OQI
Open Quantum
Institute

OQI Quantum Application Framework

Geneva · October · 2025

Table of Content

1. Introduction

As part of the Open Quantum Institute's general mission to promote global, equitable and inclusive access to quantum computing, OQI is working to rebalance the focus of quantum computing applications towards creating impact for the benefit of humanity, while counteracting the hype effects. To advance this goal, OQI is building a curated repository of SDG use cases [1], designed to inspire the global community of researchers and developers.

Although the technology is still at an early stage, there is value today to anticipate the potential benefits of quantum computing for humanity. The international R&D quantum community is dedicating increasing effort to exploring where quantum computing could effectively be applied—with tremendous potential on the economy and safety. Yet the finding is unanimous: this is a hard endeavor. Determining the right set of problems that can rigorously demonstrate potential advantage against conventional computing is complex. It requires not only a deep knowledge of quantum computing algorithms and their practical implementation on quantum devices, but it also requires a deep understanding of the application domains and the current limitations of the most advanced conventional computing approaches.

OQI is taking on an additional challenge of exploring which types of applications would have a beneficial impact on society and our planet, ensuring an alignment with the UN agenda to accelerate the achievement of the SDGs and beyond, while minimizing the risk of anyone being left behind in the quantum revolution. Over the past three years, OQI has developed a rigorous framework to explore use cases relevant to the SDGs.

Such use cases focus, for instance, on SDG 3 (Good Health and Well Being) exploring how quantum computing could accelerate the discovery of new antibiotics or better understand drug metabolisms to reduce side effects; on SDG 6 (Clean Water and Sanitation) by improving water management by optimizing the placement of water leak detectors in urban water distribution networks or with modeling groundwater resources to monitor climate change effects and contaminant breakthroughs; on SDG 13 (Climate Action), by enhancing weather and climate forecasting models or predicting flood risks in vulnerable regions. A full overview of the OQI use case portfolio is available in the online repository of SDG use cases [1], and detailed descriptions in the 2022-2025 Use Case White Papers ([13]-[16]).

The multifaceted nature of quantum computing applications for the SDGs requires a thorough exploration with continuous alignment with the evolving state of the technology. OQI's role is to remain agile—integrating new findings that emerge from the scientific community and pushing the use case exploration as far as the technology allows.

This **OQI Quantum Application Framework** is based on OQI's experience working with use case teams from all around the world on specific global challenges—where quantum computing could contribute to a novel solution. Four key aspects are intrinsic to this framework:

- **Multidisciplinarity**
- **Multi-phase development**
- **Access**
- **Pathway to impact**

This framework offers practical guidelines and a methodology to support the global community in developing robust quantum computing use cases that address global challenges. OQI provides a platform for collaboration and mentorship, bringing together multidisciplinary use case teams composed of quantum experts, domain experts and SDG experts from UN or large NGOs to develop use cases. The use case development phases progress from ideation to a proof of concept, with OQI providing technical and project management support. If resources permit, selected use cases may receive free credits for testing and implementation on early quantum simulators and quantum processors via OQI's partners' cloud platforms.

OQI is fostering the growth of a global community of practice dedicated to rigorously exploring potential quantum solutions to address real world problems. With OQI, this global community contributes to the UN agenda while preparing for when quantum computers will be available at scale. In this context, OQI focuses on demonstrating the applicability of existing quantum methods, rather than discovering new ones. While some ideas generated through OQI collaborations may reveal the need for new quantum methods, their research and development lie outside the scope of OQI's focus and support.

In the following sections of the **OQI Quantum Application Framework**, detailed information is provided to guide through the use case development:

- **What is quantum computing and what are the SDGs**
- **What are the phases of development of use cases supported by OQI**
- **What are the roles and responsibilities of diverse stakeholders**

2. Focus of OQI: Quantum Computing Applications for SDGs

2.1 What is Quantum Computing?

Quantum computers exploit quantum mechanics—the laws of physics that govern the behaviour of matter at the very small scale. Quantum computers are not general-purpose, and for many tasks they provide no advantage over current computational technology. But, for certain problems they can, in theory, provide unprecedented computational benefits (e.g. speed-ups, accuracy) over classical computers [2]. These capabilities could impact key economic sectors, including pharmaceuticals, materials science, chemistry, energy, finance, security, and logistics. Quantum computers could also help address a range of challenges central to the SDGs.

The most relevant approaches for quantum computing applications towards the SDGs can be grouped under the following categories:

— **Quantum simulation [3]:** to model quantum systems at the nanoscale and below, where quantum effects are significant and relevant to physical, chemical and biological processes. Quantum computers are a natural fit for simulating quantum phenomena, and could offer greater accuracy for modelling large quantum systems and exponential speedup over what is intractable on classical computers.

— **Machine learning [4]:** to improve the predictive ability of statistical models and to analyse and draw inferences from data patterns. This approach is particularly promising for applications involving small datasets, which are challenging to learn using current machine learning approaches.

— **Optimisation [5]:** to approximate the optimal solution to a problem (i.e. maximising or minimising an objective function) with a large number of options and constraints, including through heuristic approaches.

— **Linear system of equations and partial differential equations (PDEs) [6]:** to simulate complex, high-dimensional processes and dynamics through solving linear systems of equations and PDEs.

Other quantum approaches, with limited relevance to SDGs, also exist. For instance, factorisation is the process of breaking numbers down into smaller ones and serves as the basis of modern encryption schemes [7]. While important in the realm of cybersecurity, its direct relevance to the SDGs is more limited.

It is important to emphasize that the categorization of quantum approaches above is independent of the performance of the related (quantum or quantum-inspired) algorithms. In this sense, a specific quantum approach does not necessarily imply that the (quantum or quantum-inspired) algorithm, if implemented, would outperform classical benchmarks. We make a distinction between quantum and quantum-inspired algorithms:

— **Quantum-inspired algorithms** are classical in nature, but are inspired by quantum physics / quantum algorithms [8], [9]. Such algorithms are designed to run on classical computers and offer performance improvements. However, they are not a substitute for quantum computing solutions.

— **Quantum algorithms** harness quantum mechanics principles and are designed to run on quantum computers, offering potentially an advantage for specific problems. An exhaustive list is available on the Quantum Algorithms Zoo [10].

In support of exploring the most promising use cases, the OQI scientific committee works alongside the broader scientific community to build a compendium of problems that have identified promising prospects for a super-quadratic quantum advantage. This is an effort to rigorously define the "regimes of advantage", i.e. the conditions or constraints that must be satisfied for meaningful applications of quantum algorithms. This compendium is a critical tool that aims to serve not only the OQI community, but also the wider quantum community – academic and private sector – in the collective pursuit of quantum advantage.

This compendium will be available online soon on OQI website.

2.2 What are the Sustainable Development Goals (SDGs)?

In 2015, the United Nations Member States adopted the 2030 Agenda for Sustainable Development, which provides a shared blueprint for achieving peace and prosperity for both people and the planet, now and in the future. There are 17 Sustainable Development Goals (SDGs) [11] each with clear targets and actions addressing the global challenges, including those related to poverty, inequality, climate change, environmental degradation, peace and justice. All 17 SDGs are interconnected, recognising that development must balance social, economic and environmental sustainability. The UN is working on a succeeding framework [12] for global partnerships beyond the 2030 Agenda.

A core mission of OQI is to harness quantum computing to address the SDGs. OQI's science diplomacy community supports and emphasises the importance of anticipating the readiness of quantum computers and identifying future SDG-relevant use cases for quantum researchers and developers to start exploring now.

Quantum computers are still under development, with a timeline for reliable, scalable devices operational in the next 5 to 25 years. Today, SDG-relevant use case solutions can already begin to take shape with small-scale proof of concepts using currently available quantum simulators and processors. This approach will guide the R&D community to focus on areas with the greatest potential to contribute to the UN 2030 Agenda for Sustainable Development and its succeeding framework.

2.3 Examples of OQI use cases under development

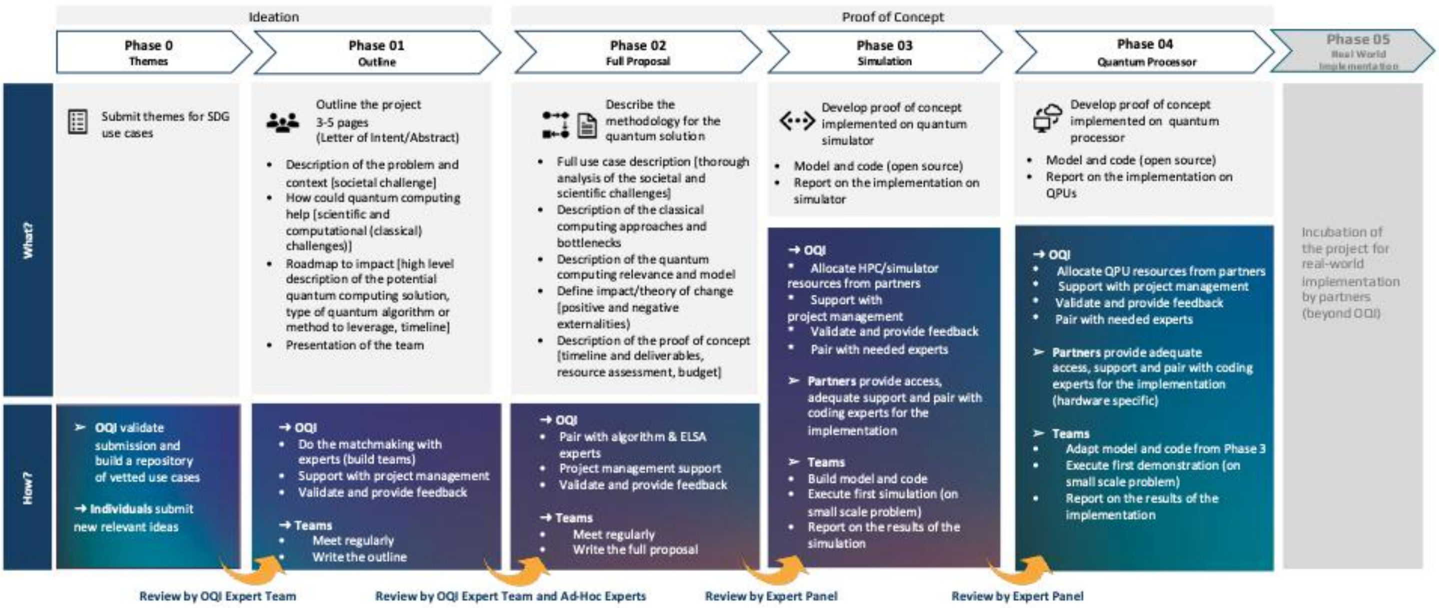
Examples of use case outlines can be found on the OQI website [1] and in the OQI SDG Use Case White Paper 2025 [13], White Paper 2024 [14] White Paper 2023 [15] and White Paper 2022 [16]. New proposals should not be limited to the topics and examples illustrated on the OQI website.

3. Process for developing a use case with OQI

The development of use cases with OQI is a multiphase process, as outlined below. Due to the current low maturity of quantum computers and the varying complexity of potential use cases, only a selection of proposed use cases is likely to progress to advanced stages, such as simulation on classical supercomputers and implementation on quantum devices.

As a governance initiative rather than a research institute, OQI focuses its efforts on identifying and supporting quantum computing use cases that align with the SDGs.

3.1 Use case development phases



3.1.1 Ideation

The first two phases focus on clearly defining the problem statement in relation to the SDGs and assessing its suitability for quantum computing. Selected ideas contribute to building a large repository of vetted use cases. The ideation is sub-divided into 2 phases:

— **Phase 0:** Initial selection of use case ideas
This is the starting point for identifying relevant SDG challenges that can be addressed by quantum computing. OQI is building a large repository of use case ideas to further inspire and encourage more participation in the journey. This repository is populated through direct contributions (e.g. call for submissions, workshops, etc.) and through the curation of external use cases initiatives (e.g. OQI partners and like-minded organisations). Submission of use case ideas can be done through the online form [17].

— **Phase 1:** Refinement of selected ideas, with OQI support, into more concrete use cases. This refinement process leads to the preparation of an outline, following the OQI outline template (Annex 1). The outline describes the context surrounding the identified SDG-relevant problem, including the societal and scientific challenges that can be addressed with computational solutions. It outlines how quantum computing could potentially help and the expected impact of such an innovative solution. The outline is reviewed by the OQI Coordination Team, and, as needed, may be consulted with an expert panel spanning diverse areas of expertise (quantum, domain specific, impact and SDGs). An extract of the outline is then featured as contributions to the annually published OQI Use Case White Papers [13]-16].

3.1.2 Proof of Concept

A few use cases are selected for OQI support (technical and financial) to move to advanced phases and develop a **proof of concept (POC).** In the context of OQI, a **POC** is a demonstration that quantum computing can solve a problem, either on current quantum hardware devices, within the Noisy Intermediate-Scale Quantum (NISQ) era, or in terms of future Fault-Tolerant Quantum Computing (FTQC) hardware. This problem must also be representative of a real-world SDG problem, and its quantum solution must aim to provide some sort of advantage over its classical counterparts, at least when being deployed on FTQC.

Going through the process of the POC, the use case team rigorously assesses the complexity and computational challenges and analyses the potential (feasibility) of a quantum computing solution, with the identification of the quantum approach (quantum or quantum-inspired), the resources needed, the benchmarking strategy against state-of-the-art classical approaches, the timeline for an implementation on quantum devices, which could lead—resources permitting—to testing on quantum devices. The proof of concept is sub-divided into 3 phases:

— **Phase 2:** Development of a POC, with OQI support. This leads to the preparation of a full proposal, using the OQI full proposal template (Annex 2). The full proposal should detail the POC, with its methodology—including planning, developing the computational model with a rigorous justification of the quantum approach and a strategy for benchmarking with classical computers, with the aim of demonstrating a potential quantum advantage, at least in the FTQC context. It includes a rigorous resource assessment, which is a projection of the needs for (i) HPC simulation, (ii) current quantum computing hardware (NISQ) and/or (iii) scalable solution on future quantum platforms (FTQC). It also presents an impact assessment of the potential quantum solution. Following the completion of the full proposal, the OQI scientific and impact panels with diverse expertise (quantum, domain specific, impact, SDGs) review it and provide feedback on the value and feasibility to move to the next phase.

— **Phase 3:** If a small-scale POC is implementable on today's quantum simulators accessible on the cloud and could lead to meaningful results, then this phase is designed to test and optimize the potential quantum computing solutions. OQI offers cloud access to selected projects to implement their POC, through close collaboration with OQI's quantum computing provider partners. The results of the simulations are reviewed by the OQI scientific and impact panels to provide feedback on the value and feasibility to move to the next phase.

— **Phase 4:** If Phase 3 is satisfactory, implementation on suitable cloud-available quantum processors, depending on the type and size of the proof of concepts, is then considered. The results of the implementation then inform a scaling assessment to evaluate the performance on future large-scale fault-tolerant quantum computers (FTQC). This phase is also carried out in close collaboration with OQI's quantum computing provider partners.

— **Phase 5:** Testing and deployment in the real world—this phase goes beyond the responsibility of OQI, although OQI may help in finding a sponsor.

3.2 Pathway to impact

While quantum computing technology is central to the exploration of use cases, the benefit for humanity of each solution is equally essential–and the raison d'être of OQI.

In collaboration with its impact committee, OQI has developed an impact anticipation framework to articulate, anticipate the benefits for the population, planet and prosperity of use cases once deployed in the real-world. Based on the Theory of Change, it maps the conditions and steps that would lead to the intended long-term impact. It ensures the engagement of relevant stakeholders and accounts for both risks and unintended consequences. It also maps the interlinkage between relevant SDGs, illustrating the multifaceted impact of a quantum computing use case.

This impact anticipation framework provides a timeline for real-world implementation, as well as a pathway to prepare the necessary conditions for when the technology will be available at scale and the quantum solution ready to be deployed. Small-scale pilot projects (Phase 5 and beyond), carried out with local communities who stand to benefit most, lay the foundations for building local capacity and infrastructure needed for sustainable adoption of the quantum-enabled solution. Embedding impact thinking and design from the start of the ideation helps developers to not only contribute to technological advancement but also to a purpose driven innovation ensuring alignment with societal transformation.

Link to the Impact Anticipation Framework (to be available online soon on OQI website).

3.3 Selection and evaluation process

In this multi-phase exploration of relevant and impactful use cases, it is natural that some use cases are concluded after the ideation or during the proof of concept stages. To keep the use case pipeline relevant, OQI engages leading experts at every stage, ensuring alignment with both the current state and the evolving capacity of the technology. In practice, this may mean that highly SDG-relevant problems may be paused if they cannot yet be addressed due to resource demands or technological limits, or if the scientific community recently demonstrates that a selected quantum approach yields no meaningful advantage over classical methods. Conversely, previously concluded use cases may be reactivated as technology advances or new approaches emerge from the scientific community. Through this continuous review, OQI ensures its use cases remain scientifically rigorous, socially impactful, and responsive to progress in quantum computing.

At the proof of concept stage, the OQI scientific panel and the OQI impact panel are also involved to assess the quality of use cases. This evaluation is crucial to maintain scientific rigor and SDG-alignment, neutrality, and transparency. It is a key step to guide in the progress of the use cases and to ensure that today's scarce quantum computing resources are used for the implementation of the most feasible proof of concepts.

The evaluation of use cases to move to an advanced phase is based on three main criteria:

1. Relevance, feasibility and readiness of the proposed quantum solution
2. Level of global impact
3. Quality of the team

General evaluation criteria	
Scientific & computational relevance	a. To what extent is the proposal scientifically sound? b. To what extent is the problem defined and detailed mathematically? c. To what extent is the computational approach framed, and to what extent are classical bottlenecks clearly identified? d. For data-driven problems, to what extent has the team secured access to relevant datasets (ideally real-world datasets, or a clear method for generating synthetic datasets)?
Quantum computing relevance	a. To what extent is there a detailed justification of the relevance and need for quantum computing (e.g. does the level of complexity of the problem require quantum computing)? b. To what extent are the computing resource requirements estimated (for scalable solutions on future quantum platforms and HPC simulation)? c. To what extent is the benchmarking strategy against state-of-the-art classical computing solutions detailed? d. To what extent could a small-scale proof of concept be tested on small-scale devices (NISQ) with potentially meaningful results? *e. In phases 3 & 4 - Is the code adapted to an implementation on a quantum simulator and/or quantum processor?*
Impact relevance	a. To what extent does the quantum solution meet a "business" need (e.g. challenge validated or prioritized by an IGO)? b. At a local level, to what extent is impact assessed on people, planet, and prosperity conducted across short-, medium-, and long-term timeframes? c. At a global level, how transposable is the use case to other contexts? d. At a macro-level, to what extent have the interlinkages between SDGs been clearly assessed (benefits vs risks to negatively impact other SDGs)?
Use case team composition	a. How diverse and inclusive is the team, in terms of geography and demography? b. To what extent does the team have the necessary expertise and means to achieve the project? c. How much is the team able to collaborate openly across multiple stakeholders (e.g. IP limitations, private data)?

OQI provides support, with constructive feedback and access to a network of experts, throughout the use case development process to maximize the progress of the projects and ensure high quality use cases. The table below summarizes the selection process.

	Deliverable	Selection Committee	Additional Step
Phase 0 to Phase 1	Detailed use case idea	OQI coordination team, with the support of the CERN-QTI.	
Phase 1 to Phase 2	Outline (see template Annex 1)	OQI coordination team, with ad hoc consultation with multidisciplinary experts of in-depth knowledge on quantum computing applications and/or in SDGs and its succeeding framework.	For use cases deemed to be eligible for Phase 2, the use case team is invited to prepare an action plan (see template in Annex 4), including an assessment of the budget and resource required to complete a full use case proposal (deliverable of Phase 2). Once this plan is approved, the use case team proceeds to Phase 2.
Phase 2 to Phase 3	Full proposal (see template Annex 2)	OQI coordination team, with a panel of multidisciplinary expert panel of in-depth knowledge on quantum computing applications and/or in SDGs and its succeeding framework and quantum computing provider. Recommendations and constructive feedback are shared with the teams – without possibility of complaint and dispute.	For use cases deemed to be eligible for Phase 3, the use case team refines its action plan (see template in Annex 4), including an assessment of the budget and resource required to complete an implementation on simulator (deliverable of Phase 3). Once the plan is approved, the use case team proceeds to Phase 3. The use case team then works closely with the selected quantum provider to plan an effective implementation.
Phase 3 to Phase 4	Open-source code and report on the simulation results (see template Annex 3)	OQI coordination team, with a panel of multidisciplinary expert panel of in-depth knowledge on quantum computing applications and/or in SDGs and its succeeding framework and quantum computing provider. Recommendations and constructive feedback are shared with the teams – without possibility of complaint and dispute.	If simulation results are satisfactory and could lead to realistic implementation of the code on a quantum processor, the use case team refines its action plan (see template in Annex 4), including an assessment of the budget and resources required to complete an implementation on a quantum processor (deliverable of Phase 4). Once the plan is approved, the use case team proceeds to Phase 4. The use case team then works closely with the selected quantum provider to plan an effective implementation.

4. Multistakeholder collaboration

OQI serves as a neutral platform to support use case teams of multidisciplinary backgrounds to work on use cases. In particular, OQI is working to foster inclusive and equitable participation by collaborating with researchers and developers from regions historically marginalized in access to emerging technologies and training (defined below as "quantum-underserved geographies").

4.1 Key stakeholders and what's in it for them

UN Organisations & large NGOs	— Participate in the acceleration of achieving the SDGs and succeeding framework — Inject innovation for future solutions of existing/projected real-world issues — Think out of the box through exposure to quantum and domain expert networks — Foster interdisciplinary collaboration
Domain experts	— Exposure to quantum and UN networks — Apply their expertise on solutions to validated real-world issues — Access new funding streams — Access new datasets
Quantum experts	— Access UN and domain expert networks — Apply their quantum expertise on solutions to validated real-world issues — Access free quantum computing resources for proof of concepts — Access new funding streams — Publish high impact publications with OQI affiliation
Quantum industry	— Access talent (new hires) — Showcase their technology capability, with validated real-world issues and benchmark against other providers — Participate in global sustainability effort — Access UN and domain expert networks
Countries	— Build local capacity - related to OQI's educational pillar (A3) — Bring quantum computing applications to local areas

4.2 Use case participants

Participants in each use case form multidisciplinary teams of researchers and developers. Each use case team is composed of:

— **Quantum computing experts,** with deep knowledge of quantum algorithms and their practical implementation on quantum devices.

— **Classical computing experts,** with deep knowledge of state-of-the-art classical approaches and their current limitations with conventional supercomputing.

— **Domain experts,** with deep knowledge of the problem statement and its real-world applications.

— **Impact experts,** with deep knowledge of the relevant SDGs and the UN priorities, to ensure that solutions would maximize impact for humanity, especially for underserved geographies.

OQI actively serves as a matchmaker, providing a neutral platform that drives collaboration and knowledge exchange among these diverse experts. By leveraging the richness of multidisciplinarity perspectives and cultural backgrounds, OQI takes a central role in translating across different levels and domains. This bridging function embodies science diplomacy in action, which lies at the core of OQI's mission.

Roles and responsibilities:

— Suggest the topic for a use case.

— Work in a team to develop a use case.

— Contribute to the OQI use case repository.

— Leverage OQI (and other) tools and resources available for learning and training to be equipped to fully develop a use case.

— Communicate needs to OQI for support with complementary expertise or seed funding.

— Perform the necessary work to develop a proof of concept (see use case development phases below).

— Each participant becomes an official OQI member through their affiliation, abiding to OQI values, after completing the bilateral OQI Framework Agreement—which defines the confidential information and intellectual property consideration.

— Each participant is required to complete the multilateral OQI Use Case Project Agreement—which defines the use case statement of work and the role of each participant in the use case team.

— Each participant is responsible for bringing their own funding for their time invested in the development of use cases. Requests with detailed justification can be made for additional financial support from OQI. OQI has a limited budget for seed funding, prioritising team participants with fewer resources and access.

4.3 OQI team

OQI coordinates and supports the participants in their use case development, with technical support, project management, and financial support.

Roles and responsibilities:

- Accompany participants in developing the use case, with project management support, ad hoc technical support and training.
- Offer matchmaking to form teams of participants with complementary expertise.
- In some cases, provide seed funding for the development of use cases (based on specific criteria and availability).
- Activate cloud access to quantum simulators and quantum processors from OQI partners for projects that reach the phase of implementation of their proof of concept.
- Provide participants with access to the OQI use case repository.
- Provide participants with access to OQI repository of tools and resources for learning and training.
- Organise events (e.g. workshops) and provide a platform for exchange of best practices.

4.4 Confidentiality and intellectual property

In the spirit of contributing to the OQI repository of use cases, selected ideas and outlines are openly shared with the OQI community and published on the OQI website.

For later stages of the use case development (phase 2 and beyond), all details provided in the submissions to OQI remain confidential. However, in the spirit of open science and to contribute to collective community knowledge, use case teams are required to share their proposals and results publicly in some format (e.g. arXiv, GitHub, etc.) to help advance the field.

Participants retain ownership of the intellectual property (IP) they contribute to the use case projects, as well as any developed during the project. OQI serves as a neutral platform to facilitate use case development and does not retain any IP. For use case teams moving to Phase 2, a project agreement is signed by all use case team participants to define the intellectual property agreement.

Personal data that is provided is processed in accordance with OQI privacy policy [18]. If necessary, a standard mutual non-disclosure agreement (NDA) can be requested.

By confirming their participation in the OQI programme, the selected teams agree to actively participate in the activities provided by OQI, as well as allocate the necessary resources to successfully complete the deliverables in each phase.

OQI reserves the right to exclude any project that does not comply with these guidelines or whose behaviour could harm the reputation of the programme, OQI teams, its stakeholders or other participants. This includes, but is not limited to, lack of team engagement, failure to complete tasks or deliverables, disrespectful behaviour towards OQI, its team members and stakeholders or other participants, violation of confidentiality agreements or unethical business practices

OQI reserves the right to modify, at any time, the content, duration and services of the programme, including, but not limited to the support provided, the guidance, materials and resources, as well as the seed funding.

OQI cannot be responsible for any loss perceived or incurred, damage, liability, cost or expense of any kind that may arise from or in connection with the teams' participation in the programme, any advice, guidance or recommendation provided by OQI or actions or omission from OQI, its teams and stakeholders or other participants.

5. About OQI

OQI is a multilateral governance initiative that promotes global and inclusive access to quantum computing and the development of applications for the benefit of humanity. As a novel science diplomacy instrument, it brings together research, diplomacy, the private sector and philanthropy stakeholders.

OQI's mission is divided into four pillars

A1: Accelerating applications for humanity: Harnessing the full potential of quantum computing to have the widest possible societal impact by accelerating the development of use cases geared towards achieving the United Nations' Sustainable Development Goals (SDGs) and succeeding framework; thanks to the combined forces of researchers, developers and entrepreneurs from academia and private sector as well as the United Nations and large NGOs.

A2: Access for all: Providing global, inclusive and equitable access to a pool of public and private quantum computers and simulators available via the cloud.

A3: Advancing capacity building: Developing educational tools to enable everyone around the world to contribute to the development of quantum computing and make the most of the technology.

A4: Activating multilateral governance for the SDGs: Providing a neutral forum to help shape multilateral governance of quantum computing for the SDGs.

Objective of the OQI – Pillar A1

As part of the A1 pillar, OQI aims at becoming a centre for expertise in the application of quantum computing for the SDGs (and their future succeeding framework). OQI supports the development of use cases, which are rigorously vetted based on their scientific and impact merits. Given the current limited resources and experts in the field, OQI hopes to contribute to rebalancing the focus of quantum computing applications towards impact while avoiding feeding into hype effects surrounding concepts of quantum advantage and quantum primacy.

Point of Contact

Please reach out to oqi.usecase@cern.ch for any questions.

FAQs

Use Case Team	I would like to submit an idea, but I don't have a full use case team—how should I proceed?	It is part of OQI's role to do the matchmaking. For relevant ideas, OQI supports the completion of use case teams, bringing UN organisations, domain experts and quantum experts together to form a team.
Funding	Is there funding for the development of use cases?	For the ideation and scoping of use case outlines (phases 0 and 1), there is no financial support. For the proof of concept (phases 2, 3 and 4), OQI can provide seed funding for only a limited number of projects, prioritising quantum-underserved geographies and high impact projects. If your project and use case team do not fall into the selection for support, OQI may be able to direct you to other funding mechanisms that can support advanced use case development phases (e.g. regional government funding, etc.)
Scope of topics	Which topics do not fall into OQI scope?	Topics falling outside of OQI's scope include, but are not limited to, encryption, post-quantum cryptography, national security and defense applications. OQI is aware of the potential risks and threats of quantum computing for national security and the geopolitical implications. This is considered in OQI's diplomatic pillar (A4). However, for use case development, OQI's focus is on where global cooperation can bring positive impact to humanity, leveraging the UN framework on the SDGs and succeeding framework.
Access	How and when do I have access to quantum simulators and quantum processors (as part of an OQI use case team)?	For selected projects, OQI provides access to its partners' cloud platform, providing use case teams with free credits for implementation on quantum simulators and quantum processors. Use case teams from selected projects work closely with quantum providers (OQI partners) to prepare implementations and optimise the utilisation of the quantum resources. OQI cannot support all projects for implementations to advanced phases (see selection criteria).
Intellectual property	If I develop a new quantum method, who owns the intellectual property?	Participants retain ownership of the intellectual property (IP) they bring to the use case projects, and IP they develop as part of their use case. For teams moving to Phase 2, a project agreement is signed by all participants to define the IP agreement. OQI is a neutral platform to facilitate use case development and does not retain any IP.

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Annex 1 - Use Case Outline Template

OQI Use Case Outline Title

Authors | Date

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1. Title

— List the relevant SDGs

2. Short Summary (3-5 lines)

— Description of the scope and key objectives of the project

3. Description of the problem and context (0.5-1 page plus references)

— What is the societal challenge and why is it critical?
— Who and where is the affected population?

4. Computational Challenge (0.5-1 page plus references)

— How is the societal challenge connected to a computational problem?
— What is the mathematical description of the problem?
— How is the challenge currently approached with existing technologies?
— How is this type of computational problem solved on classical computers and why are computational models useful?
— What type of computational methods are used?
— What is difficult to model and what are the current limitations/bottlenecks of the best-in-class classical computing approaches?

5. Potential Impact of a Quantum Solution (0.5-1 page plus references)

— From the classical computing approach, which part could be tackled with quantum computing?
— What type of quantum algorithms and methods would be used and why?
— What are the projected expected benefits over classical approaches (speedup, accuracy etc.)?
— What would be the timeline for implementation (by classifying if a proof of concept could be done with NISQ[1] or FTQC[2]
— What quantum resources would be required to run a proof of concept (specify e.g. type of quantum hardware, number of qubits, depth of circuits, computation time needed (if possible), ...)
— What datasets are available to this project? (please also specify other known / necessary initial conditions for the model)
— Describe how you envisage completing a proof of concept for this project.

6. References

1 NISQ refers to Noisy Intermediate-Scale Quantum devices available today.

2 FTQC refers to Fault-Tolerant Quantum Computing devices, error corrected.

7. Presentation of the use case team

Team Member (First name, Last name)	Affiliation	Country (of the affiliation)	Relevant domain expertise for the project — Quantum computing, — SDG domain, — Application domain, — Classical computation (e.g. AI) — ML, chemistry, operation research, fluid dynamics, etc.), — Other	Short Bio (3-5 sentences)

Please present use case team participants and specify their relevant expertise for the project.

Please indicate any expertise needed to complete the use case team.

Needed expertise to complete the above mentioned use case team	Names of potential experts to join the use case team	Profile links if available
Quantum computing		
SDG domain		
Application domain		
Classical computation (e.g. AI, ML, chemistry, operation research, fluid dynamics, etc.)		
Other (please specify)		

Annex 2 - Use Case Full Proposal Template

OQI Use Case Full Proposal Title

Authors | Date

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Abstract

Please add a short description of the scope and key objectives of the project. (Max 250 words.)

Relevant SDGs

Please list the relevant UN SDGs.

1. Description of the problem and its societal context

Please describe the societal challenge you are tackling, including who is affected and where the affected population is, why it is critical and what are the risks if no solution emerges (timeline), and what are the current approaches and/or current initiatives from the SDG communities to solving the societal challenge. Please include relevant references.

2. Description of the computational challenges

2.1 Mathematical formulation of the problem

Please describe the mathematical problem associated with the societal challenge in a detailed quantitative formulation with a mathematical model / conceptualisation and identify the key variables. Please include relevant references.

2.2 Classical computational approaches

Please explain how the mathematical problem is solved computationally. Based on state-of-the-art classical computational approaches, this includes specifying what are existing limitations and identifying bottlenecks. Provide references on the literature review of this topic and comment on known initial conditions for the model to be useful.

2.3 Description of the potential quantum computing solution

Please argue in detail for the relevance and the need for quantum computing to solve the problem at hand. Specify which of the identified classical bottlenecks could benefit from a quantum computing approach, what quantum approach you are proposing to do, and why. Where it is possible, use references to justify your decisions, alongside mathematical proofs of scaling advantages or complexity analysis of the classical vs quantum methods. If this problem has been tackled with quantum computing in the past, please explain how the proposed approach differs and include references.

3. Implementation of a proof of concept

A proof of concept can vary in meaning depending on whether the proposed quantum computing solution is feasible on near-term hardware or requires fault-tolerant quantum computers anticipated in the longer term. A proof of concept on near-term hardware might demonstrate that a simplified version of an algorithm can run on current noisy intermediate-scale quantum devices. A proof of concept on anticipated fault-tolerant quantum hardware might explore the scalability or theoretical performance of an algorithm.

If not already clear from the previous section, please make clear what your proof of concept is about. If your proposal includes both a near-term implementation and an anticipated fault-tolerant implementation, please provide the relevant information in the subsections below.

3.1 Description of the proof of concept

Please describe your proposed proof of concept to demonstrate the feasibility of the proposed quantum solution. This includes defining the regime of parameters to achieve quantum advantage and the problem size to be tackled (now and/or with future quantum computing devices). Please also specify whether access to real-world datasets has been secured and whether other known necessary initial conditions for the proof of concept are met. As always, include relevant references.

3.2 Benchmarking strategy

As part of the proof of concept, please specify the strategy to benchmark the proposed quantum computing solution against state-of-the-art classical approaches and quantify the expected benefits of the quantum approach. Include relevant references.

3.3 Resource estimation

Using existing resource estimation tools, please assess the resources needed both for the quantum and classical parts of the proposed solution, including but not limited to circuit depth, qubit count, function calls, and run time. This includes specifying what type of quantum computing

device would be most suitable and, in the case of a proposed implementation on near-term hardware, which hardware providers would be ideal for the implementation of the proof of concept. Please also discuss whether it is feasible to first perform small-scale tests on existing quantum simulators and, if so, which would be the ideal simulation providers.

Please also comment on the projected energy consumption for both a small-scale implementation during the proof of concept and a full-scale implementation at a later stage.

3.4 Steps to achieve a proof of concept

Please describe the steps to deliver a successful proof of concept, from code writing to optimizing the code to tests on simulators and QPUs, including specifying what is conducted by whom in the team.

4 Impact design

Anticipating a future deployment of the full-scale quantum solution in the real-world, please assess the impact of the proposed solution. An impact framework toolkit will soon be available to guide you through this assessment.

— At a local level, please assess the impact of your proposed solution on people, planet, and prosperity conducted across short-, medium-, and long-term timeframes. Detail the impacted areas and expected outcomes, documenting all assumptions and supporting references.

— At a global level, how transposable is the use case to other contexts? What are other geographies or populations that would benefit from the proposed quantum solution (pro- vide facts and references)? Would the conditions be conducive to a similar proof of concept (e.g. access to data)?

— At a macro-level, please assess the interlinkages between SDGs to positively or negatively impact other SDGs (benefits vs risks), including mitigation measures if any?

5 Methods

Add further details and supplementary material in this section. This section is for lengthy explanations of methods and other details, if applicable. It can be deleted if not needed.

6 References

How to add Citations and a References List: You can upload a .bib file containing your BibTeX entries, created with JabRef; or import your Mendeley, CiteULike or Zotero library as a .bib file. You can then cite entries from it, like this: [?]. Just remember to specify a bibliography style, as well as the file name of the .bib.

You can find a video tutorial here to learn more about BibTeX.

7 Team Presentation

Team Member (First name, Last name)	Affiliation	Country (of the affiliation)	Relevant domain expertise for the project — Quantum computing, — SDG domain, — Application domain, — Classical computation (e.g. AI) — ML, chemistry, operation research, fluid dynamics, etc.), — Other	Short Bio (3-5 sentences)

Annex 3 - Use Case Report Template

OQI Use Case Phase 3 Report Title

Authors | Date

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Abstract

Please add a short summary of what has been achieved in Phase 3 of the OQI use case and what were the most important findings. (Max 250 words.)

Relevant SDGs

Please list the relevant UN SDGs

Link to GitHub Repository

Please provide the link to the github repository, where your code and datasets for the OQI Use Case are stored.

1 Setting up the Simulation

Describe and discuss what has been done in this phase in terms of simulating the quantum algorithm, how the problem was mapped to the simulator, data pre-processing, hyper-parameter tuning (if applicable), etc. This section should include specification of the (classical) hardware used for the simulation. It also includes describing the small scale (if applicable) and real-world data used, its source and its relevance in the targeted context. Please link the datasets (if not already included in the linked github repository).

2 Results

Present the results of the simulations and put them in context. That includes: explaining why you chose the problem sizes you did, and if they were related to the limits of the (classical) hardware, comparing it to classical benchmarks (refer to the benchmarking strategy stated in the Full Proposal). Please also discuss how the results scale in terms of runtime, accuracy, and/or energy efficiency etc. and extrapolate findings to larger scales. Also state to what extent noise was modeled in the simulations, and what are the findings in this regard. Use graphs and tables where possible to aid in the description of your results.

3 Discussion and Conclusions

Discuss all relevant aspects and learnings from the simulations. How did the performance degrade with different levels of noise or embeddings of the problem, how was the data preprocessed (if applicable) and could this be done in a better way? Strategize techniques to improve the performance (error mitigation techniques, circuit construction and depth reduction, data pre-processing, code optimization, etc., essentially any aspect that may be relevant for the next phase). Finally, please name and discuss problems encountered and how you overcame them, or are planning to do so (e.g. optimizing transpilation on IBM machine, noise affecting the results of the simulation / QPU runs, how to measure the time-complexity, etc.)

4 Impact assessment: Updates to the Full Proposal

Based on the results of the simulations, and the further analysis using the OQI impact framework tool, please re-assess the anticipated impact of the Use Case once it could be deployed in real-world. Please expand on what was discussed in the Full Proposal and discuss any updates in this regard.

5 Moving to Phase 4

This section is relevant for justifying the feasibility of your Use Case to move on to Phase 4 with implementation on QPUs (based on the results and discussion). Why does this lay a good basis for implementing the Proof of Concept on QPUs? Please reassess the resource estimation for QPU implementation.

6 References

How to add Citations and a References List: You can upload a .bib file containing your BibTeX entries, created with JabRef; or import your Mendeley, CiteULike or Zotero library as a .bib file. You can then cite entries from it, like this: [?]. Just remember to specify a bibliography style, as well as the file name of the .bib.

You can find a video tutorial here to learn more about BibTeX

Annex 4 - Use Case Journey and Action Plan Template

OQI Use Case Journey & Action Plan

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Below is a sample of the action plan for each phase of the use case journey. A spreadsheet template will be provided to the use case team. This project management document outlines the necessary action items towards a proof of concept with OQI. It is designed to help the use case team assess the effort, resources, and timeline to accomplish the use case project.