Through the Valley of Death

– How can Finland grow?

beyond the obvious

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"At VTT, our mission is to generate technological expertise that industry can use to renew itself and to help create new, growth-driven companies in Finland. Growth comes from harnessing technology, and we invest in first-rate expertise and research infrastructure to help businesses and innovations succeed. We believe Finland can overcome its current economic slowdown and return to growth. Doing so will require bold action and clear choices."

Kalle Härkki, President and CEO, VTT Technical Research Centre of Finland

"Through the Valley of Death – How can Finland grow?" is a fact-based review of the growth potential of the Finnish economy undertaken by VTT Technical Research Centre of Finland. It combines currently available information with data from national and international sources. The viewpoints are intended to spark discussion and spur concrete action. In particular, we examine the role of technology-based growth sectors, industrial renewal, and startups and deep tech companies as drivers of economic growth.

Summary – How can Finland grow?

The Finnish economy has not grown in 17 years. Poor profitability growth in the corporate sector, lower value in export items and the sustainability gap in public finances amount to a formidable challenge[1]. However, making a turn for the better is possible. A structural change, comprising business renewal and a strengthening startup sector, provides realistic growth opportunities for Finnish society and companies. In this publication, we describe examples of potential growth sectors and opportunities that are most promising for Finland.

Renewal of business and new companies generate growth

Large companies

- Large companies are responsible for a significant share of exports and productivity growth[4].
- According to a study by McKinsey[5], large Finnish companies have grown at a slower pace and invested less in R&D than their international peers.
- A turnaround is necessary and possible.
- Examples of renewal: forest industry, mobile machinery

Startups and deep tech companies

- The Finnish startup sector has grown to over EUR 10 billion and includes over 2,000 companies[6].
- The combined impact of startups on Finland's GDP is around one per cent while a continuous and strong growth is notable.
- Tesi has identified about 270 deep tech companies[7].
- Examples of leaders in their field: Oura, ICEYE, Bluefors, IQM

"The stagnation of market sector growth is the biggest problem for our national economy."
Matti Pohjola, Professor Emeritus of Economics.

Half of the business sector has grown by 18 per cent since 2018, while the other half has seen an equivalent decline. Thus, there has been no total growth[2]. The lack of total productivity growth is reflected as a weakness in real competitiveness in export markets[3].

Business renewal and innovations are the engines of growth

Globally, technological renewal has been the basis of growth in recent years, and the same phenomenon applies to Finland. Growth requires long-term investments in R&D and expansive cooperation. Public R&D investments aim to strengthen and help leverage private investment. Private R&D investments have started to grow over the past decade. The level is not yet sufficient, but we see signs that new companies with growth potential are emerging.

Renewal of companies, society, innovations and R&D investments are the engines of growth. Finland has world-class expertise, strengths and resources – and all the prerequisites to return to a path of growth. At VTT, we have already rolled up our sleeves.

We have identified technological growth sectors where Finland has strong know-how and massive potential:

Semiconductors and microelectronics

The turnover of the Finnish semiconductor industry is projected to triple by 2035 from 1.6 to 5–6 billion euros. The number of employees is expected to increase from 7,000 to 20,000[8]. One of Europe's leading hubs for semiconductor and quantum technology R&D is being created in Finland.

Quantum technology

In 2023, the Finnish quantum industry turnover was EUR 130 million, while the vision stated in Finland’s quantum technology strategy is to increase the turnover to EUR 3 billion by 2035[9]. Europe’s largest superconducting quantum computer is located in Finland.

Defence and dual-use technologies

There are 368 defence companies operating in Finland. Out of these, 144 are growing significantly and focusing on defence technology or dual-use applications. Over the last few years, revenue development has been solid and accelerating, averaging 5–8% per year (CAGR)[10]. Finland's strong expertise in disruptive technologies presents numerous opportunities as the needs of the defence industry evolve and expand (the so-called "New Defence").

Biotechnology

The biotechnology sector is projected to experience rapid global growth over the next decade, with annual expansion rates estimated at 12–14 percent. In Finland, there are more than 800 companies dedicated primarily to biotechnology, generating a combined turnover exceeding EUR 7 billion. The sector employs over 19,400 professionals.

Energy transition and energy technologies

Finland has a unique opportunity to generate growth based on the energy transition and the clean transition[11]. The prerequisites are cheap and clean electricity, strong expertise and investments in new technology. Four potential themes for Finland can be identified in the energy transition:

- hydrogen and carbon capture and utilisation (CCU)
- nuclear energy of the future
- raw materials and material value chains
- data economy as part of the clean transition

Industrial renewal and sustainable utilisation of natural resources

The foundation for Finland's industry renewal is high expertise and state-of-the-art technology. The mobile machinery industry, based on smart solutions, aims to triple its turnover from the current EUR 19 billion[12]. More than half of Finland's GDP is based on the utilisation of natural capital[13]. New business opportunities are most prevalent with battery and rare earth minerals, bio-based materials and circular economy solutions. Technological development is paramount for cost-effective and sustainable utilisation of Finland's raw material reserves.

1. Finland grows with the power of innovation

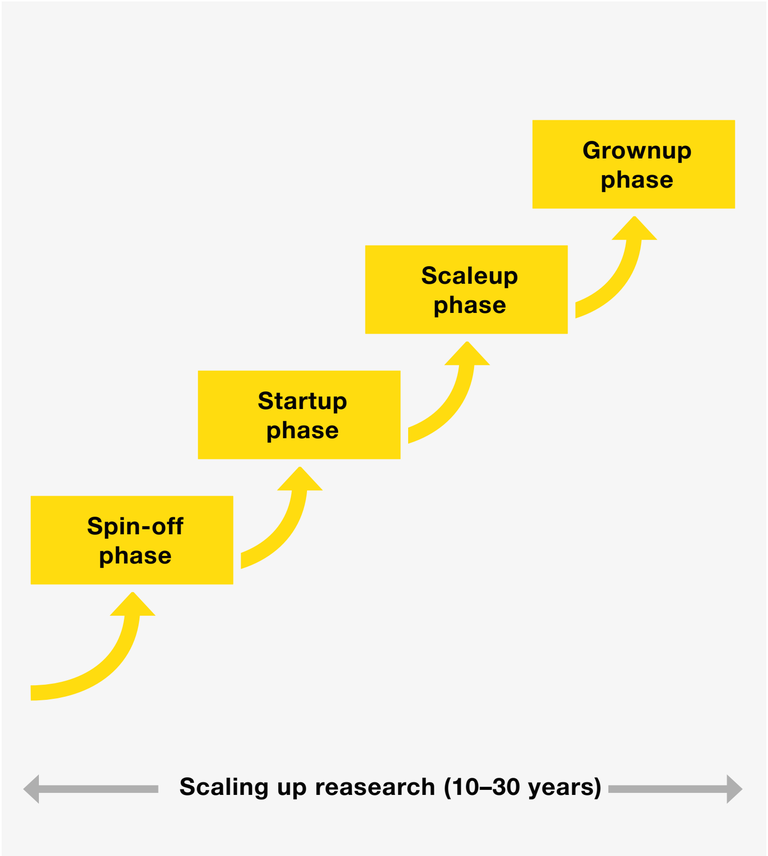
How to cross the valley of death?

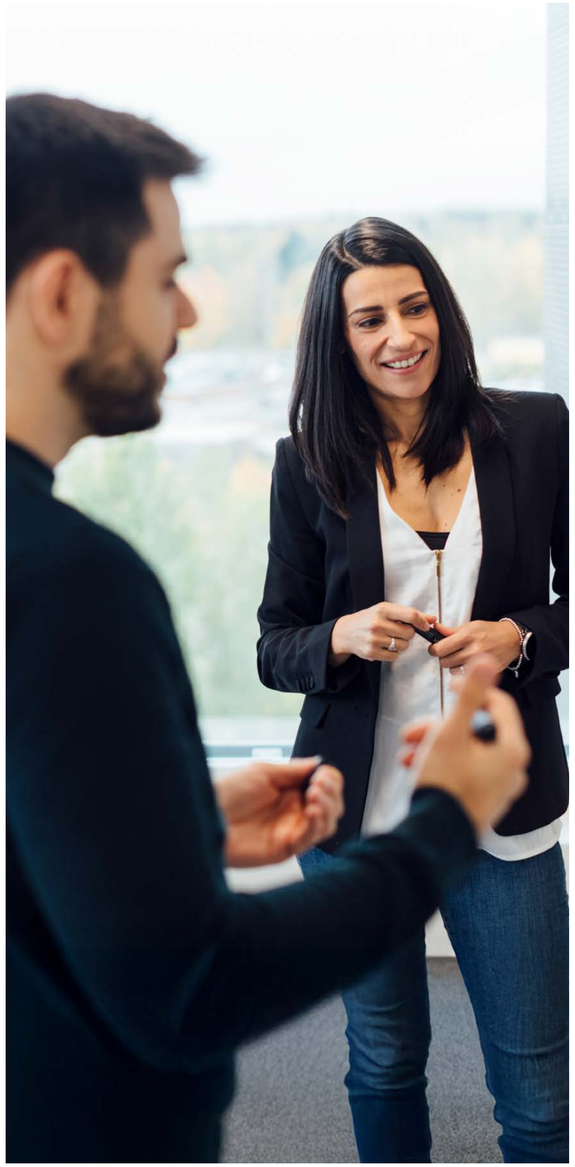
Finland is committed to increasing R&D funding to four per cent of GDP by 2030. Long-term R&D investments are essential to accelerate structural change and economic renewal, while also giving a strong indication of Finland's direction.

Public investments are aimed at leveraging private R&D investments, strengthening goal-oriented cooperation between research and the business sector, developing top-notch research and piloting environments and doctoral education[14].

Business based on research and new technology develops over a long time span – the journey from a scientific breakthrough to a growth company can take 10–30 years. However, research and development is the best way to renew business and create new avenues – in essence, cultivate growth. One R&D euro will generate several euros the national economy over a period of 10–15 years[15].

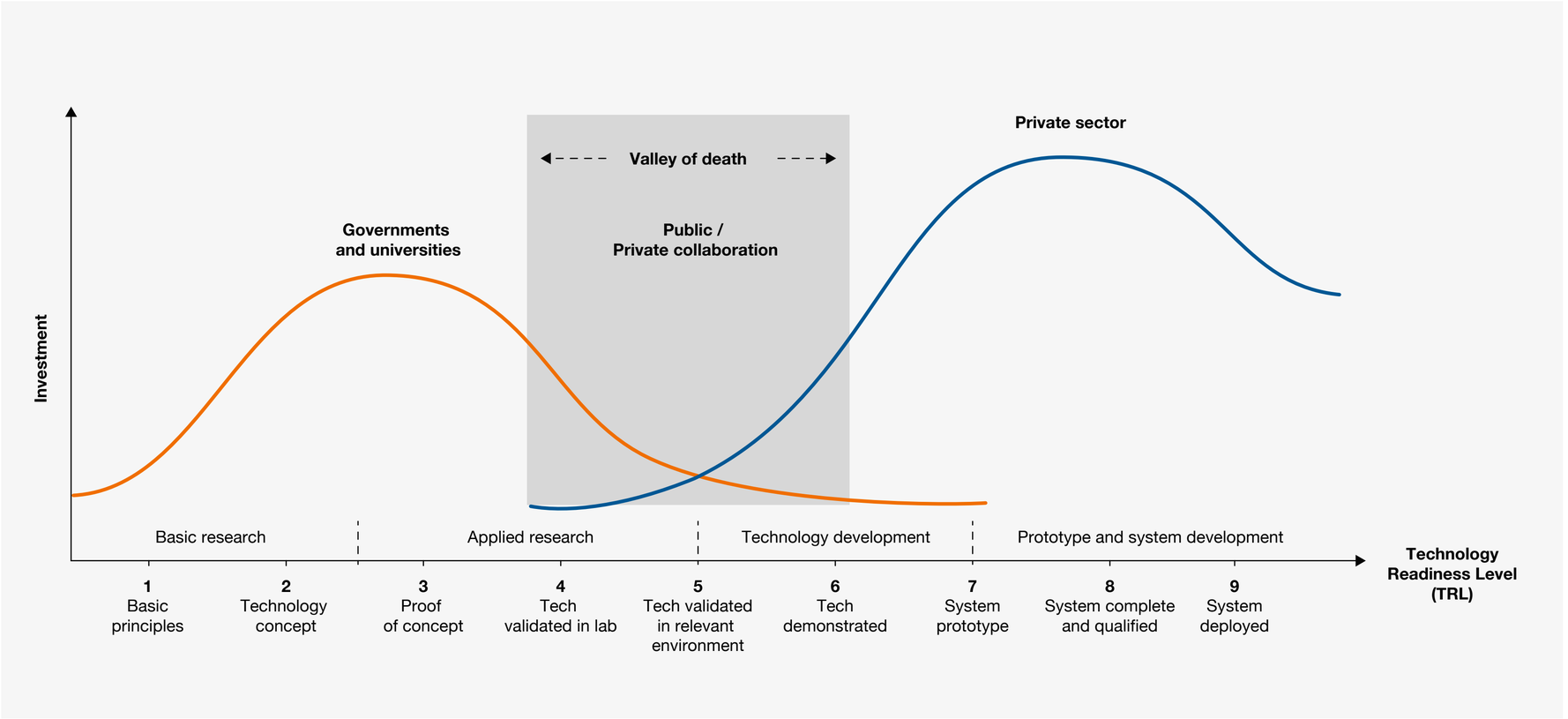
The time span in the figure illustrates how research generates business and how technology is matured towards commercialisation and scaling.





The impact of R&D investments stems from long-term systematic work and effort. **The Valley of Death** is a term for a series of challenges that technology companies face in their early stages of development. At this stage of monetisation, an idea can simply take off or die. To cross the valley of death requires hard work – cooperation can prove very helpful.

Applied research organisations can help companies cross the valley of death by assisting with the maturation of research-based knowledge and developing and piloting technological breakthroughs towards commercial application. This will improve the conditions for creating new, notable innovations and accelerate the commercialisation of research. Public funding is important in the applied research phase as it enables the advancement of ambitious, high-risk projects and the required research and piloting environments. In addition, public funding brings together large companies, SMEs and RTOs to co-create and connect to the market opportunities.



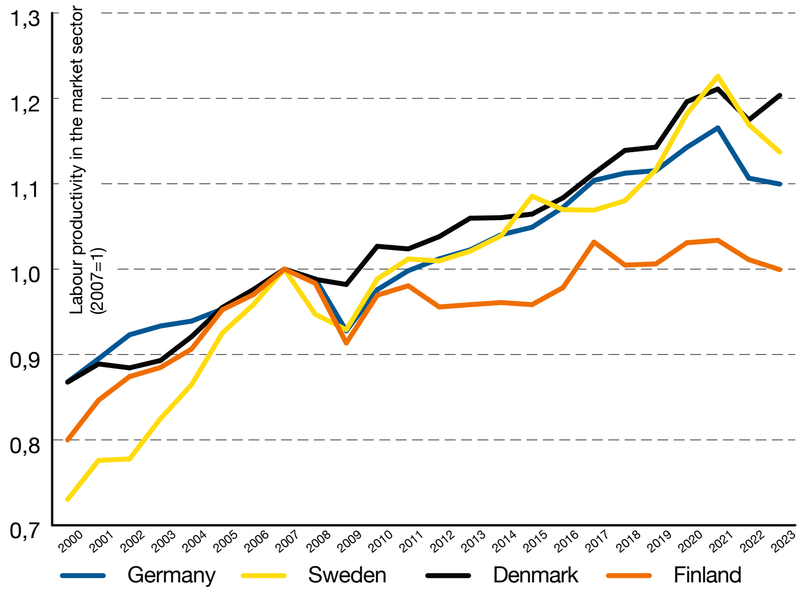
Growth requires industrial renewal and new growth companies

According to Matti Pohjola, Professor Emeritus of Economics, the stagnation of growth in the market sector is the biggest problem facing the Finnish national economy[16]. A prerequisite for growth is that there are growth-oriented companies in Finland that have internationally competitive products and services with high added value. According to Pohjola, the slow and dualistic development of combined profitability will not change unless we improve the conditions fostering innovation.

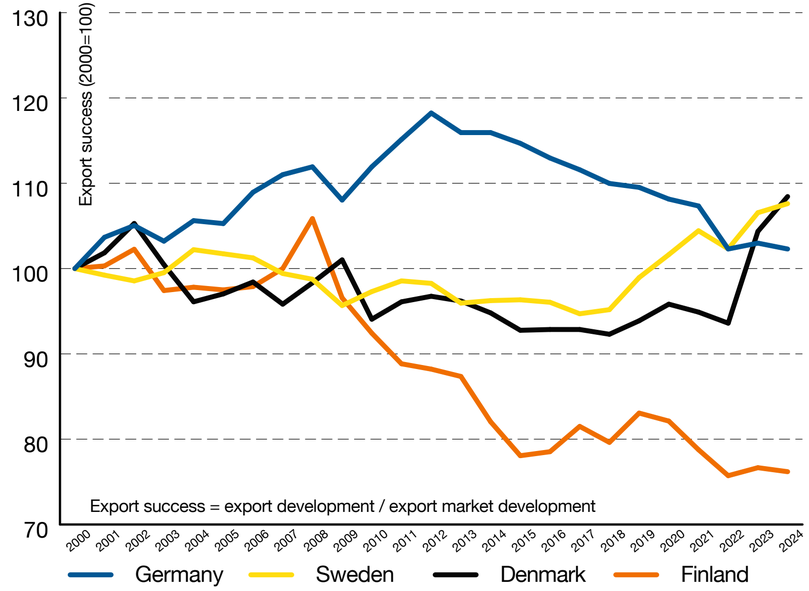
According to Pohjola's study, the most significant growth has been generated by information and communication services, the high-tech industry, professional, scientific and technical services, energy production and companies providing social and healthcare services. Higher productivity has yielded growth in the energy production sector, with growth in social and healthcare services centred on rising demand. Other growth sectors have reaped rewards via both avenues. Economic growth has been slowed down most significantly by non-high-tech manufacturing, construction, transport and storage services and trade.[17]

Innovation enables both industrial renewal and emergent business by growth companies. Globally, the most significant value added over the past decade has come from technology-based companies. The growth opportunities of Finnish companies are rooted in their ability to develop and utilise technology to create successful products and services.

Development of labour productivity in the market sector



Export success



Source: The Finnish Innovation Fund Sitra: Miksi Suomen talous ei kasva? Elintaso ja tuottavuus verrokkimaihin verrattuna

Renewal of the business sector through R&D investments

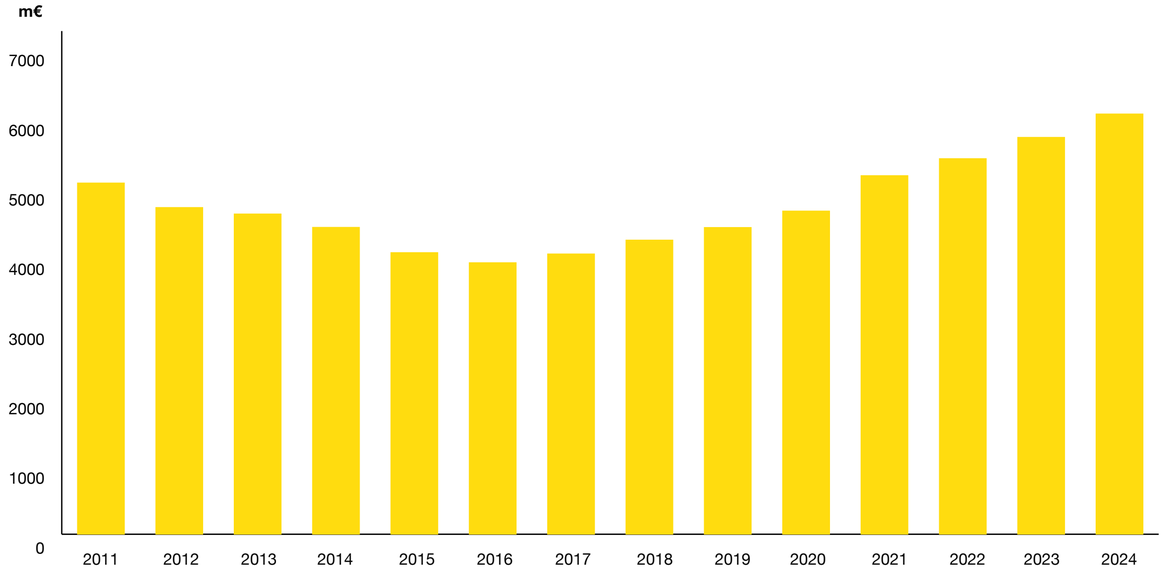
Next, we will delve deeper into the ongoing structural change in the Finnish business sector and present a reaffirming scenario of growth for future Finland through the lens of R&D investment development.

The Finnish economy is heavily dependent on large companies, as the 100 largest export companies account for almost 60% of exports, which is larger than for any other Nordic country. The technology industry accounts for about 30%[18] of GDP value, and large-scale companies are featured prominently in export and overseas trade statistics. These companies mainly represent the five sectors of the technology industry: the machinery and metal industry; the electronics and electrical industry; information technology; metals processing; and design and consultancy. Many of these industries are resource and investment intensive.

It is promising that private R&D investments have started to grow over the past ten years.

Most of these investments are made by large industrial companies, but the decrease of the relative share of industry from about 80% (2010) to less than 60% is indicative of the ongoing structural change. Financial markets may also have a part to play, especially in resource intensive sectors.

Enterprises' research and development expenditure by industry, 2011–2024



Source: Statistics Finland: Yritysten tutkimus- ja kehittämistoiminnan menot T&K:n tyypin mukaan toimialoittain, 2011-2024

According to a report by McKinsey, large Finnish listed companies have grown much slower than large international companies, which also invest up to three times more in R&D activities[19]. If Finnish companies had grown at the same rate as an average global corporation during the measured period, their turnover would now be about 70% higher. Finnish companies have not invested in growth comparably to their international peers but instead paid above-average dividends.

In Finland, a significant public funding source for corporate R&D is Business Finland. In recent years, Business Finland's goal has been to incentivize large Finnish companies to significantly increase their research, development and innovation activities in Finland, as well as to create new jobs and billion-euro ecosystems aimed at new business.

Business Finland's Veturi programme has been a key funding instrument. According to the mid-term evaluation (2025)[20], companies participating in the programme through their ecosystem projects have increased their R&D investments considerably[21]. According to assessments, especially the number of jobs requiring high expertise has increased. From 2020 to 2023, the number of hires by the valued companies (incl. R&D and ICT) increased by about 5,000 employees, which is an increase of roughly 20%.

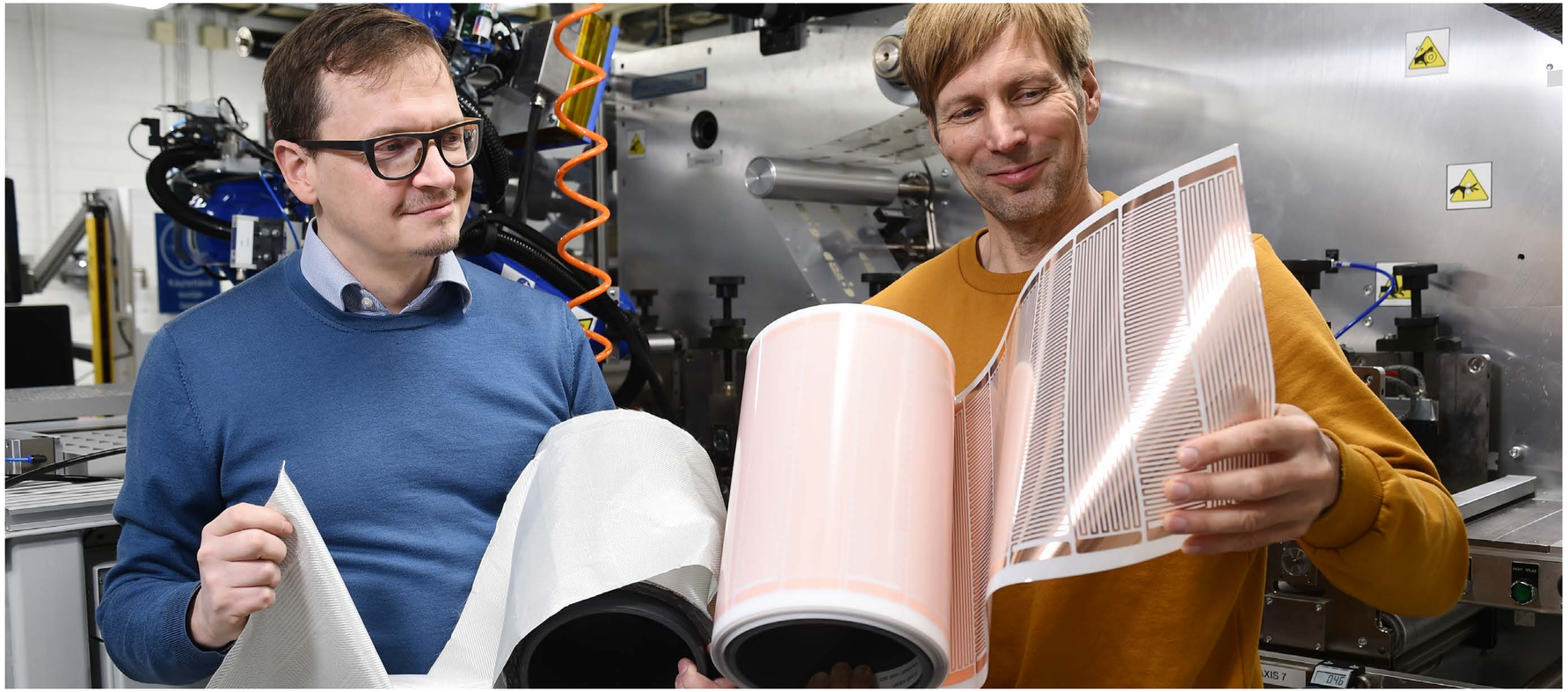
The list of large Finnish companies has remained unchanged for decades. Elsewhere in the world, in Sweden for example, newcomers have risen to the list of the largest companies – these are mainly venture capital-based startups built on new technology that have managed to grow to an internationally significant size. Finland is also undergoing a promising development of the startup field.

By definition, startups are young SMEs that aim for rapid international growth[22]. In Finland, the startup sector has grown over the past decade and is becoming strongly growth-oriented, with heavy investments into new development. The largest ones have already reached the so-called scale-up phase, where the company's business idea has proven successful and the turnover and number of jobs are growing rapidly.

According to the Finnish startup community, between 2007 and 2021, the annual turnover of Finnish startups increased from EUR 310 million to EUR 9.23 billion, while the number of startups increased from 177 to 1,932. The combined impact of these companies on Finland's GDP is still moderate – about 0.5% – but the continuous growth is remarkable.

Overall, the Finnish startup sector is third on the list for Finland's largest R&D investors. According to a member survey conducted by the Finnish startup community, companies aim to triple their R&D investments, which would amount to nearly a billion euros in total[23]. This is significant for Finland as a whole and a strong indicator that new business is emerging. The development of the startup sector is also affected by the development of the venture capital market. Globally, investment volumes declined sharply after the peak of 2021. A similar decline has occurred in Finland, but Finnish companies have fared relatively well – in 2024, Finnish startups raised a total of EUR 1.4 billion in investments. The R&D investments of the startup sector can also be examined through patenting. The top 10 list of Finland's most active patent applicants includes one startup: IQM, which builds quantum computers[24].

3. Members of the Finnish startup community. A total of EUR 360 million in 2024[26]



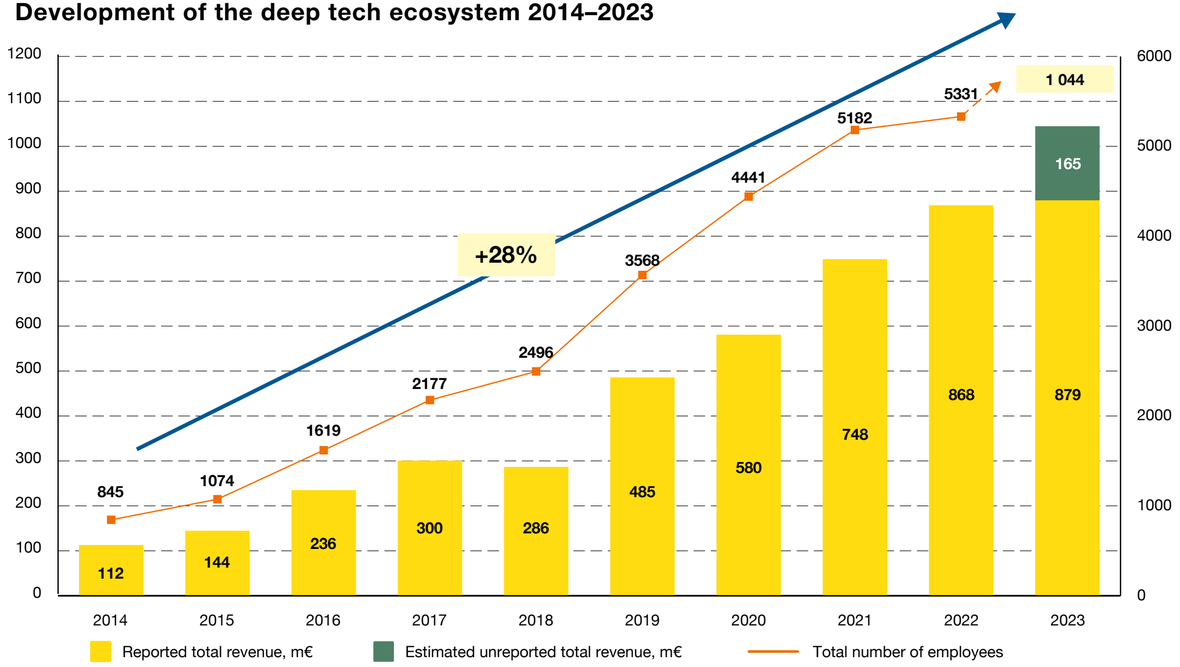
Finland's 10 largest R&D investors (in 2023, EUR million):[25]

1. **Nokia** (4327)
2. **UPM Kymmene** (538)
3. **OP Financial Group** (356)
4. **Wärtsilä** (258)
5. **Kone** (185.8)
6. **ABB** (155)
7. **TietoEvry** (129,4)
8. **Orion** (126.9)
9. **Stora Enso** (114)
10. **Valmet** (114)

The significance of the technology sector in renewing Finland's economic structure is greater than its size suggests

In recent years, the public debate in Finland has focused especially on the number of startups and the funding they receive, but the significance of technology-based sectors in renewing Finland's economic structure reaches further. The field of impact covers not only startups but technology companies more broadly, with new companies spurring industry-wide renewal. For example, semiconductor and microelectronics, quantum technology and health technology already form billion-euro industries and employ thousands of experts.

Development of the deep tech ecosystem 2014–2023



Source: Tesi: Deep Tech Study 2024

Finland is in an excellent position to become a leading country in technological innovation in Europe. This requires determined investments in RDI activities, international cooperation, competence development and an attractive investment environment. Technology-based clusters and ecosystems play a key role in how Finland succeeds in linking scientific research, business and exports in a sustainable and productive way.

Over the past decade, promising deep tech companies have emerged among startups in Finland. The business of deep tech companies is based on highly developed, often scientific and technological know-how, and their products or services are based on substantial research and development. The competitive advantage of a deep tech company is primarily based on technology and research-based expertise that is difficult to copy.

According to Tesi's estimate[27] , there are currently about 270 Finnish deep tech companies, and their combined turnover recently exceeded one billion euros for the first time. This corresponds to about a tenth of the turnover of all startups in Finland. According to Tesi, Finnish deep tech companies raised an approximated total of EUR 360 million in venture capital (VC) investments in 2024. Although the exact percentage of all venture capital investments in Finland is not detailed, there are strong indicators that deep tech companies make up a significant part of the Finnish VC market. A noteworthy example is the quantum computer company IQM, which raised EUR 275 million in growth funding in 2025[28].

For deep tech companies, both the direction and speed of growth are significant. Emerging or already established market leaders in the field include the satellite company ICEYE, smart ring manufacturer Oura, quantum technology cooling equipment manufacturer Bluefors, and quantum computer builder IQM[29].

Deep tech companies develop entirely new technologies that are not commercialised overnight. Therefore, their growth is slow and requires capital.

Examples of growth opportunities created by Finnish expertise in transformational technology:

Semiconductors and microelectronics

- The turnover of the Finnish semiconductor industry is expected to triple from EUR 1.6 billion to EUR 5–6 billion. The number of employees is expected to increase from 7,000 to 20,000 by 2035[30].
- Case Kvanttinova hub: Kvanttinova is a joint R&D hub by VTT, Aalto University, the City of Espoo and companies focusing on the development of microelectronics and quantum technologies. A new microelectronics and quantum technology cleanroom environment will be built jointly by VTT and companies in the semiconductor industry, with an investment of approximately half a billion euros. The aim is to create one of Europe's semiconductor clusters around it.

Quantum technology

- In 2023, the turnover of the quantum sector in Finland was EUR 130 million, with the aim of increasing the turnover to EUR 3 billion by 2035[31].
- Case IQM: In September 2025, the Finnish market-leading quantum computer company announced it had raised EUR 275 million in growth funding[32].

Health technology

- The value of Finnish health technology exports was EUR 2.57 billion in 2024. The industry has been growing steadily for 20 years[33].

Space technology

- In Finland, about 200 companies operate in the sector, with turnover tripled between 2018 and 2022 (from EUR 20 million to EUR 62 million). In 2022, Finnish growth companies in the space sector raised EUR 119 million in private funding, the fourth highest number in Europe[34].
- Case ICEYE: In June 2025, Business Finland granted the space and defence technology company ICEYE one of the largest individual grants in its history, approximately EUR 41 million. ICEYE is about to launch an investment programme of over EUR 250 million[35].

6G technology

- The development of 6G technology has triggered significant investments and competition worldwide. According to some estimates, the global 6G market value could reach up to USD 281.5 billion by 2030, which corresponds to an annual growth rate of approximately 34.8%.
- In terms of 6G research, Finland is clearly a pioneer and among the leading countries. It is estimated that Finland will invest approximately EUR 1 billion in 6G RDI activities between 2018 and 2030. The expected commercial and public financial benefits of 6G and its value for Finnish exports is considerable: the global analyst consensus is about 25–35 times higher than the 5G market, for example[36].

Defence and dual-use technology

- There are 368 defence companies in Finland, of which about 144 are growing strongly. They focus on either defence technology or dual-use applications. In 2022, combined revenue was approximately EUR 235 million, and they have grown at an average annual rate (CAGR) of 5–8% in recent years [37].
- Many of the above-mentioned technologies are also dual use (e.g. space technology), meaning that the solutions are viable for both civilian and defence purposes.

Biotechnology

- The biotechnology sector is predicted to experience rapid growth globally over the next decade, by as much as 12–14 per cent per year. The EU[38] has identified biotechnology as one of the critical technology areas. There are more than 800 full-time biotechnology companies operating in Finland, generating a total turnover of more than seven billion euros. The sector employs more than 19,400 people. The range of companies is diverse, and almost half of the companies are classified as part of the food industry[39].
- VTT-based startup Solar Foods[40] is solving the global problem of food production by offering a completely new alternative to current animal and plant proteins. Another example is Onego Bio[41], which produces egg whites without poultry using precision fermentation.

2. Technology-based growth opportunities

Addressing global challenges requires new technologies. To position itself as a leader in sustainable growth, Finland must boldly invest in areas where it possesses unique expertise and competitive advantage. By focusing and investing in these areas, it is possible to drive sustainable growth on a global scale.

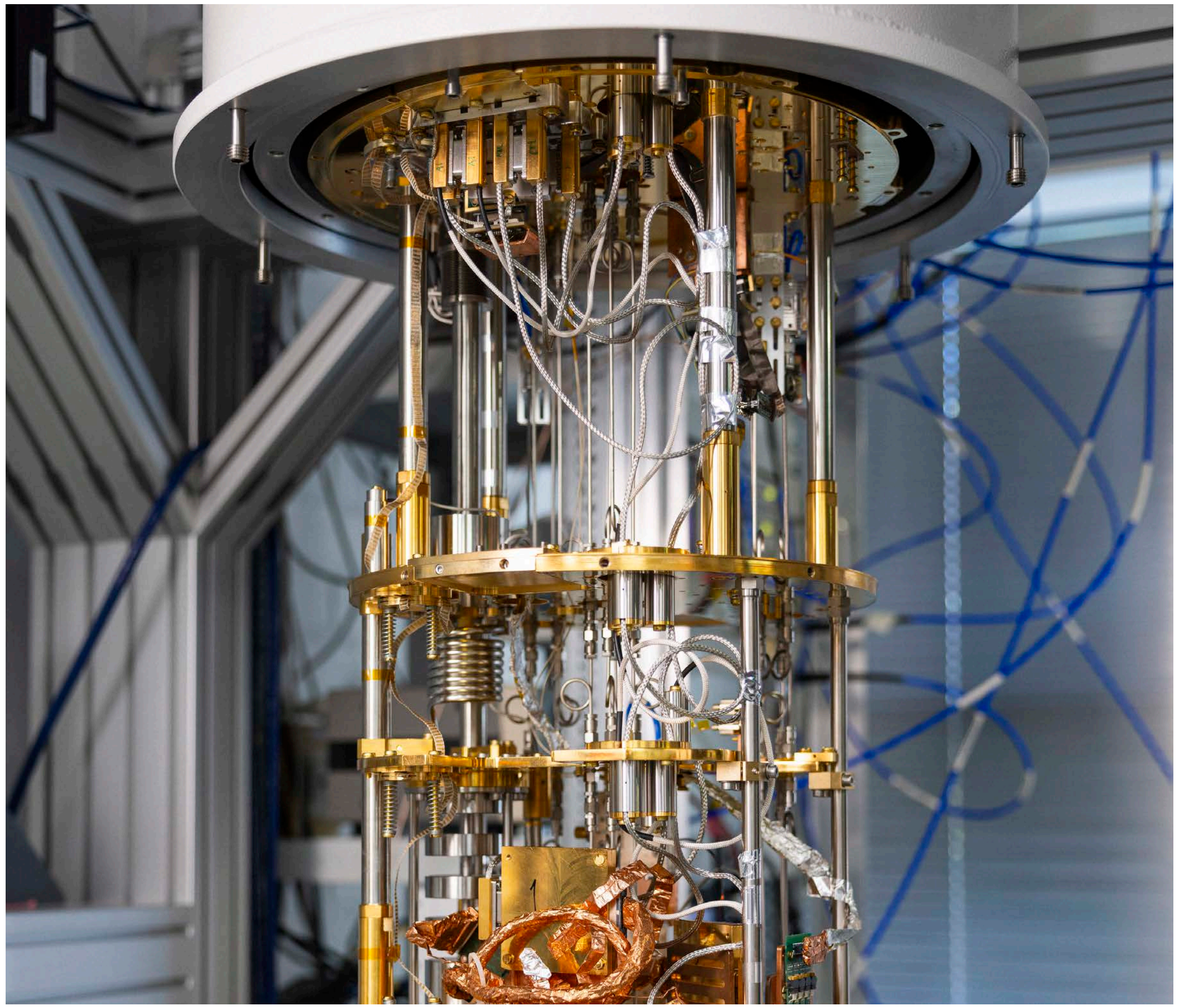
The winning formula places Finnish expertise as a means to tackle global challenges and spearhead solutions in nascent markets or by disrupting existing markets with a fresh approach. Finland has growth opportunities and strengths in many sectors with global potential, such as semiconductors and microelectronics, quantum technology, bio-based materials and energy transition.

VTT carries out extensive research and development activities as well as commercialises research together with the Finnish business sector. The goal is to renew Finnish business and create growth through technology. From this perspective, we will take a closer look at some of the key technology areas and themes relevant for Finland and suggest how the growth challenges could be solved in these areas.

Opportunities for growth

- **Semiconductors and microelectronics**
- **Quantum technology**
- **Materials**
- **Energy transition**
- **Defence, dual-use and crisis resilience**
- **Industrial renewal**
- **Deep tech growth companies**

Naturally, Finland also has other significant sectors and themes for stimulating growth. There are also growth initiatives that cut across different sectors.



Growth from semiconductors and microelectronics

Semiconductors are one of the critical technologies defined by the EU[42]. They are very important for Finnish society and national security. Finland has diverse strengths, which are described in the Chips from the North strategy.

The growth rate of the sector depends on the availability of experts, R&D funding and cooperation, and investments. The global semiconductor industry is growing strongly, and the sector is expected to almost double from EUR 570 billion to around EUR 1 trillion by 2030[43]. According to Tesi's report, interest in quantum technology and semiconductor companies is rising, driven by the increasing demand for computing power amid the AI boom[44].

Semiconductor technology and microelectronics are critical technologies forming the foundations of modern society, such as telecommunications and computers. In particular, integrated photonics enables modern telecommunications and is an essential part of 6G and future telecommunications solutions. Quantum technology is also microelectronics in terms of manufacturing technology – you could even say that quantum technology is the next frontier in microelectronics.

For Finland, strengths in microelectronics lie in specialized applications, not in CMOS processors. The Chips from the North strategy[45] identifies six growth opportunities for the Finnish semiconductor industry:

- **Chip design**
- **Microelectromechanical systems (MEMS) and sensor innovations**
- **Photonics**
- **Quantum technologies**
- **Advanced materials**
- **Sustainable process technologies**

Finland will strengthen its expertise to manufacture specialised chips by utilising the support provided by the EU, the Ministry of Economic Affairs and Employment, and Business Finland through pilot lines. VTT participates in several pilot projects and is also involved in Chips JU's quantum pilots[46]. The University of Tampere participates in Chips JU's WBG pilot line[47], where the investments particularly support photonics packaging solutions. The other Nordic countries will also benefit from these investments, as they will enable component and application development based on established manufacturing technologies. European pilot lines in microelectronics and quantum technology create an opportunity to develop equipment in Finland without expensive cleanroom investments for new companies. The pilot lines enable the development of products based on new technologies and facilitate integration into the European supply chain.

Challenge:

The development of new products and the rise of new pioneering companies require investments in product development, as well as expensive manufacturing equipment and cleanrooms.

Solution:

Kvanttinova[48] offers companies and research institutes the opportunity to develop and pilot new solutions and scale them towards industrial production. Kvanttinova is the first in Finland to feature a 300-millimetre silicon wafer production line, which allows for the development of new solutions and products via cutting-edge microelectronics manufacturing technologies and processes in Finland.

Finland is in an excellent position to become a globally significant player in emerging markets for microelectronics, such as materials and their manufacturing equipment, integrated photonics and quantum technology.

Growth from quantum technology

Over the next decade, quantum technologies will revolutionize many business areas and have a broad impact on both economic development and society as a whole.

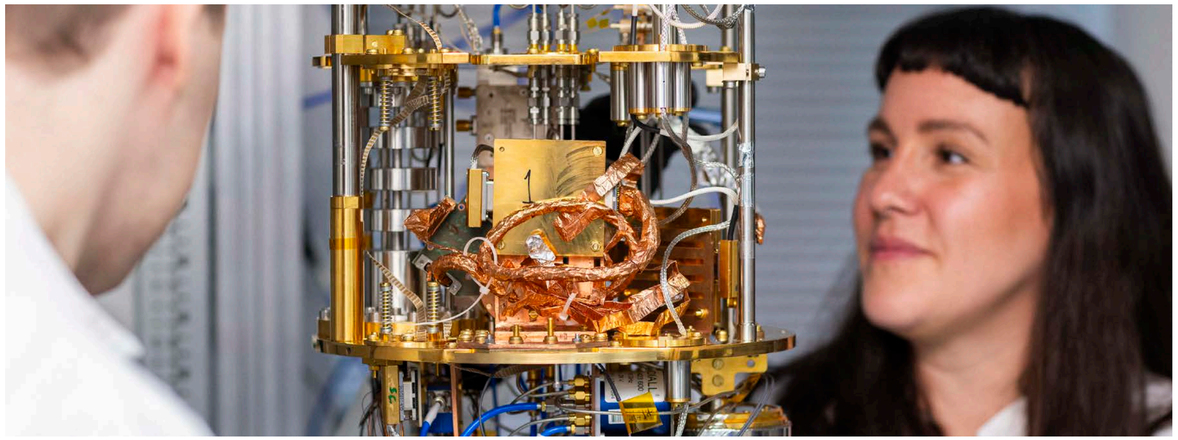
Quantum technology, such as quantum computing, sensors and communication, has the potential to transform and enable a growth leap in many industries. Finland's National Quantum Technology Strategy[49] was published in spring 2025. The aim is to create a significant new industrial sector and competence cluster in Finland.

Finland is one of the few countries that has been able to produce complete quantum computers, and our supply chains are strong. Globally, Finland's quantum technology sector is bolstered by an expanding ecosystem of companies, research institutes and experts. Finland holds a significant position in quantum technologies based on superconductivity. Europe's first hybrid system combining a quantum computer and a supercomputer is also located in Finland.

The potential market for quantum technologies is estimated to grow to approximately EUR 106 billion by 2040[50]. The greatest economic benefit comes through the increase in revenue and cost savings generated by quantum computing applications. Finland stands out with historically strong areas of expertise in quantum sensors and measurement technologies. In the near future, areas of development for ultrasensitive sensors – where Finland has particular research and technological strengths – include magnetometers, microwave single-photon detectors and counters, as well as low-temperature measurement devices and radiation meters[51].

Key application areas of quantum technology include the chemical industry, life sciences, finance and logistics[52]. Quantum technology has been studied in Finland for more than 60 years, and Finland has developed a unique well-functioning ecosystem of core research, applied research and industry over a high-quality infrastructure.

In 2023, the net sales of the quantum sector in Finland were EUR 130 million. The vision of the National Quantum Technology Strategy[53] is to increase turnover to EUR 3 billion by 2035, and the number of jobs is expected to increase from around 500 to 10,000. Finland is well positioned in the global quantum technology race: it is among the first to adopt and use quantum technology in both quantum computing and quantum software. Finland has committed major funding to quantum technology: the Finnish government granted EUR 20.7 million for the development of a 50-qubit quantum computer in 2020 and EUR 70 million for a 300-qubit quantum computer in 2023. During this time, Finland has developed expertise in the construction of quantum computers, quantum computing algorithms and their usage. Finland is now the first country to have a 50-qubit superconducting quantum computer developed and manufactured in Europe[54].



Finland’s national quantum technology strategy aims to grow the entire sector, with companies playing a critical part in global value chains and leading the way in their respective markets. To achieve this, it is necessary to develop both quantum technology devices and software. **To advance quantum technologies, competitiveness and infrastructure must be ensured while driving quantum technology adoption in applications and end-user companies**[55].

Challenge 1:

Scaling quantum devices into larger systems and wider use requires the most advanced chipmaking technology.

Solution 1:

The European SUPREME quantum pilot line will establish Finland as a leading cluster for superconducting technology research, manufacturing and innovation. SUPREME, Kvanttinova and Micronova will work together to create a strong and impressive cluster of expertise to address this challenge.

Challenge 2:

Developing quantum technology applications and delivering benefits to end-users.

Solution 2:

The first applications where quantum computing provides tangible advantages in terms of speed, power consumption or accuracy are likely to arise from the synergy between supercomputers and quantum computers. By combining quantum computers and supercomputers, new breakthroughs can be achieved in materials science or biomolecular modelling in medical applications.

End-users and developers must be brought together to ensure developers can solve end-user challenges and end-users can benefit from quantum technology. Finland needs both facilitation of ecosystemic dialogue and resources that support RDI activities in companies for the application of quantum technology, such as access to a quantum computer (software development) or to pilot line manufacturing (quantum device development).

Growth from material development and sustainable use of natural resources

Natural resources are central to Finland’s economic growth, with over half of its GDP reliant on the utilisation of natural capital[56]. Finland plays a key role in producing and refining minerals in Europe. The forest industry offers new opportunities, especially in the utilisation of production side streams, biogenic carbon dioxide, innovative export products and technologies for production efficiency. The mining industry, including battery mineral value chains, has growing potential due to the green transition and geopolitical changes[57].

Finland's strength lies in the sustainable use of natural resources, which can serve as a foundation for innovative, scalable business. Security of supply and self-sufficiency have become critical priorities and competitive advantages in the industrial sector. High-value production from natural resources is both a technological and a competence challenge.

The development and circulation of materials are at the core of sustainable growth. Various industries should rapidly phase out fossil raw materials and replace them with carbon-neutral alternatives. At the same time, materials must be circulated more efficiently to solve the global resource shortage and decouple economic growth from the overconsumption of natural resources. Sustainable growth requires biomaterials (nature-derived, nature-inspired or biotechnologically produced) and new materials (e.g. sustainable battery materials) to replace fossil-based or animal-based raw materials.

Materials-related capabilities are a key enabler in all sectors of the technology industry. Examples include components and solutions for the electronics and electrical industries, as well as mobile machinery and equipment.

The development cycles of materials technology are long due to the resource-intensive nature of the field. Development cycles can be accelerated and insights applied to further development via research that combines the opportunities in computational materials science, artificial intelligence and quantum computing, and advances in manufacturing technologies, automation and robotics. The parallel development of materials technology and related technologies and harnessing them together offers Finland new opportunities for growth. Digitalisation and the use of artificial intelligence can also alleviate the resource intensity of the field, making it easier for new players to access the market.

Minerals are used in a wide range of industries, from electronics to automotive, renewable energy, fertilisers, and cosmetics. **There is a clear potential for economic growth in mining and products of the mineral value chain**. In 2024, there were 43 mines in Finland (metal mines and industrial mineral mines). The value of mining investments in 2023 was EUR 380 million[58]. In addition, processing and technological development of metals are a significant part of Finland's export industry, directly employing 16,200 people in 2023[59].

Finland must strive to extend domestic value chains and increase the added value of raw materials and products.

The potential of the battery cluster is great, as the European Commission has estimated that the market for the battery cluster will grow to as much as EUR 250 billion[60]. Finland is in a unique position with prerequisites to produce key minerals needed in battery production[61]. With the Critical Raw Materials Regulation, the EU aims to ensure the availability of critical raw materials for European industry and to significantly reduce the EU's dependence on single raw material suppliers outside the EU[62]. In this respect, Finland’s significance exceeds its size.

Climate change and biodiversity loss have long been global societal challenges. Additionally, geopolitical tensions and threats to the availability of critical raw materials have risen. Finland faces the additional challenge of weak economic and productivity development that has continued for years.

However, it is possible to respond to these challenges and turn them into drivers of new sustainable growth.

Challenge 1:

The availability of critical raw materials is under threat in a changing global environment. The growing demand for raw materials and availability uncertainties are forcing industries to look for new solutions. This is particularly topical in sectors relevant to the green transition, such as the battery and energy industries. Addressing the raw material demand requires multiple parallel solutions: new ways to use existing raw materials, new circular economy solutions, new substitute materials and novel material solutions tailored to specific use cases.

Challenge 2:

The operating environments of materials are changing, and materials technology must be able to respond to these changes at an accelerated pace. New fossil-free technologies will become increasingly important in the future; for example, fusion and hydrogen technologies will present new requirements for materials.

Challenge 3:

Finland needs to increase the value of products made from biomass. The traditional 10–15-year time span for the development of bio-based materials is no longer sufficient. Sectors such as the forest industry must refine biomass and biogenic carbon dioxide into diverse, high-value-added products.

Solution:

The common denominator of the challenges described above is the need to accelerate and enhance the development and production of completely new types of materials. This requires new methods and tools that enable rapid development from laboratory to industrial scale and profitable business. For Finland to succeed, it is necessary to ensure the development and utilisation of technologies for sustainable raw material recovery that companies can also export.

New types of business and new actors, especially SMEs, are needed to drive innovation in mineral exploration, mining technology, mineral processing, metal recovery and metal production and processing. Applying mineral industry and materials technology data competitively plays a pivotal role in advancing the industry. The goal must be to utilise raw materials comprehensively and sustainably.

The utilisation of advanced materials research and new technologies requires investments in new, sustainable and cost-effective processing technologies. This also brings opportunities to strengthen Finland's industrial base, increasing added value with new materials, products and production methods.

Finland should develop a full production value chain for processing mineral raw materials and seek IPCEI status (Important Project of Common European Interest). The goal should be to attract an industrial-scale investment in Finland that harnesses domestically developed technology.

Case:

VTT Materials Innovation Hub

Traditional materials research relies on theory, experience and experimental development. Finding completely new material solutions with these methods is laborious, time-consuming and expensive. Reaching an industrial scale and bringing new materials to the market can take 15–20 years and require investments of hundreds of millions, even billions of euros.

The VTT Materials Innovation Hub[63], a multi-level material design, development and production platform, brings unprecedented speed and precision to materials development. Through AI-assisted material development, materials with desired properties can be developed in a fraction of the time previously required and scaled rapidly from piloting to industrial production.

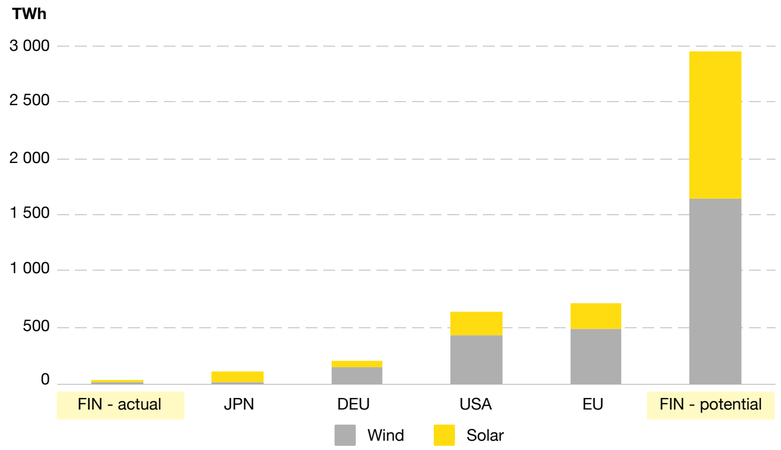
The VTT Materials Innovation Hub concept enables the use of sustainably produced raw materials in a resource-neutral manner, accelerating development. In addition, the concept supports investments in breakthrough technologies such as cost-effective and sustainable processing methods. This may include biological, chemical or mechanical raw material modifications to commercialise new materials.

Growth from the energy transition and energy technologies

The most significant variables and phenomena affecting the energy transition in the near future are electrification, the development of financing and R&D investments in the industry and the development of the regulatory framework. In addition to politics, the driving factor in electrification is the diminishing costs of clean electricity production. From a global perspective, key drivers are security of supply, resilience and energy dependencies. Hydrogen produced from clean electricity and water will play a significant role in future energy systems as an energy carrier and industrial raw material. In the field of financing, most of the R&D work in the energy sector is still financed by companies, but the share of venture capital (VC) funding is increasing.

Finland has an excellent opportunity to benefit from the clean transition, as OECD's recent country report[64] emphasises. According to the data window maintained by the Confederation of Finnish Industries, investments in the green transition will continue to grow in Finland, and investment intentions worth more than EUR 300 billion were by September 2025[65]. According to Gaia's assessment[66], the biggest impacts will be generated by wind power, hydrogen projects and battery technology plants.

Finland's potential in renewable energy production



Source: OECD Economic Surveys: Finland 2025

Four potential themes for Finland can be identified in the energy transition:

- Hydrogen and Carbon Capture and Utilisation (CCU) to enable new tools for global energy trade and clean industrial transition
- Nuclear energy of the future
- Raw materials and material value chains
- Data economy as part of the clean transition

Case:

Finland at the forefront of the energy transition and clean aviation fuels

A differentiating strength of Finland is the availability of clean electricity: thanks to wind and nuclear power, electricity is reasonably priced and widely available. This enables the production of electrofuels: electricity is used to produce hydrogen. Synthetic hydrocarbon created from biogenic carbon dioxide and hydrogen are equivalent to current fossil fuels and are directly suitable for use in sectors such as aviation.

In Finland, significant amounts of biogenic carbon dioxide are produced at large hotspots like industrial plants. If all this carbon dioxide were used to produce aviation fuels and other synthetic hydrocarbon products, the added value of direct production could reach up to EUR 2.5 billion. The export of technology, equipment, services and research would increase the value even further, as demand in global markets is growing rapidly. There is significant growth potential in the European electrofuel market, especially in aviation. The annual value of the market is estimated to reach EUR 30 billion by 2050, and technology investment in the sector is projected to exceed EUR 50 billion. To take advantage of this opportunity, several parallel measures are needed: utilising modern technology, long-term R&D work, and public sector support for market creation and supporting companies in risk-taking.

Challenge 1:

The number of Finnish technology providers and Finnish technologies needed for a clean transition is still relatively small. Most of the current activity in Finland takes place in project development companies that implement their projects with the most cost-effective (foreign) technology, which means that the economic value of investments in Finland and the environmental handprint for Finland may remain moderate.

Challenge 2:

Finnish technology providers were not early enough in developing technologies and solutions for global markets.

Challenge 3:

For R&D efforts in the Finnish energy sector, it is essential how the startup ecosystem develops in Finland, how the current economic situation affects funding or energy infrastructure investments, and what is the willingness for R&D investment in heavy industry and long-distance transport sectors and how this could be strengthened.

Solution:

Finland must invest in the following measures to realise the disruptive growth potential of the energy sector:

- Industrial renewal can be supported by implementation and transfer of technology, along with innovation ecosystems. It is essential to create an innovation environment that brings together actors in the field from basic research to industry, and where solutions required by markets are developed utilising existing and emerging technologies. In practice, goal-oriented cooperation can be supported through a solution-oriented programme with the goal of raising Finland to the global top in energy research.
- It is important for Finland to enable disruptive change in the energy sector based on cutting-edge expertise and deep technology. At the forefront of the change are startups, whose growth and scaling needs to be supported. VC funding plays a key role.

Finland is one of the pioneers in the development of energy systems and sector integration globally. Our strengths are our modern electricity distribution infrastructure and a high degree of digital readiness.

Finland has invested significantly in the production of clean energy, enabling the availability of affordable and environmentally friendly energy. This attracts energy-intensive industries and supports sustainable economic growth[67]. Finland has enough clean water available for industrial processes and room to increase clean energy production and energy-intensive industry. In addition, Finland's climate makes it possible to utilise the excess heat generated by industrial processes.

Finland has extensive experience and expertise in the safe and economical use of nuclear energy. Finland is a global pioneer in the final disposal of nuclear waste, having also invested in the development of new technologies, such as small nuclear reactors and fusion.

Finland has the potential to be a significant export country for hydrogen-related technology, clean hydrogen and hydrogen products. Clean electricity, the capture and utilisation of biogenic carbon dioxide, and mineral resources create prime conditions for the development of hydrogen economy and the battery industry.

Data centre investments are also accelerating investments in clean electricity production in Finland.

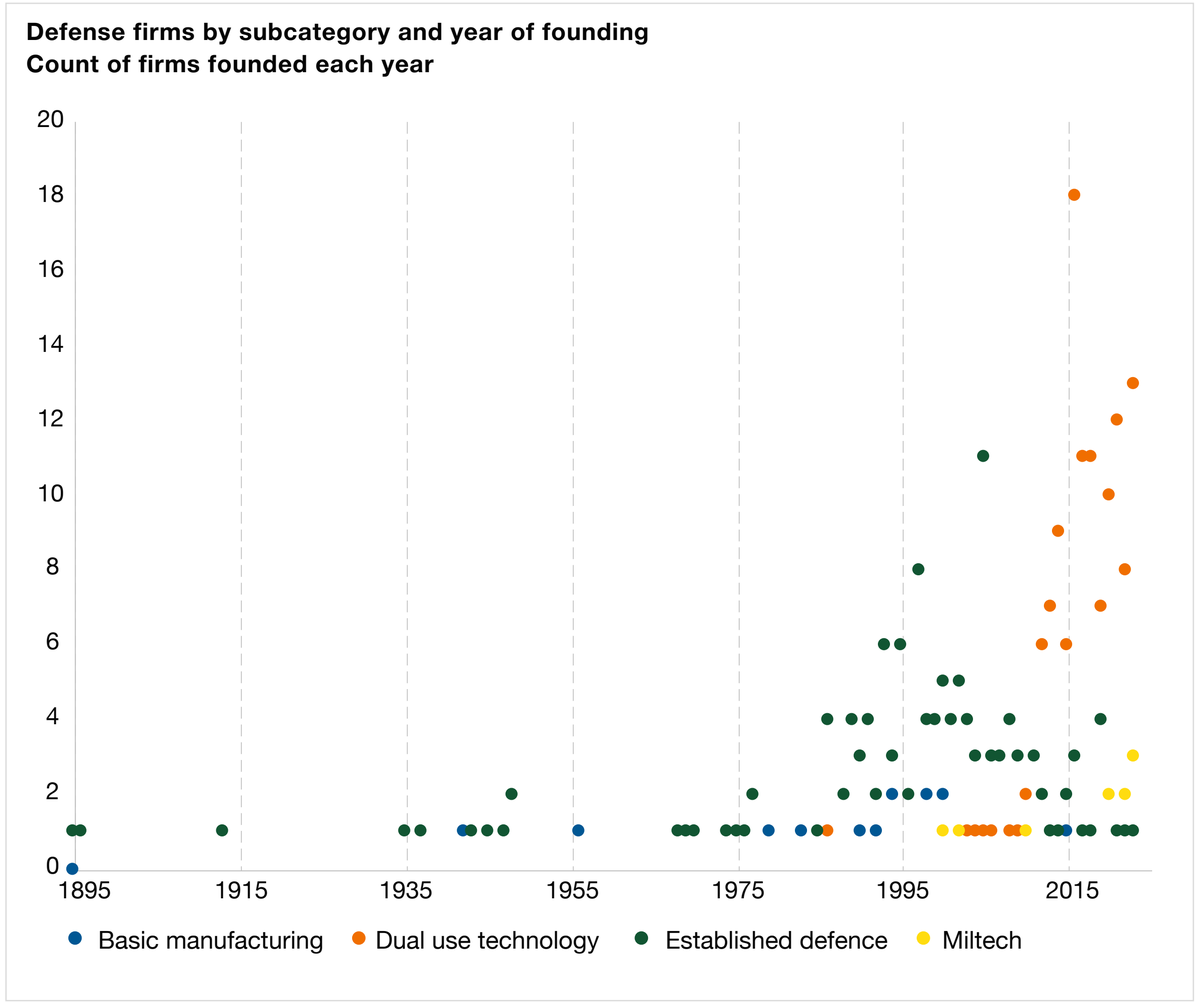
Growth from defence, dual-use technology and crisis resilience

The geopolitical turmoil creates needs to strengthen Europe's defence capabilities. Funding for defence and security will be significantly increased in the next few years. For example, the European Commission's EU ReArm plan includes EUR 150 billion worth of loans for joint procurement by EU countries[68]. Finland will strengthen defence funding by approximately EUR 3.7 billion over the next four years, with the aim to increase defence expenditures to at least three per cent of GDP by 2029[69]. NATO's goal is to increase defence expenditure of member countries to five per cent of their GDP[70].

A paradigm shift is taking place in the defence industry. Traditionally, established large defence sector operators have delivered solutions to state actors. This relies on long-term strategic partnerships, with funding from government bodies focusing on defence. This operating method can be slow; procurements are long processes and market entry is difficult for new players. The development cycle in the defence industry has typically been over 10 years, and the flow of innovation has shifted from defence to civilian applications.

The New Defence Economy features a growing number of dual-use and civilian startups: innovations are transitioning from civilian application to the defence sector (e.g. drones, space industry, artificial intelligence). Typical actors are civilian dual-use companies and ecosystems, and funding comes from a variety of sources, including the EU and venture capital funds. Modes of operation are characterised by speed, agility and innovation. Development cycles range from mere months to even weeks, and there is seamless cooperation between defence and civil administrations, as well as industry and research.

Changes in the security environment highlight the rising significance of the defence and dual-use sectors. The Finnish defence industry is a combination of traditional industrial companies and new startups. According to Tesi's estimate[71], there are more than 140 rapidly growing defence companies in Finland that focus on defence technology or dual-use applications. The largest sectors in the entire defence sector are information technology and industry. Narrower sectors, such as augmented and virtual reality (AR/VR) and robotics, show the highest revenue growth figures among emerging defence technology and dual-use companies. In Tesi's report, the growth figures for turnover in the dual-use technology category are by far the highest, at about 30–40%. The revenue development of dual-use and defence technology companies has been strong and accelerating in recent years. In 2022, total revenue was approximately EUR 235 million, with an average annual growth rate (CAGR) of 5–8% in recent years.



Source: Tesi: Puolustusteollisuus – Markkinaselvitys suomalaisesta puolustusteollisuudesta ja kaksikäyttötuotteista

Challenge 1:

R&D investments are needed to develop future capabilities in addition to the production of traditional defence materiel. This is also essential considering security of supply and preparedness for challenges, for example, in the supply chains of raw materials and components.

Challenge 2.

How to accelerate the commercialisation and export of dual-use technologies?

Solution:

The defence sector's budgets for both investments and operating expenses are increasing. In addition, more private equity funding will be allocated to the defence and security sector. Via developments in Ukraine, the utilisation of dual-use technologies has increased rapidly.

Increasing defence spending must promote growth and innovation in the sector by utilising commercial technologies for defence purposes and increasing the use of private capital in defence. According to the Bank of Finland's estimate[72], the economic impact of increasing defence spending will depend on the degree of domestic origin of procurements, and new growth opportunities will also emerge through exports.

Cooperation with companies with civilian backgrounds can cultivate new opportunities for current defence industry companies and accelerate growth. Correspondingly, civilian companies can benefit directly from the increase in defence spending. Examples of new opportunities are the joint polar icebreaker ICE Pact between Finland, Canada and the United States[73], as well as various projects geared towards energy and food self-sufficiency.

Case:

NATO's DIANA programme

In 2024, VTT and Finland were accepted into NATO's DIANA (Defence Innovation Accelerator for the North Atlantic) network to establish an acceleration programme and two test centres. The test centres are already in operation, and Finland's NATO DIANA acceleration programme will be launched at the beginning of 2026 to support NATO's goals in the development of dual-use technologies. The DIANA accelerator program provides companies with the necessary skills to develop dual-use technologies that address significant defence and resilience challenges. It provides training sessions and mentorship on commercial, technical, and defence issues, as well as access to defence expertise and investor networks. Companies selected for the accelerator programme will have easier access to NATO's commercial markets through the Rapid Adoption Service (RAS) mechanism. The strength and follow-through of the acceleration programme operated by VTT is reliant on future communication systems and quantum technology[74].

Growth from industrial renewal

A study by the consulting firm McKinsey reveals that large Finnish companies have grown significantly slower than large international companies over the past decade[75]. The slower pace of growth can partly be explained by the low target levels set for expansion, small investments and corporate culture.

McKinsey states that reversing this trend is important for the national economy. There are good conditions for the growth and renewal of manufacturing industries. Below are two cases showcasing aspirations towards growth, investments and renewal.

Photo: Ponsse

Case:

Mobile machine industry

The mobile machinery industry is one of Finland's most significant manufacturing industries. The sector's turnover is approximately EUR 19 billion; it covers more than 10% of Finland's exports of goods and services, employing 45,000 people. It supports other sectors that are key to Finland, including forestry, mining, agriculture, construction, material handling and the defence industry.

Finland’s national mobile machine growth strategy was published in August 2025. The strategy aims to triple the sector's turnover by 2035, which corresponds to an annual growth of approximately 10 per cent, and create approximately 45,000 new jobs while simultaneously improving productivity. The opportunities identified in the growth strategy are based on cutting-edge expertise and modern state-of-the-art technology. For example, smart devices that utilise artificial intelligence and sustainable solutions, such as electric powertrain systems, are areas where Finnish companies have the prerequisites to strive for global leadership. Finland aims to maintain its position as a world leader in the development of innovative solutions and in research and development[76].

Case:

Forest industry

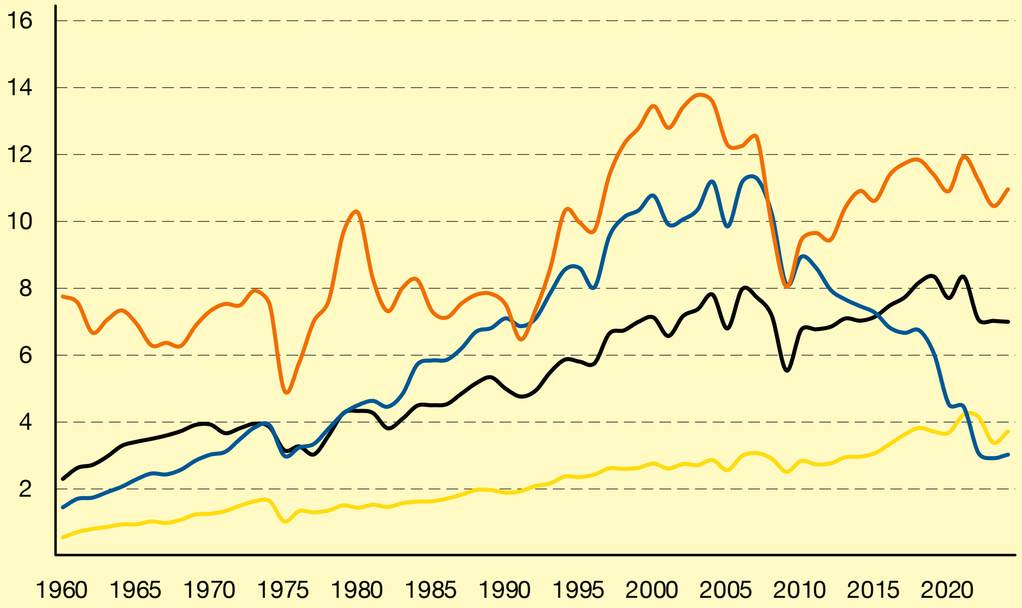
The Finnish forest industry has been undergoing a major transformation for a long time, and it is subject to high expectations regarding the national economy and sustainable environmental development. In 2024, the Finnish forest industry accounted for about 17 per cent of Finland's export of goods, and the exports of forest industry products had a value of over EUR 12 billion[77]. The decline in demand for graphic printing paper has significantly reduced the production of printing paper in Finland since 2007, which has led to the closure of production lines, and the negative market development is expected to continue in the coming years. Different types of paperboard products have become a significant segment of export: the total value (EUR 3.3 billion in 2024)[78] has already exceeded exports of paper products in terms of production volumes.

A significant structural change has taken place in the Finnish forest industry: large companies in the forest bioeconomy sector have renewed their operations while new growth companies have emerged in the ecosystem in areas such as side stream utilisation. The value of forest industry exports has remained steady at over ten billion euros throughout the 2000s, except for a dip in 2009[79]. In other words, the industry has succeeded in renewing itself. In Finland, investments have been made in new board machine lines, new pulp mills and extended products processing in the mechanised forest industry.

In the future, growth will be generated by biochemicals, value-added biomaterials (e.g. textile fibres, refined lignin products and new packaging materials) and the processing of side streams instead of incineration. Side streams from the mechanised forest industry can be processed into insulation materials, which have a wide range of applications in the construction industry.

In addition to increasing the added value of products, the industry still needs to invest heavily in new technology implementation and cultivating the competitiveness of current business ventures. For example, the paperboard industry needs to switch to lighter products and ensure regulatory compliance for products (e.g., PPWR requirements). Plenty of growth companies have emerged in the forest bioeconomy, accelerating structural change in the sector. New forest industry processes include utilising chemical industry processes, biotechnology and machine learning.

Forest industry production volumes in Finland since the 1960s



Production		2024	Change from previous year
Paper	1000 t	3 011	**3,7 %**
Paperboard	1000 t	3 716	**9,9 %**
Pulp	1000 t	6 972	**-0,4 %**
Sawn timber*	1000 m	10 935	**4,8 %**

* The further processing of products

Source: Finnish Forest Industries: Metsäteollisuuden tuotantomäärät

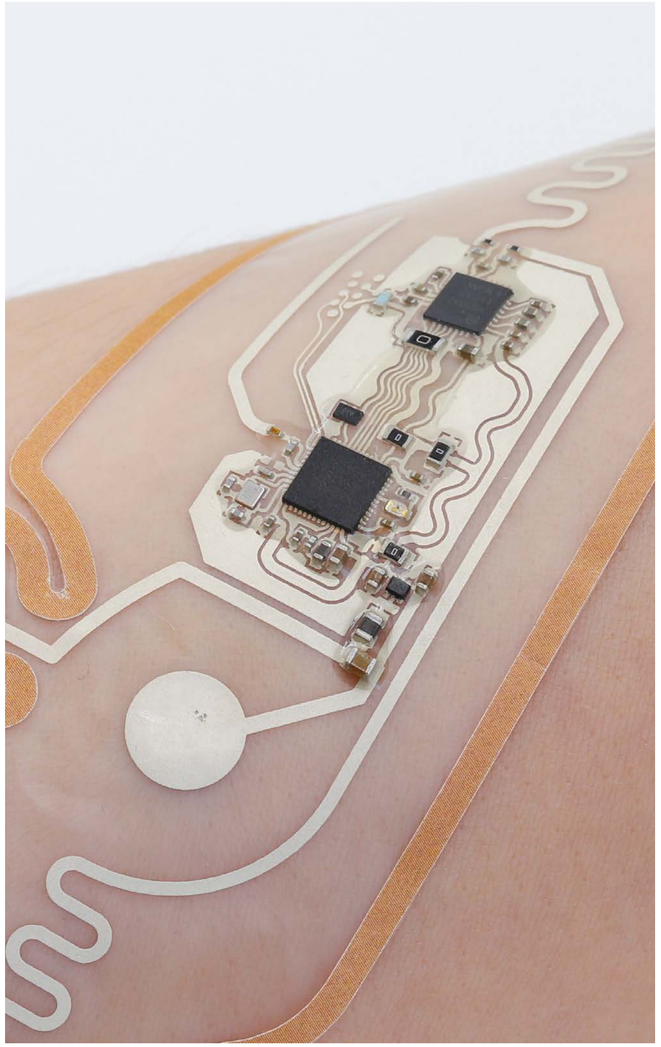
Growth from deep tech growth companies

Long-term success and expansion for Finnish growth companies is reliant on these factors: 1) new technologies must spread widely into society through established companies, 2) a steady flow of startups from various sectors gradually takes over an increased share of the corporate market, and 3) individual startups emerge as global category leaders.

Renewal and growth require technologies that are proven to be marketable and increase the production efficiency of companies. Marketability can be verified by means such as pilots or client cooperation; increasing efficiency requires broad understanding of the inefficiencies of existing solutions and current value chains. Production launches and investments in new technology development require external financing or internal funds. Finding domestic and foreign clientele is essential.

The growth of deep tech companies is slow[80]. It requires capital and often large investments in production facilities, as well as integration into existing value networks or production processes. Deep tech companies develop entirely new technologies, which is why commercialisation and understanding of market needs require close cooperation with industry players.

Deep tech growth companies that manufacture hardware and components need market leaders who are committed to their customers. It is almost impossible for a startup to get funding to commercialise its developed solution unless it can show proof of customer commitment. It is extremely important for new growth-oriented companies to be able to demonstrate and pilot their solutions before any actual production plant investments. Shared infrastructures play a key role in this.



Challenge:

The field of deep tech companies in Finland has grown, and a few top Finnish companies are on their way to becoming market leaders in their field[81]. There is great potential for growth in the renewal of existing industries and the creation of new ones. There will be no impact if Finnish research expertise is not commercialised and transferred to the market through companies, i.e. if the business sector is not renewed. How can Finland ensure that the strong development in the field of startups and deep tech companies continues, and the country gives rise to new high-value-added, science and research-driven growth companies?

Solution:

Solving global challenges, such as reducing CO2 emissions, ensuring resource sufficiency and reducing energy consumption, requires research and technology development. To succeed in international markets, Finnish actors must be able to commercialise challenge-driven research and new intellectual property (IP) aimed at global category leadership.

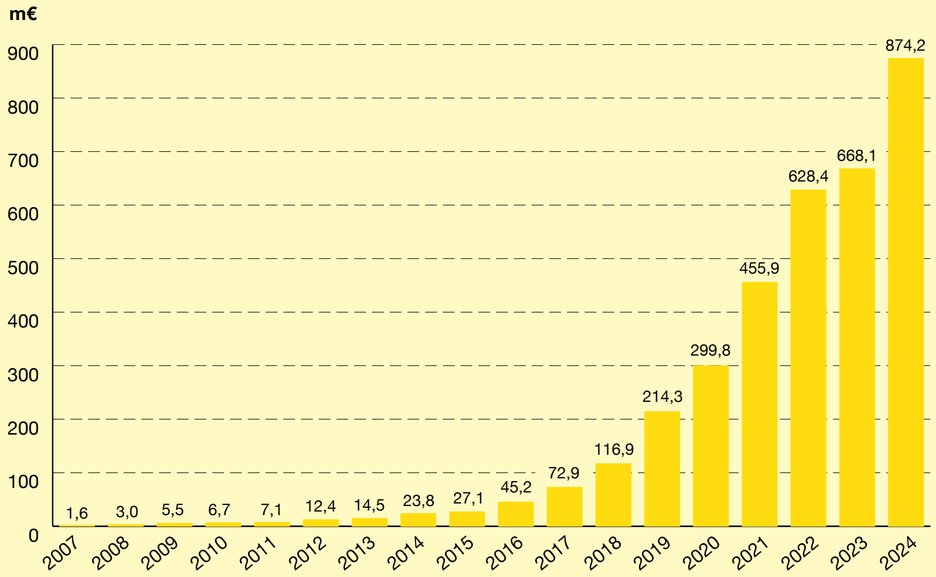
Finland must systematically support the transfer and commercialisation of technologies from research organisations to the market, as well as the widespread adoption of new technologies in society and industry. Accelerator programmes are best utilised when bringing growth companies and large companies together to enable fruitful cooperation and strengthening expertise mutually, while bringing the startup's solution to the market and attracting growth funding.

Case:

VTT LaunchPad

VTT LaunchPad is a business incubator that commercialises VTT's research and technology into startup companies. The incubator brings together VTT researchers and IP offering with the highest business expertise and investors. In 2024, VTT's startup companies raised almost 15% of the venture capital funding of the Finnish startup industry. The incubator programme is tailored around the needs of teams participating in the programme, so that each team has the best chance of attracting seed funding for their future business. Operations are based on continuous development and verified information and aim to cultivate deep understanding of the best prerequisites for success for a deep technology growth company.

Cumulative private investments in VTT's startups



Source: VTT & Finnish Startup Community: VTT spinoffs report – Scaling up research

Afterword

New technologies are needed to solve global challenges. In many ways, technology is also at the heart of global competition. At VTT, our mission is to create technological expertise for industries to utilise for renewal and for the creation of new, successful Finnish companies.

The Finnish economy will only turn for the better if the total factor productivity increases, i.e. more or higher value-added production can be achieved with the same resources. Renewal occurs through research and the development and utilisation of new technologies. Companies and Finnish decision-makers need the will to pursue growth – not to mention courage, determination and perseverance to make a turnaround.

The development of new solutions and innovations requires crossing the valley of death, a strong foundation of competence, and a predictable and innovation-friendly operating environment. Private R&D investments are on the rise, and now it is important for Finland to demonstrate its commitment to long-term R&D investments.

To accelerate growth, you need:

- Internationally competitive, high-value-added products and services
- New growth-oriented companies
- Development of technology-based growth sectors
- Close cooperation between research and business
- Strategic investments in centres of excellence

"In Finland, we have all the prerequisites to take hold of the growth opportunities described above. Finland is going through a major structural change, and we have the combined benefit of companies with growth-potential, and a maturing startup field – now we need to accelerate bold renewal."

Laura Juvonen, Chief Strategy Officer, VTT Technical Research Centre of Finland

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