

Societal Research for Quantum Technologies: A Vision for Europe

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Target audiences:

- Policymakers of the EU Member States and at the European Commission;
- Quantum researchers, industrialists and social researchers in the European Union.

Quantum technologies and their applications will bring their promised transformations to Europe and the world if they become technologically mature, can be taken into production, and are integrated into our societies. Member States of the European Union and the European Commission have taken leadership in the technological development of quantum technologies, and are, with the vision of becoming the world's Quantum Valley, scaling-up towards industrial production. The EU should urgently prepare to make the final step of shaping the integration of quantum technologies and their applications into our societies. This integration should not be done in a societally blind way: it should strengthen European prosperity, its independent position in the world, and the fundamental EU values of equity, freedom, security, sovereignty, sustainability, peace, and democracy. Within the EU there is ample knowledge about societally integrating technologies, and research communities are already applying it to quantum technologies. Collaboration between EU's quantum researchers, quantum industrialists and social researchers is however limited, leaving knowledge for governing this integration unused.

This vision document is an urgent appeal to policymakers of the EU Member States and the EC to actively incorporate societal research in the European quantum ecosystem. The final step of societal integration confronts us with creating responsible and meaningful quantum technologies that realize prosperity, sovereignty, and our values. Europe can address these challenges when it draws from societal research:

- A. Societal research should be incorporated in all phases of the quantum R&D value chain, for support to and collaboration with quantum research and industrialization;
- B. Policymakers should draw from societal research for the governance of quantum technologies.

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Quantum technologies

Quantum technologies, typically divided into quantum computation, quantum communication, and quantum sensing, have attracted increased attention in Europe over the last decade. Previously discussed mainly at physics conferences, these technologies have found their way to industry fairs, investor meetings, and governmental discussions. This rapid growth and success can be attributed to the fact that in the EU quantum research communities joined forces, initially in the [Quantum Manifesto](#) and later through the [Quantum Flagship](#), with a view to making the EU a global leader in quantum excellence and innovation. Partly in response to developments in the US and China, investments and interest in quantum technologies have surpassed the initial expectations of the EU quantum community. In 2016, a one-billion-euro investment was seen as a major achievement. Currently, EU-wide public investment pledges in quantum technologies exceed eight billion euros.

The rapid growth in public funding and the successful progress made in Europe are accompanied by an increasing acknowledgement that quantum technologies are key to Europe's economic, strategic, and societal development. The Quantum Manifesto already positions quantum technologies with respect to global economic competition. Political developments around the world, accelerated by events such as the COVID-19 pandemic, heightened geopolitical risks, and exacerbated ongoing military conflicts, have made quantum technologies of [strategic value to the EU](#). By the [Draghi report](#) the EU should create competitive industries for these strategic technologies. And the EU advanced a [Quantum Declaration](#), now endorsed by almost all of its Member States, for creating such an industry for quantum technologies.

European values

The Draghi report is not pleading for European competitiveness in a societally blind manner but presents the creation of independent technological industries as means for the EU to maintain its fundamental values of “prosperity, equity, freedom, peace and democracy in a sustainable environment.” It moreover identified security and avoidance of technological dependencies on other states as preconditions for sustainable growth and freedom. We hold that quantum technologies should similarly be developed for realizing [the aims and values of the EU](#). This means that applications of quantum technologies should contribute to our prosperity, our sovereignty, and to the development of societies in and outside of Europe because it is part of its values that the EU contributes in the wider world to support “solidarity and mutual respect among peoples, free and fair trade, eradication of poverty and the protection of human rights.”

Quantum technologies are expected to contribute to our economic prosperity, for instance, through the more precise modelling of molecules and materials in chemistry and pharmacy. Quantum technologies are expected to be of strategic value to the EU by, e.g., strengthening cyber security, as illustrate by the first identified applications of breaking regular encryption of digital communication by quantum computing and of providing inherently safe quantum encryption by quantum communication. Societal contributions are on the horizon, say when

quantum sensing and analysis by quantum computers lead to better environmental knowledge and control. We hold that the EU should take the lead in exploring and managing all the contributions quantum technologies can make. The Quantum Declaration calls for undertaking “activities to gain a deeper understanding of the social and economic impact of quantum technologies”; the EU should actively aim at efforts to translate that understanding into policies that make quantum technologies contribute to its fundamental values.

European societal research communities

Questions about what values the EU should uphold are societal, political, and cultural ones. Questions about how technologies and their applications impact, undermine, and support these values, are studied in fields such as technology ethics, legal studies, the social sciences and humanities, referred to by acronyms like ELSA, TA, STS, and SSH. Sometimes these fields are just called *ethics*; here we bring them together under the label of *societal research* on technology. Europe has ample expertise in this research with many groups that since the middle of the 20th Century study the impact and guidance of technologies. Some of these groups have already included quantum technologies in their scope and have become partners in the quantum ecosystem in a few Member States. The development of quantum technologies in other Member States and in the EU Quantum Flagship is more focused on technological and economic aims, sometimes captured by the vision of Europe becoming the world’s Quantum Valley. Europe’s chances to further extend its leadership in quantum technologies lie in substantially incorporating societal research in its efforts. A successful development of quantum technologies does not stop with inventing the technologies and creating the industrial capabilities to manufacture them. Technologies are successful when their applications become integrated into society, and societal research advances the knowledge to guide this final step in the development of quantum technologies.

There are good examples of societal research in the EU. In the Netherlands the national programme Quantum Delta NL for developing quantum technologies, has the [Centre for Quantum and Society](#) and the associated Action Line 4 focusing on the “[Societal Impact of Quantum Technologies](#)”. In Germany, efforts have been dedicated recently to the development of responsible quantum technologies under the [QuantWorld](#) project at TUM, and there are efforts to [study the potential social, legal, and ethical issues](#) that may arise from the application of these technologies on the ministerial level, and for [peace and security](#) at the parliamentary level. Austria is home to the [Innsbruck Quantum Ethics Lab](#), which focuses on developing ethical frameworks suitable for developing new quantum technologies, while France has the [Humanities for Quantum Sciences](#) based in Grenoble. Work on the governance of technologies through legal and standardization frameworks and concepts such as systems-of-systems, is done by the Denmark-based [European Quantum Readiness Center](#), part of the EU Quantum Flagship. The [Strategic Research and Industry Agenda 2030 \(SRIA\)](#) of the Quantum Flagship is stressing the importance of integrating ethical values and social objectives into the development of quantum technologies, and the above examples show that Europe has the societal research infrastructure for taking up these tasks.

Global efforts

European societal researchers are, in line with EU's global values of solidarity, mutual respect, eradication of poverty, and the protection of human rights, collaborating with efforts outside the EU towards socially responsible development of quantum technologies. Examples are the launch of the [Responsible Quantum Industry Forum](#) by [NQCC](#), the [Oxford Responsible Technology Institute](#) and the [UKRI](#) in the United Kingdom, the publication of the outputs of [The Expert Panel on the Responsible Adoption of Quantum Technologies](#) in Canada, the Australian Government's [National Quantum Strategy](#) with its strong focus on responsible innovation, and, in industry, the [declaration of IBM's commitment](#) to responsible development and Microsoft's efforts on [quantum for good and the societal impact](#) of quantum computing.

European societal researchers are moreover active in international and global actors committed to a value informed development of quantum technologies, such as [The Quantum Computing Governance Principles](#) prepared by the World Economic Forum, and the [Open Quantum Institute](#) by the Geneva Science and Diplomacy Anticipator for contributing to the United Nations Sustainable Development Goals. Finally, they participate in multilateral initiatives, like [OECD's Global Forum on Technology](#), UNESCO's [World Commission on the Ethics of Scientific Knowledge and Technology \(COMEST\)](#), that is taking up the ethics of quantum computing, and the United Nations 2025 [International Year of Quantum Science and Technology](#).

Actions

The EU should push through and include societal research on quantum technologies as a key element in its efforts. EU Member States and the EC have been taking leadership in developing an ecosystem for advancing quantum technologies and creating the industrial capabilities to manufacturing them. Incorporating social research extends and matures this quantum ecosystem and gives the EU and its policymakers the edge to also govern the final step of the societal integration of quantum technologies in a responsible and meaningful way.

The incorporation of societal research can help the EU quantum ecosystem in different ways:

1. Societal research on technologies can be descriptive by describing the state of the art and potential future impact of applications on societies and their values. This gives the EU quantum ecosystem intelligence for forecasting the impact of quantum technologies, and provides policymakers with information about the economic, strategic, and societal meaning of applications.
2. Societal research on technologies can be evaluative by assessing the ethical, legal, and social desirability of the possible future impact of applications. This may give the EU quantum ecosystem feedback on what impact of quantum technologies may be judged as meaningful in societies and what impact will be rejected, enabling policymakers to govern quantum technologies effectively. This feedback also brings in societal discussion in the ecosystem, including disagreement and political deliberation. The strength of including societal research in the EU quantum ecosystem is not that it provides quantum developers and policymakers with binary input about what is seen as

good and bad “out there” in society; this strength is in that it enables developers and policymakers to co-shape quantum technologies with society.

3. Finally, and in line with this co-shaping, societal research on technologies is increasingly aimed at actively contributing to developing applications to support our values and public goods, be it human prosperity, national sovereignty, sustainability, international solidarity, or the UN SDGs. This final contribution to quantum ecosystems includes explorations of how values and public goods are to be understood, and it includes finding ways to resolving conflicts between them. And for quantum technologies the list of values, public goods, and possible conflicts between them is growing, calling for expert support to policymakers. Quantum technologies may provide high security in the digital realm, strengthening privacy but undermining security surveillance. Quantum technologies may bring sovereignty but also protectionist policies that limit open science and international solidarity. And the economic Quantum-Valley focus on the development of quantum technologies is already competing with the strategic aim of state sovereignty, which will be extrapolated to defense, announcing future questions about the balancing of aims and values to be realized.

Call to Action

Under the leadership of Commissioner Henna Virkkunen, the European Commission is to launch further efforts to strengthen the EU quantum ecosystem. For making these efforts societally meaningful, the EU should develop the ability to integrate quantum technologies and their applications into our societies in responsible and meaningful ways.

Specifically, we recommend that national programme’s of Member States, the Quantum Flagship, and initiatives following out of the EU Declaration on Quantum Technologies, include societal research in two ways:

- A. Societal research should be systematically incorporated in all phases of the quantum R&D value chain, for support to and collaboration with quantum research and industrialization; collaboration is important for avoiding silo effects, and for letting societal research inform and be informed by research and development. One way to realize this collaboration is by making impact analysis of applications of quantum technologies and consultation of societal stakeholders compulsory,
- B. Provide policymakers of Member States and the EC through societal research with the intelligence and means to govern the integration of quantum technologies in our societies. One way to realize this support to policymaking is by creating Quantum Governance Panels on national or EC level, composed of members with societal, technological, and industrial expertise.

The EU has the ability to steer the societal impact of technologies towards its values, as demonstrated for example by its safeguarding of [the rights of citizens over their personal data in the digital realm](#), and the realization of [safety, transparency, traceability, and equity in the development of artificial intelligence](#). The time is now to do so also for quantum technologies.