



**QDNL**

# VISION 2035

## **Vision for the Quantum Ecosystem towards 2035 (published: Dec 2023)**

### Summary

QDNL is established to generate long-term economic impact for the Netherlands. To reach this economic impact, QDNL has formulated a holistic ecosystem approach in the NGF proposal of 2021:

*“QDNL is the place where the world's top talent is drawn to and where the entrepreneurial climate is so fertile that the quantum hardware and software providers of the future are born here. The ambition is that in ten years QDNL will grow into a vibrant and international hotspot where world-leading science, technology and talent come together and emerge.”*

Now that we are three years underway and have made progress in building this ecosystem, we have reshaped this rather generic and abstract ecosystem mission into a more focused and concrete goal, that more directly relates to the long-term economic impact that our ecosystem needs to realise to be successful.

Our QDNL Goal for 2035:

*“NL holds unique positions in the future global value chain of QT and its applications by fostering a portfolio of NL based quantum tech companies. By achieving this unique position, we aim to reach an ambitious macroeconomic goal – to be in the top 3 quantum economies in the world, measured by the size of the quantum economy related to the size of the country: Quantum related GDP per capita.”*

### **Ecosystem Position**

A thriving Quantum Economy is the overarching ambition of QDNL and the NGF programme. To reach this goal, our entrepreneurial ecosystem needs to be top-notch and attractive, covering the entire spectrum from talent, science & technology, shared facilities all the way to availability of capital, business, legislation, and engagement of end-users and society. The engine of the quantum economy is formed by the businesses that generate impact, value and jobs. Therefore, existing, and yet to be incorporated businesses are the anchor point for QDNL. We focus on what is needed to incorporate the right companies, and how can we help them scale and succeed. But also, on how we can engage existing industry and end-users in the quantum economy. And most importantly: how we can create the right entrepreneurial culture in the ecosystem, where talent feels challenged to embark in quantum business and where our public infrastructure is accelerating growth.

### **Unique selling points in the Netherlands**

1. **First mover:** NL was among the first countries with a national quantum strategy, a joint scientific and engineering research centre (QuTech) and a European quantum computer in the cloud. We are also pioneering in executing a national programme, with a dedicated national organisation, a roadmap for making choices, new campus facilities for the ecosystem, an innovative approach to tech transfer and IP.
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2. **Leading in science and technology:** our R&D position in quantum technologies is world leading, based on an excellent foundation of physical and engineering sciences. In the specific fields of quantum computing and quantum communications, the TU Delft scores within the top 3<sup>17</sup>. Our well organised and cooperative community is an attractive place for scientific and entrepreneurial talent.
  3. **Fertile startup ecosystem:** With 23 startups in 2023, NL is 4<sup>th</sup> in terms of number of quantum startups, only leaving the US (65), Canada (33) and the UK (26) behind. Adjusted for population size, we have the highest relative prevalence of quantum startups worldwide.<sup>18</sup> Yet, the total amount of capital raised by NL startups is only 0.8%. We commit to further nurture startup creation by the entrepreneurial talent pool and pave the way for growth by offering dedicated support, shared facilities and attracting scale up funding.
  4. **Gateway to Europe:** NL is strongly embedded in Europe both geographically and programmatically with close ties to the European Commission, France, Germany, and the Nordics. As we follow an 'open strategic autonomy' policy, we also have strong partnerships with like-minded nations including USA, UK, Japan, and Switzerland. With excellent physical, social, and digital infrastructure, and near 100% English speaking population in the EU, we can rightfully position ourselves as the gateway to Europe.

## Ecosystem in 2035

In 2035, the Dutch quantum ecosystem is comprised of an internationally networked group of industrial quantum players and state of the art shared infrastructures that facilitate R&D at the companies. We expect that some of the industrial players will be fully integrated full stack providers and others will take up a significant piece of the supply chain. We also foresee a significant presence of end-users from sectors like agriculture, energy, security, science, and digital infrastructure providers by that time.

The business ecosystem will be a combination of several international tech companies and Dutch grown tech scale ups. By nurturing many startup seeds, attracting international companies and by creating a beneficial environment to grow with a strong ecosystem of suppliers, it is our intent to ultimately create two to four companies that are well positioned to become international leaders and shape the ecosystem. It is too early to paint the picture of the exact focus of the portfolio companies. To become an industry leader, it is crucial to have access to international markets and partners. The Netherlands and even Europe are too small to create independent quantum technology supply chains and end markets. Therefore, we double down on our international presence and partnerships and sit in the front row when economic policies and standards are defined, ready to protect the interests of our local players. For this we work closely together with EZK and other important stakeholders. We engage international talent to support our ecosystem from the inside and outside. Netherlands should be strongly embedded in the fabric of the international supply chain, at all levels, in all forms.

On the infrastructure part, for the longer term, we foresee crucial synergies between semiconductor, photonics, and quantum technologies, and this is an opportunity for us in the NL, as we have strengths in each area. To build a strong and balanced ecosystem we plan a systematic, de-verticalized approach, involving startups and scale-ups that cater to specific areas in the value chain – from quantum processors to integrated systems. The goal is to develop a quantum industry roadmap for Europe by focusing on scaling the startup ecosystem and partnering with leading technology institutes. The Netherlands will take a leading role in these areas, just as other member states will do so for others. To build towards this, QDNL should develop and support a variety of pilot and production facilities for the fabrication, testing and application needs of the quantum ecosystem. This means we will develop facilities and infrastructures: testbeds, networks, differentiating process modules and hetero-integration technology, while also leveraging existing fabs for other process modules (e.g., cryo CMOS, state of the art lithography). Partnerships with established international frontrunners are part of that vision. In addition to that, the integration of quantum computers with supercomputers, the so-called high-performance computers (HPC), will accelerate the possibilities of

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quantum software, the execution of quantum application and quantum algorithms. This will create many new opportunities, in the innovation domain, as well to attract and interact with (future) end-users.

## Ecosystem Priorities

The timelines of quantum technology extend far beyond the QDNL programme. Currently this is an R&D market, and a fully commercial market is many years away. While NL has a strong scientific base, the industry is hesitant to invest in quantum technology, and the entrepreneurial ecosystem is still in its early stages, requiring acceleration and an influx of talent and capital. The QDNL programme addresses these challenges by stimulating and supporting startups, attracting talent, funding R&D, building shared facilities, and addressing societal impacts.

However, reaching our goal will require significant additional effort and resources. Currently our companies are small and have limited access to fab or foundry services, creating a bottle neck that needs urgent fixing. QDNL sees this as an opportunity to develop a distributed (international) value chain, leveraging multiple fabs for different key components.

Phase 3 of our programme will focus on positioning ourselves optimally for this goal and developing the necessary facilities.

We will focus our activities on four priorities:

1. **Technology acceleration:** An essential aspect of our unique selling points lies in the excellence of our science and technology (S&T) ecosystem. We aim to leverage this strength by challenging our community to collaborate and compete with international peers, accelerating progress on critical hurdles toward achieving a fully commercial quantum economy. To address these challenges and prioritize technology development, we will establish a challenge-based programme. This programme will foster innovation, collaboration, and competition, driving advancements in quantum technology and positioning us as leaders in the field.
2. **Commercialisation & end-user participation:** A strong emphasis will be placed on technology transfer, industry engagement, and startup development to facilitate the transition of ideas from (applied) universities and knowledge institutes (e.g., RTOs) to new companies, ultimately scaling these ventures into industry leaders within healthy market conditions. To achieve this, clear strategies for talent acquisition and intellectual property (IP) management will be essential. Additionally, the provision of shared facilities, investment capital, and robust startup support programmes will play pivotal roles in extracting ideas from the academic environment and fostering their growth in the commercial sphere. Lastly, to go from a technology push to a pull, more end-user participation is required, to foster the adoption of quantum technology.
3. **Internationalisation:** Building international partnerships (with like-minded countries) and attracting talent and companies from outside into our ecosystem. This creates innovation power, new culture and ideas, and capital as well as an export market for our companies. Also, we believe that securing funding and to be recognised as a key hub in Europe in the context of e.g. the Quantum Flagship (with FPA's like QIA) and Chips Act will be a crucial prerequisite for our continued journey.
4. **Fabrication:** In supporting our startup ecosystem, one of the biggest challenges we encounter is fab facilities. Specific demands of companies require dedicated solutions for fabrication infrastructure. While the academic/RTO infrastructure is mainly used for research, development and prototyping and small-scale production, dedicated fabrication facilities are required for pilot lines and mid- and high-volume production. We will develop fab facilities (cleanrooms), including new (private) governance models that make it possible for companies to access them on their terms. To ensure a smooth transition from R&D&I to pilot lines and high-volume production, facilities shared by both NanolabNL and private fabrication facilities are required. This development is in line with the EU Chips Act. We will not look at this in isolation, but with partners in Europe for optimal European synergies, and make the link with adjacent tech fields such as AI, Photonics, Next Generation Internet (Digital Infrastructure) and others.

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On top of these priorities, there are three conditions that our programmatic activities will need to meet. This means that all actions we take are benchmarked/aligned on these conditions:

1. **One ecosystem:** It is vital that the QDNL ecosystem is seen both from within as from the outside as one system, which means that profiling is based on activity, expertise, and mandate -not on institutional level. This is vital since changing the perspective from university or hub to the actual programme goals, as described in the CATs, will allow us to make choices and define what expertise is really needed to progress. This network of centres and facilities with a specific focus is what we call the QDNL national campus, that we will connect via the HoQuantum in our network.
2. **Quantum for good:** We work towards technologies that are beneficial for society at large, by understanding the ethical and legal frameworks, by creating broad acceptance in society through a clear communication strategy, and by considering ethical choices that need to be made to implement the technology. We will do this in parallel with the translation of the technology into different industry domains, and the development of end-user activities. Thereby focusing the technology development towards industrial and societal problems.
3. **Self-sustainability:** our ecosystem still heavily relies on (NGF) subsidies and facilities offered by QDNL and knowledge institutes (TNO, NanoLabNL, Mesa+, QuTech, QuSoft and others). As we move towards the end of QDNL programme, we aim to shift our business ecosystem to a healthy mix of other (public and private) funding sources, such as private equity, EC funding sources, other subsidy instruments. Also, we will focus on the set-up self-sustaining public/private facilities that offer shared services to our business ecosystem, such as pilot facilities, field labs, and demonstrators. As the aim is to move the technology out of the lab, into the fab and the app, we foresee an increasing part of the budget targeting businesses and outside university / TNO facilities. We will also need to address the question if QDNL as a foundation is still needed after the programme ends, or if there is still a role to play for a national ecosystem orchestrator.