for joint research projects with Europe.

Securing a sufficient labour force with the right competencies is an important part of the South Korean quantum strategy. The political goal is to cultivate a workforce of 10,000 people by 2035; 2,500 are meant to be key personnel (persons with in-depth understanding of the principles of quantum physics and phenomena) and the rest quantum engineers (personnel that can systematically implement and operate quantum technologies).[28]

Coming from a self-estimated starting point of 384 quantum key personnel in South Korea, the goal is ambitious and therefore stands on a range of initiatives. Besides providing institutional support to universities to facilitate the establishment and expansion of quantum-related departments and programmes, along with the establishment of research immersion environments for quantum students, some initiatives also involve international scientific collaboration.

Dispatchment and exchange agreements plays an important role in the educational efforts of Korea to secure the necessary capabilities and competencies.

One of the core programmes initiated by the South Korean government to foster domestic quantum talent is QTalent.[29] This programme contains small research projects that encourage the exchange of students and professors.

[28] Ministry of Science and ICT (2023) Korea's National Quantum Strategy.

[29] Quantum in Korea: International collaborations.

Securing a competent and capable workforce for quantum technology is also an important part of the Danish strategy in relation to advancing quantum technology in the years to come. This means that Denmark will focus on making the academic environments for quantum technology internationally oriented and cultivate international relations both within and outside of the EU.[30]

The existing relations between Danish and South Korean academic environments may serve as venues for establishing exchange programmes, summer schools and other forms of collaborative talent development, where Danish and South Korean scholars can learn from each other and capitalise on each other's strengths.

2. COLLABORATING ON BRIDGING THE GAP BETWEEN ACADEMIA AND INDUSTRY

The South Korean quantum strategy emphasises experimentation with quantum in real world usage taking quantum from theory and academia to applications that can make a difference for various industries through faster, more precise, or more secure workflows.

This underlines the strategic focus on promoting mission-oriented R&D.[3132] Especially, the areas of defence, aerospace and medicine are mentioned as examples of sectors that can benefit from the development of quantum applications in South Korea.

Apart from the above-mentioned prioritised industries, patent and company data on South Korean quantum stakeholders show that companies within manufacturing, hardware, software, science and engineering are all exploring the potential of quantum technology. And companies within healthcare and biotechnology are also experimenting with the potential of quantum technology.

While the USA is considered the leading market for quantum technology with large funding, South Korean scholars are keen to collaborate with European academics when it comes to fundamental research and understanding of the technology. Europe has a reputation of research excellence on quantum technology among South Korean academics. There is a general understanding in the South Korean academic environment that Europe is the epicentre for fundamental research on the technology.

The difference in competencies and conditions offered by the Danish and South Korean governments holds potential for collaboration on international R&D-projects.

The South Korean quantum strategy, emphasizing the transition of quantum technology from theoretical and academic realms to practical applications, aligns well with the recently announced Eureka call for proposals in applied quantum technologies. The Eureka program, thus, not only complements the strategic directions of South Korean quantum initiatives but also provides a structured and funded pathway for international R&D projects, offering a unique opportunity for cross-border collaboration in the rapidly evolving field of quantum technology.

[30] Ministry of Higher Education and Science (2023) Strategy for Quantum Technology: Part 1 – World Class Research and Innovation.

[31] Ministry of Science and ICT (2023) Korea's National Quantum Strategy.

[32] Mission-oriented R&D refers to the strategic approach where R&D activities are aligned with societal or industrial challenges, aiming to achieve targeted and measurable outcomes that address these challenges.

EUROPE IS AN ATTRACTIVE PARTNER FOR SOUTH KOREAN QUANTUM RESEARCHERS

Although South Korea has committed to substantial investments and has a strong political focus on quantum technology, the nation has entered the quantum race late. To propel South Korea among the leading quantum nations, there is a need for a better fundamental understanding of the technology.

Professor Joonwoo Bae, a leading South Korean scholar in the field of fundamental quantum theory, points out international collaboration as a crucial aspect in advancing South Korea's development of quantum technology. While the USA is considered the global leader on commercialising quantum technology, the professor acknowledges and underpins the potential for enhanced collaboration with European countries like Denmark and he emphasises the European strength in fundamental research on quantum theory.

The USA is considered to be leading in terms of commercialisation of quantum technology with the most mature market. However, for the deep knowledge on the fundamental understanding of quantum theory, Europe has a global advantage.

Professor Joonwoo Bae was among the first researchers in South Korea to delve into the study of quantum information. Holding a PhD in quantum cryptography from the University of Barcelona, Joonwoo Bae currently focuses on fundamental quantum theory at KAIST seamlessly integrating aspects of physics, chemistry, and practical applications.

He has noticed the enhanced governmental focus on quantum technology and the support for facilitating international collaborations such as exchange arrangements with universities and research institutions abroad, and new strategic research partnerships with leading international quantum stakeholders.

Professor Joonwoo Bae considers South Korean research to be more focused on the application of quantum technology, whereas there is a stronger focus on fundamental research in Europe.

3. KOREA HOLDS GREAT POTENTIAL FOR COMMERCIALISATION OF QUANTUM TECHNOLOGY

Whereas Europe is considered to be leading on the theoretical and fundamental understanding of quantum technology, South Korea has a strength when it comes to scaling and commercialising the technology. Although the commercialisation of quantum technology is still more an ambition than a reality, it is clear, that South Korea has excellent prerequisites for promoting an industry around quantum technology.

Commercialisation of quantum technology is one of the ultimate objectives of developing the technology. Making the technology available to private actors who can reap the benefits in terms of more efficient and precise methods and workflows has the potential to stimulate economic growth and job creation.

The recent quantum strategy and policy act focuses on the commercialisation of the technology with coherent policies and ample investment opportunities for startups and spinouts. The substantial financial commitments announced by the South Korean government prompts the need to prove that the investments will lead to progress.

Furthermore, the South Korean government has announced a great number of high priority quantum research projects with a focus on experimenting with the application of the technology with a great diversity in the topics.

Besides the politically prosperous environment for advancing quantum technology, the market structures of South Korea also make the country an interesting partner for Danish quantum stakeholders. The potentially large market (compared to Denmark) combined with a strong tradition and expertise within several potentially related advanced technological industries makes South Korea an interesting market for Danish stakeholders.

Commercialisation also plays an important role for the Danish quantum strategy.[33] International collaboration on exploring use cases for quantum technology offers a great opportunity for bringing both Danish and South Korean companies and researchers closer to developing commercially applicable quantum technology and hereby fulfilling the potential of the technology.

CONCLUDING REMARKS

This report presents the current state of the quantum ecosystem in South Korea with a focus on the country's technological strengths and the potential collaborative opportunities available to Danish stakeholders within the field of quantum technology. An examination of the technological focus and the activity in South Korea reveals a particular strength within quantum communication combined with conducive conditions for further development in the sector.

Additionally, the report sheds light on the South Korean government's strategic focus on quantum technology by looking into specific areas of interest. Many of the areas align with Denmark's national strategies suggesting significant synergy. Key opportunities for international collaboration between Denmark and South Korea are:

- Talent development through exchange programmes and collaborative research initiatives.
- Joint efforts in bridging the gap between research and industry by combining Europe's deep theoretical knowledge with South Korea's practical application in industrial settings.
- Collaborative commercialisation of quantum technology that benefits from South Korea's advantageous market conditions and industrial strengths, particularly in the fields of semiconductors and telecommunications.

Further inquiries

If you are interested in pursuing collaboration in quantum technologies involving South Korea and Denmark, you can reach out to Innovation Centre Denmark, Seoul. We assist in facilitating innovation collaborations and can

[33] Ministry of Industry, Business and Financial Affairs (2023) National Strategy for Quantum Technology: Part 2 – commercialization, security and international collaboration.

actively support collaboration in the Global Innovation Network Program (GINP)[34]. Furthermore we can guide you to other funding schemes for joint collaboration including the open Eureka call for applied quantum innovation.

The Innovation Centre can also provide customized services for public and private stakeholders including setting up delegation visits. For SMEs we can guide you to available support schemes for internationalization.

A joint Danish-Korean quantum science and innovation event will take place in June 2024 in Seoul. Information about this and other upcoming opportunities can be requested to ICDK Seoul[35].

[34] The Global Innovation Network Program is a funding scheme with open calls 1-2 times yearly and managed by the Danish Ministry of Science and Higher Education. Read more here: Global Innovation Network Programme — English (ufm.dk)

[35] Innovation Center Seoul publishes news and events on linked-in: (12) Innovation Centre Denmark Seoul: Overview | LinkedIn

APPENDIX A – LIST OF SOUTH KOREAN QUANTUM STAKEHOLDERS

The below list gives a complete overview of the quantum stakeholders identified by the Danish Technological Institute in October 2023. The table can be used for identifying stakeholders of relevance for technological purposes or with a particular industrial or academic focus.

TABLE 1: OVERVIEW OF SOUTH KOREAN QUANTUM TECHNOLOGY STAKEHOLDERS

NAME	TYPE OF ORGANI-ZATION	FOCUS	LINK
Korea Meteorological Administration (KMA)	National authority	R&D on quantum computing to create extremely precise weather predictions.	https://www.kma.go.kr
Ministry of Science and ICT	National authority	Develops the national strategy for quantum technology.	https://nsp.nanet.go.kr
National Research Foundation of Korea (NRF)	National authority	Responsible for facilitating and coordinating international partnerships and collaboration within quantum technology.	https://www.nrf.re.kr
Electronics and Telecommunications Research Institute (ETRI)	RTO	R&D on quantum memory technology and transmission of quantum data. Innovative in all 3 areas and is a part of KQIA.	https://www.etri.re.kr
Institute for Basic Science	RTO	R&D on quantum nanoscience and information science. Innovative in quantum sensing.	https://www.ibs.re.kr
Korea Basic Science Institute	RTO	Innovative in quantum sensing.	https://www.kbsi.re.kr
Korea Electronics Technology Institute	RTO	R&D on quantum computing e.g., quantum-dots and algorithms. Also innovative within sensing.	https://www.keti.re.kr
Korea Research Institute of Standards and Science (KRISS)	RTO	Develops quantum control systems.	https://www.kriss.re.kr
The Agency for Defense Development	RTO	Non-specified R&D, but likely within defense applications. Innovative in all 3 areas.	https://www.add.re.kr

The Korea Institute of Science and Technology	RTO	R&D within quantum information processing, quantum algorithms, hardware, and software. They are also exploring applications for quantum computing.	https://eng.kist.re.kr
Catholic University of Daegu	University	Innovative in quantum sensing.	https://global.cu.ac.kr
Chonnam National University	University	Innovative in quantum computing and quantum sensing.	https://international.jnu.ac.kr
Chung Ang University	University	R&D on quantum computing e.g., quantum-dots and algorithms.	https://neweng.cau.ac.kr
Chungnam National University	University	Innovative in quantum sensing.	https://plus.cnu.ac.kr
Daegu Gyeongbuk Institute of Science and Technology	University	Innovative in quantum sensing.	https://www.dgist.ac.kr
GIST | Gwangju Institute of Science and Technology	University	R&D on e.g., algorithms, quantum erasure and quantum ring laser theory. Innovate in all 3 areas.	https://www.gist.ac.kr
Hansung University	University	Innovative in quantum computing.	https://hansung.ac.kr
Hanyang University	University	R&D on quantum computing e.g., quantum-dots. Innovative in all 3 areas.	https://www.hanyang.ac.kr
Konkuk University	University	Innovative in quantum sensing.	https://friend.konkuk.ac.kr
Kookmin University	University	R&D on quantum technology at nanometer scale. Innovative in all 3 areas.	https://english.kookmin.ac.kr
Korea Advanced Institute of Science & Technology (KAIST)	University	R&D on quantum systems and quantum sensors. Innovative in all 3 areas.	https://www.kaist.ac.kr
Korea University	University	R&D and innovation for all 3 areas e.g., quantum information with multi- or diamond spin qubits, quantum structures and quantum-dots.	https://www.korea.edu
Kumoh National Institute of Technology	University	Innovative in quantum computing and quantum communication.	https://eng.kumoh.ac.kr

Kwangwoon University	University	Innovative in quantum computing and sensing.	https://www.kw.ac.kr
Kyung Hee University	University	R&D on quantum computing algorithms, quantum-dots. Innovative in all 3 areas.	https://www.khu.ac.kr
Postech	University	Innovative in all 3 areas.	https://international.postech.ac.kr
Seoul National University	University	R&D on quantum-dots, photonic quantum engines, quantum structures and theory. Innovative in quantum communication and quantum sensing.	https://en.snu.ac.kr
Sungkyunkwan University	University	R&D on quantum-dots, quantum algorithms, networks, models, and entanglement. Innovative in all 3 areas.	https://www.skku.edu
UNIST | Ulsan National Institute of Science & Technology	University	Innovative in quantum sensing.	https://www.unist.ac.kr
University of Ulsan	University	Innovative in quantum sensing.	https://global.ulsan.ac.kr
Wonkwang University	University	Innovative in quantum sensing.	https://eng.wku.ac.kr
YONSEI University	University	R&D on quantum information technology and application. Innovative in quantum computing and quantum sensing.	https://www.yonsei.ac.kr
The Quantum Information Research Support Center (Qcenter)	University	Established at Sungkyunkwan University to support research activities in the domestic quantum information science field under the Ministry of Science and ICT's Quantum Information Science R&D Ecosystem Creation Project.	https://qcenter.kr
Center for Quantum Nanoscience	University	Established at the Institute for Basic Science in 2017 and conducts research on quantum nanoscience.	https://qns.science/
3billion	Company	Provides different genetic tests for accurate diagnosis and treatment and is a part of KQIA.	https://3billion.io
Alchera	Company	Works with AI. Innovative in quantum computing.	https://alchera.ai
Asbestos Damage Relief System (ADRC)	Company	Provides systems and support for asbestos relief. Innovative in quantum sensing.	
Baobab AiBIO	Company	R&D in bio-space. Utilizes quantum technology in their drug design and is a part of KQIA.	http://baobabaibio.com

BASESTONE HLDG	Company	Innovative in quantum communication.	No website
BEAT's S&G	Company	Provides a range of IT services. Innovative in quantum communication.	http://www.beatssng.co.kr
Bioptic	Company	Innovative in communication.	http://bioptic.com
BioSquare	Company	Provides advanced diagnostic technologies. Innovative in quantum sensing.	http://www.bio-square.com
Bluewing Motors	Company	Motorcycle manufacturer. Innovative in quantum computing.	https://www.bwmotors.kr
CICERON	Company	Provides AI translation platform. Innovative in quantum computing.	https://maro.page
CIOT	Company	Provides security solutions for the automobile industry. Innovative in quantum communication.	https://eng.ciotsecurity.com
Coinvest	Company	Investment company that utilizes blockchain technology. Innovative in quantum communication.	http://coinvest.kr
Coweaver	Company	Supplies fiber optic transmission systems to top telecommunication companies and is part of KQIA.	http://www.coweaver.co.kr
DaeaTI	Company	Works with railway systems. Innovative in quantum communication.	http://www.daeati.co.kr
DIGITLOG, Inc.	Company	Works within the aerospace industry. Innovative in communication.	http://www.digitlog.co.kr
DONGWOO FINE-CHEM	Company	Manufactures a range of components e.g., antennas, sensors and semiconductors. Innovative in quantum communication.	https://www.dwchem.co.kr
Dream D&S	Company	Offers security solutions and is a part of KQIA.	https://www.dreamdns.co.kr
EYL	Company	Produces a range of quantum computing components. Innovative in quantum computing.	https://www.eylpartners.com
First Quantum	Company	Innovative in quantum sensing, computing, and communication. They are also a member of KQIA.	https://thefirstquantum.com
FISYS	Company	Works in communications infrastructure and security. Innovative in quantum communication.	http://fisys.co.kr
Gaia3D	Company	Offers 3D technology solutions and is part of KQIA.	https://gaia3d.com

Global ZEUS	Company	Manufactures e.g., semiconductors, robotics, and displays. Innovative in quantum sensing.	https://www.globalzeus.com
Hana Bank	Company	Banking service that is also a part of KQIA.	https://www.kebhana.com
HB Solution	Company	Works with semiconductors and displays. Innovative in quantum sensing.	http://www.hb-solution.co.kr
Hexa Solution	Company	Manufactures optical semiconductors and pattern substrates. They are also a member of KQIA.	http://hexasolution.co.kr
Hyundai Motors	Company	R&D on batteries and data analysis run on quantum computing. Innovative in all 3 areas and is a part of KQIA.	https://www.hyundai.com
IBM	Company	Provides a wide variety of IT solutions and is a part of KQIA.	https://www.ibm.com
ID Quantique	Company	A leader in quantum technology that is owned by SK Telecoms and provides commercial quantum solutions such as random number generation, quantum security and quantum sensing. They are also a member of KQIA.	https://www.idquantique.com
IDV	Company	IP-based venture capital company that is a part of KQIA.	http://www.id-vc.com
inCerebro	Company	A pharmaceutical R&D company that uses new technologies and is a part of KQIA.	http://www.incerebro.com
Insilico	Company	Provides IT services within materials convergence technology such as quantum technology to analyze material properties and is a part of KQIA.	https://en.insilico.co.kr
INTELLECTUAL DISCOVERY	Company	Provides finance services. Innovative in quantum sensing.	https://www.i-discovery.com
Isotec	Company	Manufactures microwave connectors and components for wireless service providers. They also supply Cryogenic RF Connectors for quantum computing.	http://www.isoconnector.com
Jireh Energy Tech	Company	Innovative in quantum communication.	http://www.jiretec.com
Kia Motors	Company	Innovative in quantum computing.	https://www.kia.com
KM MEDIA	Company	Innovative in quantum communication.	No website

KQC	Company	Established as the first commercial quantum computing hub for the IBM quantum and is part of KQIA.	https://www.kqchub.com
KT	Company	Works in telecommunications. Innovative in communication and is a part of KQIA.	https://corp.kt.com
LABSYSTEMS	Company	Innovative in quantum sensing.	No website
LG	Company	Innovative in all 3 areas and is a part of KQIA and QCILA.	https://www.lge.co.kr
LG Chem	Company	Innovative in quantum communication and quantum sensing.	https://www.lgchem.com
LG Science Park	Company	Innovation center that fosters collaboration on technology nationally and internationally. The center is also a member of KQIA.	https://www.lgsciencepark.com
Megazone Cloud	Company	Specializes in cloud software and is a part of KQIA.	https://www.megazone.com
Mimicus	Company	Works with bio quantum topics. Innovative in quantum computing.	https://www.mimic.us
NANOCHIPS	Company	Innovative in quantum communication.	No website
NORMA	Company	Offers wireless security solutions and is a part of KQIA.	https://www.norma.co.kr
Orientom	Company	Specialized software company focused on the quantum finance platform.	https://www.orientom.com
PharmCADD	Company	Provides a drug discovery platform using AI and quantum physics and is a part of KQIA.	https://pharmcadd.com
Pharos Bio	Company	R&D on medical drugs for rare diseases and is part of KQIA.	https://www.pharosibio.com
PLS	Company	Provides integrated clinical trial solutions and is part of KQIA.	https://plscom.cafe24.com
Posco Holdings	Company	Multinational steel manufacturer that is a part of KQIA and QCILA.	https://www.posco-inc.com
QSIM+	Company	Offers commercial quantum solutions such as a quantum communication platform, processing technology for quantum cryptography communication and standards for quantum key distribution. They are also a member of KQIA.	https://www.qsimplus.com

Quantum Intelligence	Company	Offers solutions for early-stage drug development using quantum technology and is a part of KQIA.	https://www.qic.ai
Qunova Computing	Company	Provides quantum solutions for scientists and engineers and is a part of KQIA.	https://qunovacomputing.com
ReapPay	Company	Provides a payment management system. Innovative in quantum communication.	https://www.reappay.net
ROBOTEER	Company	Innovative in quantum communication.	No website
Sam Information Industry Co., Ltd.	Company	Provides construction services. Innovative in quantum communication and quantum sensing.	No website
Samsung	Company	Produces quantum encrypted phone. Innovative in all 3 areas and is a part of KQIA and QCILA.	https://www.samsung.com
SDT	Company	IT company that specializes in quantum, specifically, quantum engineering, quantum security and quantum cloud computing. Collaborates with KIST to develop quantum cryptography devices.	https://www.sdt.inc
SK hynix	Company	Manufactures semiconductors. Innovative in quantum communication.	https://www.skhynix.com
SK Telecom	Company	R&D for the development of quantum computers, quantum algorithms and quantum communication systems.	https://www.sktelecom.com
SLT Solution	Company	Manufactures a range of IT equipment. Innovative in quantum communication.	https://www.slt.kr
Space K	Company	Provides satellite systems and is part of KQIA.	https://www.thespacek.com
Spark-X	Company	Provides planning and infrastructure for building and upgrading AI systems and is a part of KQIA.	https://teamsparkx.com
Spiceware	Company	Provides data security services. Innovative in quantum computing and quantum communication.	https://spiceware.io
Spinor Media	Company	Provides financial solutions and is a part of KQIA.	https://www.spinormedia.com
TELEFIELD	Company	Manufactures transmission systems. Innovative in quantum communication.	http://telefield.com
Tesser	Company	Provides medical information services and is part of KQIA.	https://www.tesser.co.kr

THE4TH	Company	Innovative in quantum computing.	No website
TOP engineering	Company	Produces different equipment e.g., for batteries and cameras. Innovative in quantum communication.	http://www.topengnet.co.kr
Won Seok Hi Tech (WS)	Company	Produces power meters. Innovative in quantum communication.	http://wonseok_en.acus.kr
WooriNet	Company	Provides broadband solutions. Innovative in quantum communications.	https://www.woori-net.com
XIONPROCESS	Company	Works with medical manufacturing. Innovative in quantum communication.	No website
Korea Quantum Computing Industry Leaders' Alliance (QCILA)	Industry alliance	A consortium of commercial entities in Korea comprising telecom companies, including Telcos, LGE, Samsung, POSCO ICT, and more.	No website
Korea Quantum Industry Association (KQIA)	Industry alliance	Consists of 32 companies with a strong interest in finding business models for quantum technology.	https://quantuminkorea.org

Note: The list is based on data from Crunchbase, Patsnap and desk research. The research was carried out by DTI in October and November 2023.