

Progress Report

Quantum for All initiative



Introduction

This year marked significant progress in quantum technology, with rapid advancements bringing it closer to real-world applications. The United Nations General Assembly declared 2025 as the International Year of Quantum Science and Technology, following a similar decision and recommendation by **UNESCO**, focusing on responsible development to benefit humanity. **GESDA** played a distinctive role in those developments, continuously expanding the reflections around the future of quantum computing and its expected impact whilst collaborating with:

- **CERN**, to advance the **Open Quantum Institute** (OQI), supported by **UBS**, and
- **XPRIZE** and **Google Quantum AI** on the Quantum Applications XPRIZE competition.

In addition, GESDA

- updated the Quantum Computing brief in the GESDA Science Breakthrough Radar®
- worked on the future multilateral governance of quantum computing for the SDGs.
- explored means to activate deep tech companies for Quantum for All.

On 5 March 2024, CERN took over from GESDA to host the Open Quantum Institute with support of UBS. The OQI is meanwhile in full operating mode, with a community of 560 individuals involved. The OQI coordination team has onboarded three new staff. GESDA remains the lead for the diplomatic engagement. The OQI signed 18 agreements with key institutions to formalize their commitment and contributions to the Institute's mission. The OQI dedicated governance body, the **OQI Advisory Committee** has validated OQI's key objectives during its first meeting on 27 May and will again meet on 10 October 2024.

The OQI, hosted by CERN, born at GESDA, supported by UBS: <https://oqi.cern/>

OQI launch and pilot phase

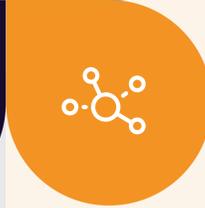
A1 Accelerating applications for humanity

We want to achieve the broadest possible societal impacts from the full potential of quantum computing. To accomplish that, we're working to accelerate the development of use cases geared towards achieving the United Nations' Sustainable Development Goals (SDGs) and its succeeding post-2030 framework. We're confident we can fulfill our vision thanks to the combined forces of researchers, developers and entrepreneurs from academia and private sector, as well as from the United Nations, and some prominent NGOs.



A2 Access for all

We want to provide global, inclusive and equitable access to a pool of public and private quantum computers and simulators via the cloud.



A3 Advancing capacity building

We are developing educational tools to enable everyone around the world to contribute to the development of quantum computing and to make the most of the technology.

A4 Activating multilateral governance for the SDGs

We are providing a neutral forum to help shape the multilateral governance of quantum computing for the SDGs



AI

Accelerating applications for humanity

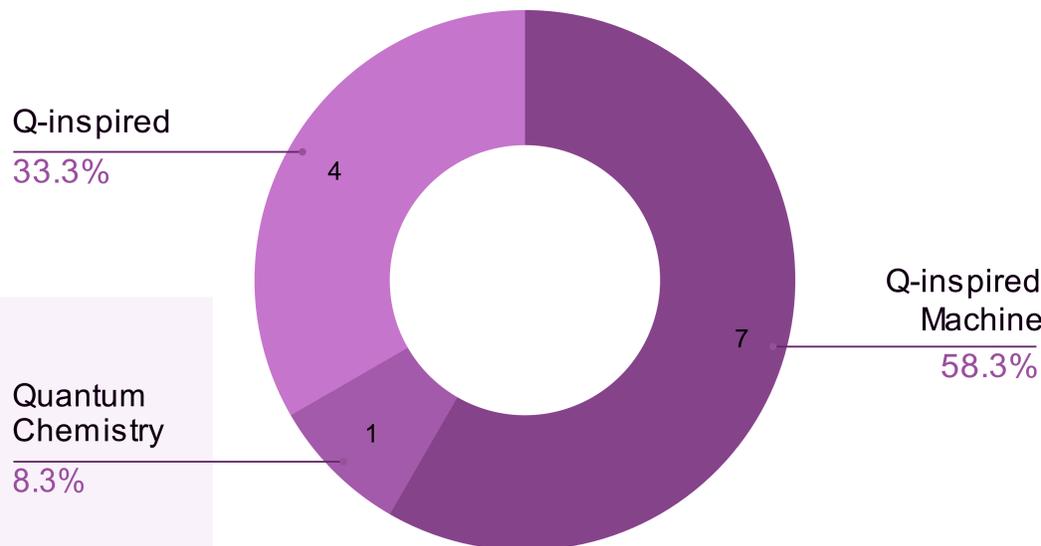
Open Quantum Institute

Two use cases (water management, food production) from the incubation phase are on track for first implementation on simulators by end of 2024. Ten additional use cases generated through a call for proposals issued in May-June 2024 are being nurtured and further calibrated.

AI Key achievements

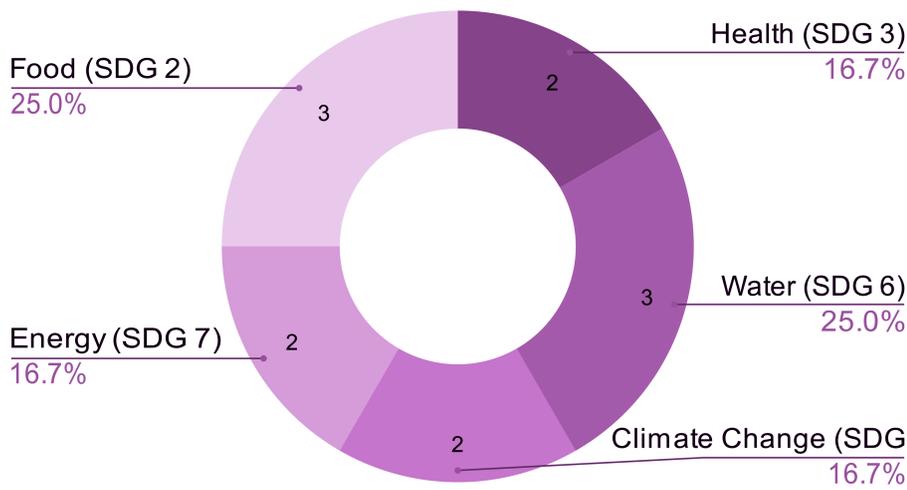
- **12 use case teams** are currently supported by the OQI, exploring the relevance of quantum computing for SDG 2, 3, 6, 7 and 13.
- **Quantum and subject experts** of the OQI community collaborate with U.N. agencies to explore the potential of quantum computing in these domains, with the support of OQI.
- **UN organizations**, such as UN Habitat, UNFCCC, WHO, WFP, UNDRR, FAO have either validated the use cases or are in the process .
- Like-minded organizations supporting OQI are collaborating to enlarge the repository of use cases, such as **XPRIZE Quantum Applications Competition** and **The Quantum Insider**. The OQI website is currently being updated with the list of OQI and externally curated use cases.

Quantum Approaches to SDG applications

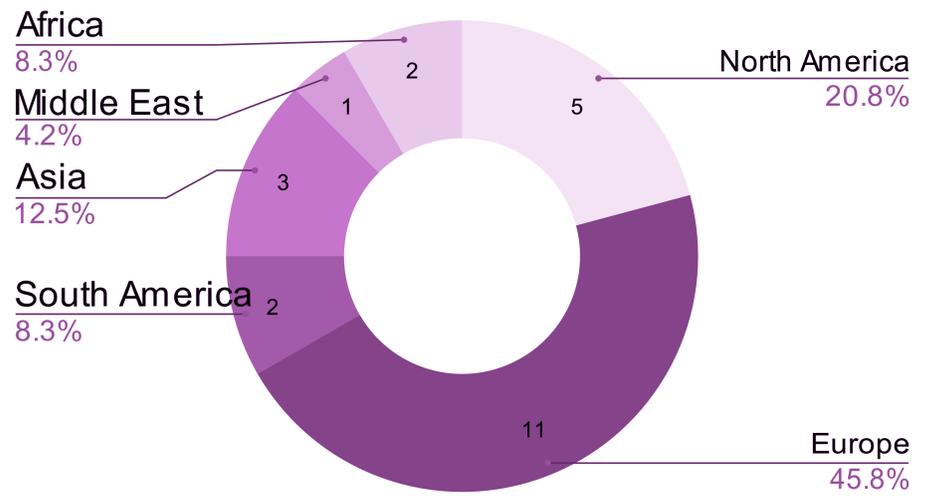


- **Experts participation across continents**, including: Africa (Morocco, South Africa), Middle East (Israel), Asia (India, Japan, Malaysia), Latin America (Brazil, Uruguay), North America (USA, Canada), Europe (Italy, Finland, France, Poland, Portugal, UK, Spain, Switzerland).

SDG relevance of quantum computing applications



Global participation to the OQI use case development



The two most advanced use cases are being tested on quantum simulators by end of 2024.



Water Leak Detection

This quantum machine learning solution could improve the placement of sensors that detect water leaks in urban water systems, helping prevent severe water crises. Rapid urban growth and aging infrastructure pose a challenge for many cities facing water shortages.

Mexico City's water shortages, for example, are exacerbated by the need to pump water uphill over long distances from sources outside the city. About 40% of that water is lost to leaks. Finding the leaks often is challenging due to the vastness and complexity of the city's water pipe systems. This network can be represented as a graph problem; classical computational approaches to the problem exist, but they struggle to cope with the complexity. Quantum algorithms could help find a better way to place sensors within a water distribution system to efficiently detect leaks. Accomplishing that would mark a turning point in the maintenance and repair of essential urban infrastructure.

Team: Quindata, SigmaReply, UN Habitat, Pasqal



Sustainable Food Production

This quantum optimization solution could produce more nutritious food locally on less land, accelerating improvements in the consumption of safe and nutritious food that is produced sustainably.

A nutritional value score for the application would take into account nutrient density and dietary factors related to non-communicable diseases. But societal, environmental, and economic factors would also need to be mapped. This class of optimization problems is known as mixed-integer linear programming. Classical algorithms to find approximate solutions (heuristics) for this class of problems exist but are computationally difficult. As a result, finding ways to optimize large-scale scenarios for crops, farmers, consumers and other factors is challenging with classical computers and algorithms and take too long to reach a solution. Quantum algorithms hold the potential to solve these optimization problems.

Team: École Polytechnique Fédérale de Lausanne (EPFL), Global Alliance for Improved Nutrition (GAIN), National Institute for Theoretical and Computational Sciences (NITheCS).

The table below illustrates some of the projects under development at the OQI. More details can be found in the OQI Use Case Whitepapers, available at <https://oqi.cern/applications/>

SDG (main)	Topics	Short description (Quantum approach; Phase of development; Experts; Countries)
<p>2 ZERO HUNGER</p> 	<p>Nutritious Food production</p>	<p>Quantum computing optimization solution to produce more nutritious food locally using less land, taking into account key food and environmental parameters.</p> <p>Combinatorial optimization (quantum inspired)</p> <p>Phase 2 – from the OQI incubation phase</p> <p>École Polytechnique Fédérale de Lausanne (Switzerland), National Institute for Theoretical and Computational Sciences & Stellenbosch University (South Africa), The Global Alliance for Improved Nutrition (U.K., Switzerland)</p>
	<p>Food security</p>	<p>Quantum computing optimization of the food supply chain, in particular in the route planning of food delivery in underserved regions impacted by climate change or other crises.</p> <p>Combinatorial optimization (quantum inspired)</p> <p>Phase 1 – reactivated from the OQI incubation phase</p> <p>QWorld (Poland), QAI Fondation (Poland), Hassan II University of Casablanca (Morocco), Yale University (U.S.)</p>
	<p>Plant Genomics</p>	<p>Quantum computing solution to improve wheat, corn and soy yield by targeted Genomics gene editing.</p> <p>Machine learning (quantum inspired)</p> <p>Phase 1 – reactivated from the OQI incubation phase</p> <p>QuEra (U.S.), Inari (U.S.), Eversoles Associates (U.S.), Venturus (Brazil)</p>
<p>3 GOOD HEALTH AND WELL-BEING</p> 	<p>Accelerating Novel Antibacterial Discovery</p>	<p>Quantum simulation and quantum machine learning solution to accelerate the antibacterial discovery and lower resistance.</p> <p>Simulation (chemistry), Machine learning (quantum inspired)</p> <p>Phase 1 – reactivated from the OQI incubation phase</p> <p>GARDP (UK), McMaster University (Canada), Università degli Studi di Cagliari (Italy), qBraid (U.S.)</p>
	<p>Molecular docking to clean up pollution</p>	<p>Quantum simulation and quantum machine learning solution to accurately model the chemical process of molecular docking involved in removing organic pollutants in water/air.</p> <p>Simulation (chemistry), Machine learning (quantum inspired)</p> <p>Phase 1 – from the call for submission</p> <p>Quandela (France), QunaSys (Japan)</p>
	<p>Predicting Gastrointestinal Cancer</p>	<p>Quantum machine learning solution to improve accuracy of gastrointestinal cancer diagnosis and speed up medical treatment and prevention.</p> <p>Machine learning (quantum inspired)</p> <p>Phase 1 – from the call for submission</p> <p>University of Coimbra (Portugal)</p>

A1 What's next

- Collaborating with the **quantum experts on the OQI Advisory Committee** to create a **“cookbook” on how to build use cases**, in particular on keeping rigor in the selection and application of quantum algorithms, so that the level of quality continues to improve while a broader community participate in the use case development. Ongoing **targeted ‘call’ for additional use case ideas**, with the objective of a consolidated pipeline of about 20 high quality use cases in 2025. **Balanced geographical representation and application domains** are important targets and support of the diplomatic community is welcome to achieve it.



A2

Access for All

Open Quantum Institute

Nine partnership agreements with industry providers transferred to CERN, with expanded scope (support in expertise to develop use cases in addition to the capacity on devices), four agreements signed.

A2 Key achievements

- The **9 incubation industrial partners** are renewing their partnership with OQI for the pilot phase. Their support and contribution span from providing free access to their simulators and quantum computing devices and supporting the implementation, providing technical support, actively participating in use case development, actively participating in co-developing educational resources, including supporting the deployment of future OQI hackathons.
- **1 use case** (on water leak detection) is currently working with an industry partner (Pasqal) to perform the **first tests on a simulator**.

A2 What's next

- 1 use case (on nutritious food production) will be reaching similar phase as the one on water leak detection by end of 2024.
- Continued **consultations with industry providers** to perform a selection of use cases that best fit the different quantum computing devices, as well as to provide expertise throughout the development of the use cases. Target for the implementation of selected relevant use cases is Q3 2025.

A3



Advancing capacity building

Open Quantum Institute

OQI's educational consortium brings together domain experts, quantum experts and diplomatic stakeholders to align on and co-shape best practices in advancing capacity building, avoiding duplication of efforts and making capacity building initiatives, educational tools and material globally available.

A3 Key achievements

- Active **OQI Educational Consortium** is set up
- 11 membership agreements signed
- First jointly vetted OQI educational products are launched, including a “**hackathon in a box**” that is put at disposal of the community in view of 2025 International Year of Quantum Science and Technology (IYQST25).
- Preparation for the **deployment of the educational products in 2025** are ongoing with excellent traction (manifestation of interest to deploy specific OQI supported activities with the support of OQI consortium on the 5 continents).
- OQI is an **IYQST25 UNESCO Steering Committee member**, actively shaping the activity programme. The IYQST25 received a similar endorsement by UNGA in June 2024.

A3 What's next

- Additional products and activities (internship, mentorship programmes, targeted courses focusing on **how to build quantum applications for the SDGs**, “train-the-trainer” workshops for the deployment of a hackathon for instance) are being prepared for deployment in 2025-2026 , in line with IYQST25.
- In 2025, the OQI will **roll out OQI educational activities globally on 5 continents** (impacting **quantum-underserved geographies** through amplification of OQI's activities and piloting of new activities as key support of IYQST25).
- OQI targets diplomates/policymakers to play **OQI's quantum diplomacy serious game** during 2025 and offers support to lead institutions to host the game.
- OQI targets young researchers and developers to participate in a hackathon. OQI will support lead institutions who host the hackathons through its **hackathon-in-a-box toolkit**. OQI will also provide a mutualized educational program to support qualitative and impactful hackathons (including a training program for hackathon organizers (hosts), and upskilling of participants ahead of the hackathons and ad-hoc support by the OQI pool of mentors.

- Initial **manifestation of interest to organize a hackathon** has been expressed by Abu Dhabi, Egypt, Ghana, Lebanon, Malaysia/Singapore and Costa Rica.



OQI

Quantum diplomacy game



This simulation serious game, a role play on quantum diplomacy, was developed and tested by GESDA with its diplomatic community and advisors during the incubation of the OQI. The game's objective is to raise awareness of the geopolitical implications of quantum computing as an emerging technology.

This resource promotes science diplomacy to be anticipatory, action-oriented and to promote inclusive public private partnerships.



OQI

Quantum for SDGs hackathons



OQI's hackathon-in-a-box is a step-by-step guide to organize hackathons at the nexus of the application of quantum computing and the SDGs, available by September 2024 on OQI's website.

This resource offers a comprehensive toolkit for developing quantum for SDGs hackathons including timeline, a realistic overview of the entire organizational chain behind a functional hackathon, tips for creating a wide community of alumni, collaborators and sponsors that could help broaden educational access to quantum computers

A4



Activating multilateral governance for the SDGs

Open Quantum Institute

Commitment to shaping multilateral governance is crucial in ensuring that quantum technologies are democratized and integrated into global policy frameworks and strategies.

A4 Key achievements

- Involvement of **OQI Diplomatic Engagement Expert Group (DEEG)** in key events, providing updates on the intelligence report and quantum governance state of play, ensuring constant feedback and collaboration
- Delivery of a **regional briefing** to the Latin America and Caribbean regional group **GRULAC** specifically tailored to address the region's unique challenges that could be addressed with current quantum technology use-cases

- Participation in “ad hoc events”
 - UNIDIR event for “Quantum Technologies and Their Implications for International Peace and Security” by **UNIDIR**
 - **FAO’s** panel on quantum computing for Agrifood systems, presenting use-cases and scope of OQI
 - Science and Technology Diplomacy Series
- Update of the **Intelligence Report on Quantum Diplomacy** for the Sustainable Development Goals (SDGs) with two new chapters on Human Agency and Quantum Cryptography

A4 What’s next

- Diplomatic engagement is expanded to promote science and futures-literacy and anticipatory action, notably on quantum computing for good, and to organize the **2025 Quantum Diplomacy Symposium** (June 2025).
- A specific panel at the 2024 GESDA summit is organised, focusing on how **academics, industry leaders, and policymakers** can collaborate to build global capacity, leveraging the UN Year of Quantum Science and Technology (UNYQST), and activate a market for **quantum applications** that benefit humanity.
- **Innovations Dialogue on Quantum Technologies** and their impact on peace and security is co-organized with UNIDIR (November 22, 2024).



Participants to the Quantum Diplomacy Symposium

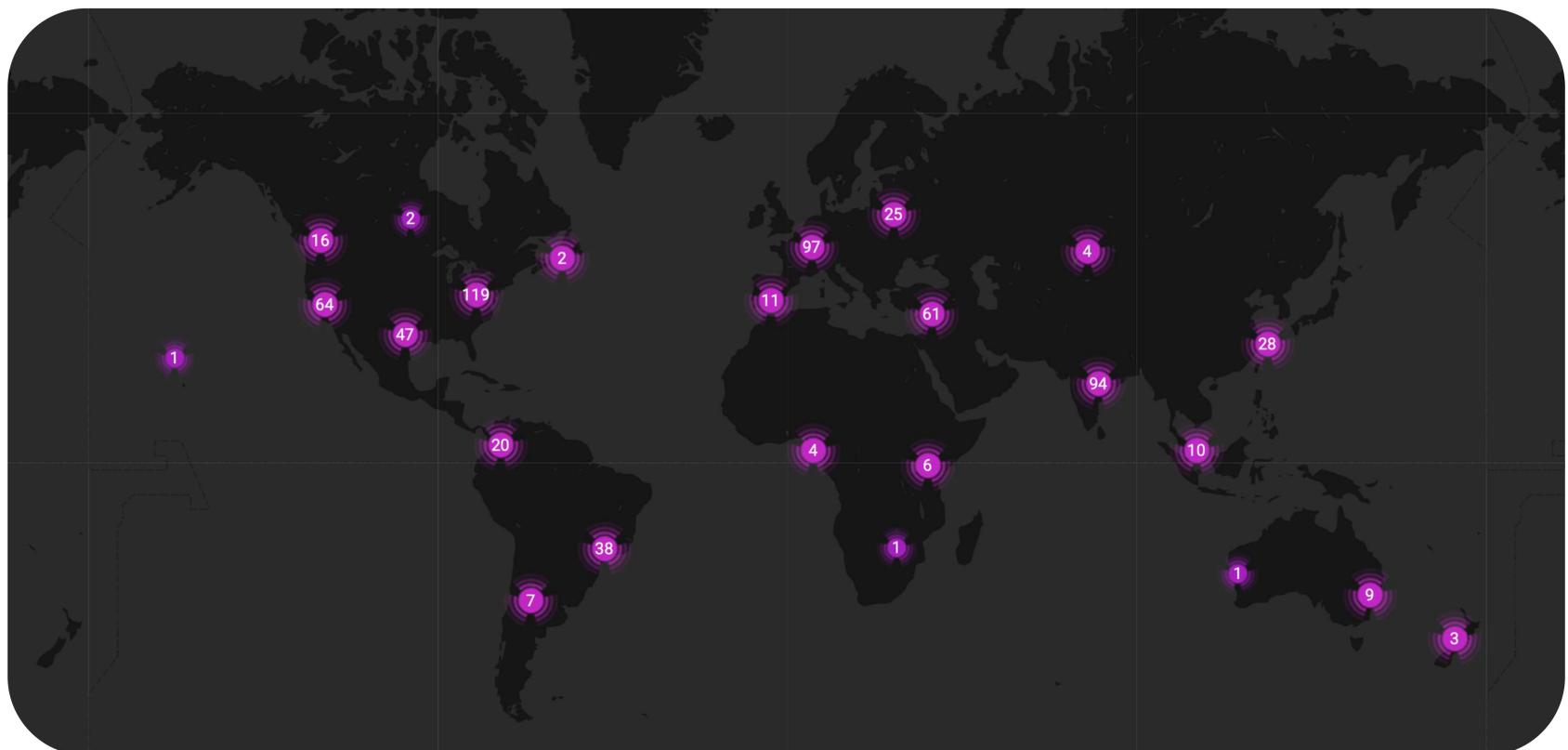
Quantum Applications XPRIZE supported by Google Quantum AI and GESDA



XPRIZE, Google Quantum AI and GESDA are positioned as a collaborative force driving innovation and motivation in the quantum field.

XPRIZE Quantum Applications is a 3-year, \$5M global competition designed to generate quantum computing (QC) algorithms that can be put into practice to help solve real-world challenges.

- The **visibility of the prize in over 95 new outlets with 593.1M+ impressions** raises awareness on the potential of developing quantum applications that can address real-world challenges.
- The development of uses cases could potentially help to build a **pipeline of investment opportunities**.



- By August 2024, 440 teams from 63 different countries at least started the registration process to participate in the competition. As of Oct 2024, more than half of them, **240 teams are fully registered representing 43 countries**. On the prize website (<https://pop.xprize.org/prizes/xpqa/overview>) an interactive map displays their location (cf. screenshot above).

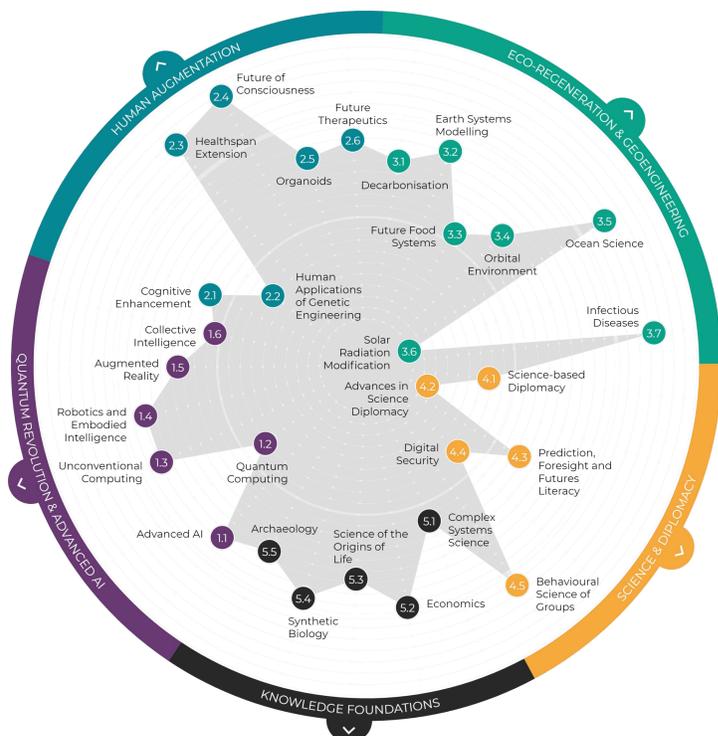
Quantum Computing brief in the GESDA Science Breakthrough Radar®



Key Takeaways

After more than 40 years in development, quantum computing is coming of age, and looks likely to become a multi-billion-dollar industry over the next couple of decades. Though progress has been faster than expected, Quantum hardware development remains a challenge, and there is still no consensus over which of the many hardware approaches will eventually achieve scalable fault-tolerant quantum computation. Similarly, Quantum algorithms design is still in its early stages, and the number and range of applications that are uniquely suited to quantum computing remain small. Because noise-inducing disturbances of any kind are a fundamental obstacle to quantum computing, a significant effort is being made in the field of Quantum error correction and noise mitigation. Here too, there is reason for optimism, as implementations are growing in complexity. Implementations of Near-term applications of quantum computing are achieving not only proofs of principle, but also rudimentary — and promising — advances in areas such as battery development and cancer treatment.

More at <https://radar.gesda.global/>



Survey Observations

Impactful breakthroughs in Quantum Computing are expected to happen with a high level of confidence in five to 10 years. Developments in hardware and algorithm design are the sub-topics with highest transformative effects. These are the areas that also require more internationally coordinated action to realise future opportunities, driving the high Anticipation Potential score of this field

Quantum Diplomacy Symposium

The organization of the first **Quantum Diplomacy Symposium** on June 17, 2024 represented a fundamental landmark for the Quantum for all initiative. The symposium -a multistakeholder event with more than 70 participants from all GESDA's communities- aimed at fostering dialogue between Permanent Representatives in Geneva and other international key stakeholders, representing a concrete attempt to anticipate the future **multilateral governance of quantum computing for the SDGs**



Highlights from the Symposium include:

- **Encryption and Security:** The imminent threat posed by quantum computers to current encryption systems, necessitating a swift transition to post-quantum solutions for data protection and IT interoperability.
- **Value Chains and Sovereignty:** Quantum computing's critical choke points in global value chains, with the need for multilateral coordination to ensure technological sovereignty.
- **Access and Education:** The risk of quantum computing exacerbating digital inequality, highlighting the urgent need for actionable information, education, and upskilling in quantum technologies.
- **Human Capital:** The ongoing quantum talent gap, with high demand for software expertise and enterprise readiness, while training programs are expanding in Europe and the USA but remain limited in emerging economies.
- **Human Agency:** The impact of quantum computing on human agency, with regional gaps emphasizing the need for futures-literacy and adequate multilateral governance to ensure equitable decision-making and action to realize the SDGs.

Activation of deep tech companies for Quantum for All

GESDA hosts with the leading investment fund in the quantum field, Quantonation, an exclusive event

- GESDA invited 40 experts to discuss **market opportunities for quantum technologies** on October 2024.
- GESDA, XPRIZE, ID Quantique, whose R&D center is located in Geneva, and Qnami, a start-up in which quantonation has invested will take part.
- The objective is to **validate** that the **'Quantum for All' initiative** is creating investment opportunities and economic value, particularly for Geneva.

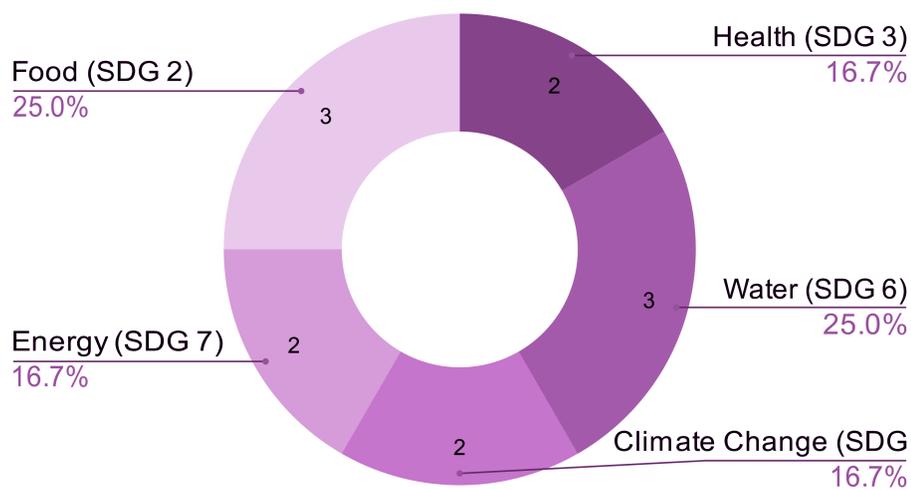
Workshop of the GESDA Impact Forum at the GESDA Summit 2024 positions the Quantum for All Initiative as a use case for a "deep-tech-for-all" type investment vehicle

- Workshop takes place on 11 October, 14.00 – 16.30.

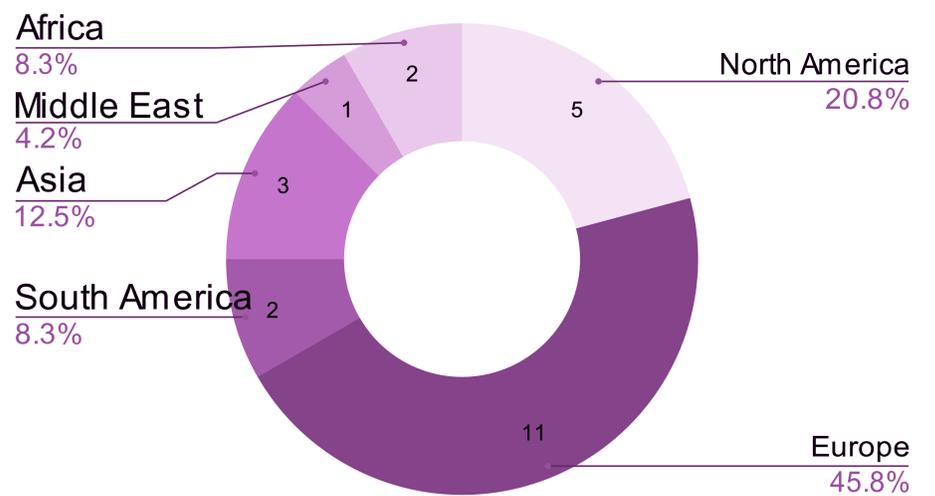
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SDG relevance of quantum computing applications



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