OQI
Open Quantum
Institute

# OQI Quantum Application Framework

Geneva · September · 2026

DOI: https://doi.org/10.17181/p5ffb-k8s23
Corresponding Editor: OQI.usecase@cern.ch

# Table of Content

# Acknowledgment

The **OQI Quantum Application Framework** is a living document, which is continuously updated to reflect the progress of the field and to incorporate the most recent insights gained from OQI's activities.

The October 2025 edition was validated by experts from sixteen leading regional and national quantum hubs, along with representatives from prominent institutions, during the *Quantum Application Framework Workshop* held at CERN, Geneva, on October 15, 2025.

OQI extends its profound appreciation to all participants of the workshop, as well as members of the OQI Scientific and Impact Panels and the OQI Use Case Teams, for their invaluable contributions. Their expertise and collaboration ensure OQI is at the forefront of the technology, with a scientifically robust, socially impactful approach responsive to the rapid evolution of quantum computing.

OQI is committed to openly sharing this framework and the knowledge gained through the exploration and development of real world quantum computing applications, for the benefit of the global community.

Sincere thanks to:

**October 15, 2025 Workshop Participants**
Julien Baglio, **Quantum Basel** // Philippe Caroff, **EPFL** // Jonathan Felbinger, **QED-C** // Géraldine Haack, **Université de Genève** // Jaegyoon Hahm, **Korea Quantum Industry Association** // Brad Kim, **Megazone** // Megan Lee, **Quantum City at University of Calgary** // Koen Leijnse , **QDNL & University of Amsterdam** // Cedric Membrez, **UBS** // David Morcuendem, **QuIC** // Hirofumi Mori, **Q-STAR & Toshiba** // Natasha Oughton, **UK National Quantum Computing Centre** // Christian Sarra-Bournet, **Institut Quantique at Université de Sherbrooke** // Flavia Schlegel, **International Science Council** // Urbasi Sinha, **University of Calgary & Raman Institute** // Kathrin Spendier, **XPRIZE** // Anu Unnikrishnan, **ETHZ** // Sofia Vallecorsa, **CERN** // Pieter Vermaas, **QDNL** // Jon Wingborg, **Quantum Sweden Innovation Platform**.

**OQI Scientific Panel**
Ryan Babbush, **Google Quantum AI** // Marcin Dukalski, **TNO** // Olivier Ezratty, **Quantum Energy Initiative** // Yacine Haddad, **CERN** // Clément Javerzac, **FHNW** // Elica Kyoseva, **NVIDIA** // Brad Lackey, **Microsoft** // Ryan Landfield, **Oak Ridge National Laboratory** // Jean-Frédéric Laprade, **University of Sherbrooke** // Koen Leijnse, **QDNL & University of Amsterdam** // Markus Reiher, **ETHZ** // Barry Sanders, **University of Calgary** // Daniel Stilck Franca, **University of Copenhagen** // Ivano Tavernelli, **IBM** // Sofia Vallecorsa, **CERN** // Albert Werner, **University of Copenhagen** // Will Zeng, **Unitary Foundation**.

**OQI Impact Panel**
Oezge Aydogan, **Beyond Lab** // Ignacio Cerrato, **Inter-American Development Bank** // Julia Cramer, **QDNL & Leiden University** // Diego Estrada, **PwC** // Davide Fanciulli, **Beyond Lab** // Amal Kasry, **UNESCO** // Kyriacos Koupparis, **World Food Program** // Gillian Makamara, **International Telecommunication Union** // Stela Mocan, **World Bank Group** // Deborah Nas, **QDNL** // Natasha Oughton, **UK National Quantum Computing Centre** // Damien Somé, **Global Antibiotic Research and Development Partnership** // Yvan Serret, **PwC** // Mira Wolf-Bauwens, **GESDA** // Zhijun William Zhang, **World Bank Group**.

**OQI Use Case Teams**
Full list of participants in White Papers 2022-2025 - thank you for testing and co-shaping the OQI methodologies!

**The OQI Team**
Alexandra Bernasconi, Yacine Haddad, Marieke Hood, Philipp Kammerlander, Catherine Lefebvre, Josua Rochat, Francesca Schiavello, Tim Smith, Mira Wolf-Bauwens.

# 1. Introduction

As part of the Open Quantum Institute's general mission to create pathways for 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 four years, OQI has developed a 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 optimising the placement of water leak detectors in urban water distribution networks or by 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 and impact communities 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 the solving of 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 emphasise 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 the 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.


Figure 1. 17 Sustainable Development Goals defined by the United Nation 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 performed by multidisciplinary teams with the support of 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, OQI focuses its efforts on identifying and supporting quantum computing use cases that align with the SDGs.

## 3.1 Use case development phases

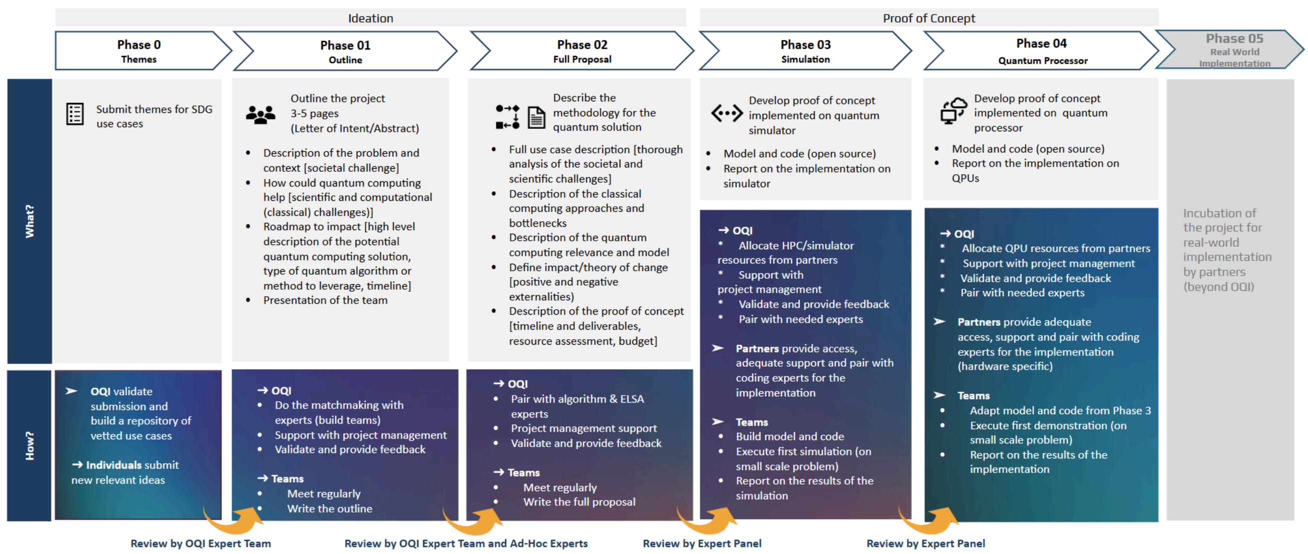



Figure 2. Phases of development of use case projects, from ideation to completion of proof of concept.

### 3.1.1 Ideation

The first 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 the following phases:

— **Phase 0:** Initial selection of use case ideas. This is the starting point and main filtering pass 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, is successfully done with the contribution of diverse expertise (quantum computing, domain specific, impact and SDGs), with the aim to convert ideas 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 problems, 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 Team, and, as needed, may be consulted with an expert panel spanning diverse areas of expertise. An extract of the outline is then featured as a contribution to the annually published OQI Use Case White Papers [13]-16].

- **Phase 2:** Development of a PoC proposal, with OQI support, using the OQI full proposal template (Annex 2). The full proposal should detail the envisaged PoC, with its methodology. It includes planning, developing the computational model with a thorough assessment of the complexity and computational challenges and the analysis of the potential (feasibility) of a quantum computing solution, a clear identification of the quantum approach (quantum or quantum-inspired) and a strategy for benchmarking against state-of-the-art classical approaches, with the aim of demonstrating a potential quantum advantage, at least in the FTQC context. It also includes a proper 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). If possible, the resource estimation should be tailored to the specific hardware modality chosen, given this will produce substantially different answers than with respect to a hardware agnostic or abstract architecture estimation. Beyond the traditional resources to be considered, an estimation of operating costs may also be included in the estimations. These evaluations will necessarily mean a careful consideration in choosing a hardware modality that suits the use case needs. This full proposal 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 computing, domain specific, impact, SDGs) review it and provide feedback on the value and feasibility to advance to the implementation of the PoC. OQI recognises the effort involved in developing a PoC proposal, and for use case teams in need, financial support may be available through OQI seed funding.

### 3.1.2 Proof of Concept

A few use cases are selected for OQI support (technical and financial) to move to advanced phases and implement 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. In addition, the problem addressed must be representative of a real-world SDG challenge, and its quantum solution must explore a pathway in pursuit of some form of advantage over classical counterparts, at least in the FTQC regime.

OQI recognises the effort involved in implementing a PoC, and for use case teams in need, financial support may be available through OQI seed funding. The PoC is sub-divided into 2 phases:

- **Phase 3:** If a small-scale PoC is implementable on today's quantum simulators accessible on the cloud, then Phase 3 is designed to test and optimise the potential quantum computing solutions. To prepare and optimise the results that could come from QPU implementation, this phase allows the use case teams to, where possible, perform noisy simulations, perform circuit-reduction techniques, include code optimisation methods, and smart transpilation strategies among other hardware specific implementations. These strategies mean simulating the hardware at the most realistic level possible, while already introducing and testing techniques that will aid NISQ-level hardware in performing at its best. OQI offers cloud access to selected projects to implement their PoC, through close collaboration with OQI's quantum simulator and HPC providers. For some use cases, HPC resources are needed to increase the fidelity of simulations and tackle larger problems, leading to more accurate representations of quantum hardware. 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 PoC, is then considered. Satisfactory results from the previous phase will have shown how well the quantum algorithm performs against state of the art classical methods, and potentially, how well the quantum algorithm scales. Given the limited quantum hardware resources available, these results will also inform decisions on priority access, among other factors, like real-world data availability and hardware availability restrictions. Within this Phase 4, the results of the implementation 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 strategic partner(s) to bring the work forward.

## 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 (https://oqi-impact-tool.app.cern.ch/ ).

## 3.3 Evaluation process

To keep the use case portfolio relevant, OQI engages leading experts at every stage of this methodological framework, ensuring alignment with both the current state and the evolving capacity of the technology. The evaluation of use cases 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

The Scientific and Impact Evaluation Panels provide neutral and transparent assessments of the quality of use cases and can recommend discontinuing OQI's support to a use case project at any stage of this process. Through this continuous review, OQI ensures the use case portfolio remains scientifically rigorous, socially impactful, and responsive to progress in the quantum computing field, while optimising today's scarce quantum computing resources for the implementation of the most feasible PoCs.

Figure 3 illustrates the decision process of evaluating a PoC and of advancing it through the development phases, under a fixed timeframe, with the support of OQI.

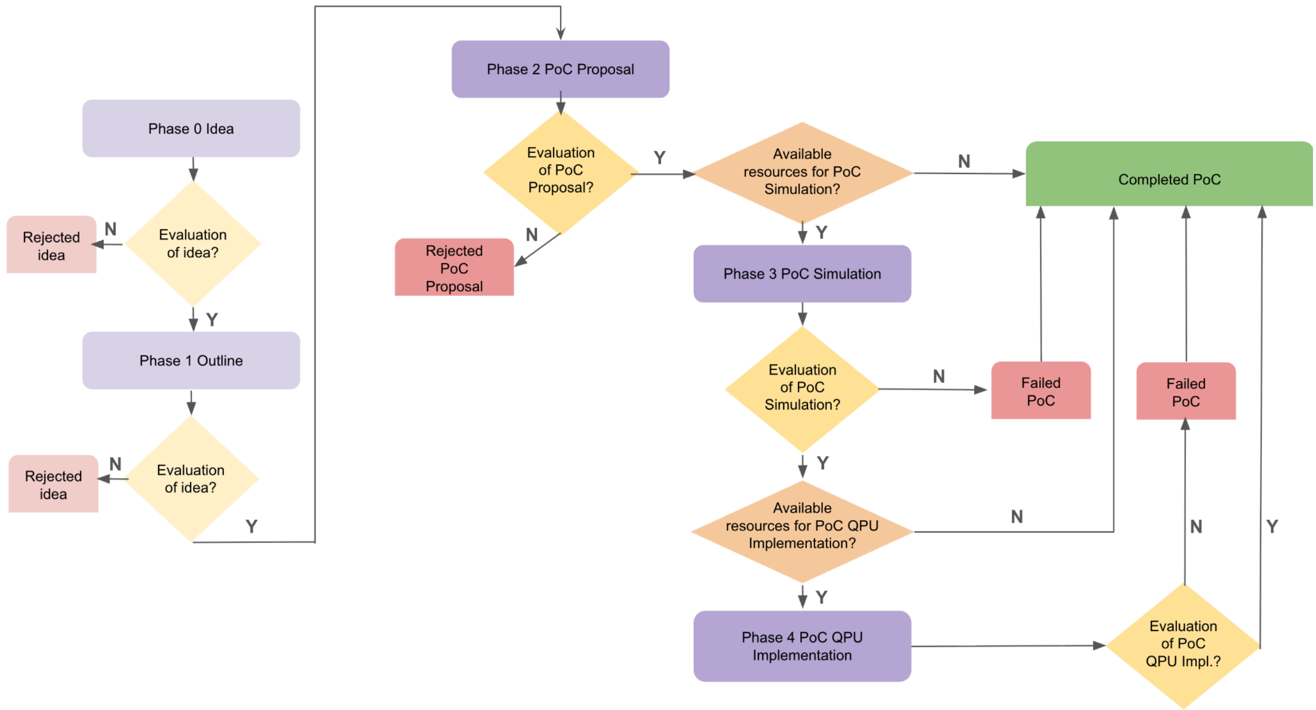



Figure 3. The flow chart indicates the process of evaluation, advancement and completion for ideas and proof of concepts (PoCs) along the OQI pipeline.

Table 1 summarises the deliverables and evaluation process depicted in Figure 3.

| Table 1 - OQI Phase | | |
|---|---|---|
| | **Deliverable** | **Evaluation** |
| **Phase 0** | Detailed use case idea | Reviewed by OQI team, with ad hoc consultation with multidisciplinary experts of in-depth knowledge on quantum computing applications and/or in SDGs and its succeeding framework. Following the evaluation, the decision can either:<br><br>i) approve the use case idea. The use case team collaborates with OQI to refine the use case idea into Phase 1.<br><br>ii) reject the use case idea. |
| **Phase 1 - Outline** | Outline<br><br>(see template Annex 1) | Reviewed by OQI team, with ad hoc consultation with multidisciplinary experts of in-depth knowledge on quantum computing applications and/or in SDGs and its succeeding framework. Following the evaluation, the decision can either:<br><br>i) approve the outline to be featured on the OQI use case repository. The use case team is invited to prepare an action plan (see template in Annex 5), including an assessment of the budget and resources 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.<br><br>ii) reject the outline |
| **Phase 2 – PoC Proposal** | Full proposal<br>(see template Annex 2) .<br><br>The full proposal presents a convincing computational model with a rigorous justification of the quantum approach and a strategy for benchmarking with classical computers. The proposal 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. | Reviewed by the Scientific and Impact Panels (evaluation criteria in Table 2). Following the evaluation, the decision can either:<br><br>i) approve the proposal for PoC and advance to Phase 3. The use case team then refines its action plan (see template in Annex 5), including an assessment of the budget and resources required to complete an implementation on a simulator (deliverable of Phase 3). Once the plan is approved, the use case team proceeds to Phase 3.<br><br>ii) approve the proposal for PoC and mark PoC as complete, if the full proposal was convincing but cannot yet be addressed due to resource constraints or technological limits.<br><br>iii) reject the proposal for PoC, if the full proposal does not satisfy the evaluation criteria. |

| | | |
|---|---|---|
| **Phase 3 – PoC Simulation** | Simulation report (see template Annex 3). Open-source code.<br><br>The simulation report presents meaningful results from the small-scale PoC implementation on cloud-available quantum simulators. Simulation tests are performed to optimize the potential quantum computing solutions. In this phase, the use case team works closely with the selected quantum provider to plan an effective implementation. | Reviewed by the Scientific and Impact Panels (evaluation criteria in Table 3). Following the evaluation, the decision can either:<br><br>i) pass and advance the PoC to Phase 4. The use case team refines its action plan (see template in Annex 5), 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.<br><br>ii) fail and complete the PoC, if the simulation report does not satisfy the evaluation criteria, for instance if advancing to Phase 4 is constrained by the maturity of current quantum computational technologies or the availability of sharable resources within OQI, or if the strategy of the full proposal was carried out but did not achieve positive results (e.g. limited pathway for advantage and scaling on QPU) |
| **Phase 4 – PoC QPU Implementation** | QPU implementation report (see template in Annex 4) Open-source code.<br><br>The QPU implementation report presents meaningful results from the small-scale PoC implementation on cloud-available quantum processors. The report should conclude with an assessment of the performance scaling on future large-scale fault-tolerant quantum computers (FTQC). This implementation also serves as practical capacity building for effective use of the computing resources. In this phase, the use case team works closely with the selected quantum provider to plan an effective implementation. | Reviewed by the Scientific and Impact Panels (evaluation criteria in Table 4). Following the evaluation, the decision can either:<br><br>i) pass and complete the PoC.<br><br>ii) fail and complete the PoC, if the final report does not satisfy the evaluation criteria.<br><br>Note: Advancing to a further phase, with deployment and testing in real-world settings, is beyond the scope of OQI. |

Tables 2-4 detail the evaluation criteria used by the Scientific and Impact Evaluation Panels in Phase 2-4, respectively.

| Table 2 - Evaluation criteria of PoC full proposals (Phase 2) | |
|---|---|
| **1. Problem Formulation**<br>(evaluation done by all Experts)<br>(20% total weight) | 1.a To what extent is the problem clearly defined, both in terms of scientific rigor and its relevance to a concrete real-world problem?<br><br>1.b To what extent would the quantum solution transform how the identified SDG challenge is addressed? |

| | |
|---|---|
| **2. Scientific and computational relevance** (evaluation done by Scientific Experts) (45% total weight) | 2.a To what extent is the problem clearly detailed mathematically?<br><br>2.b To what extent is the computational approach framed, and to what extent are state-of-the-art classical bottlenecks clearly identified?<br><br>2.c 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)?<br><br>2.d To what extent is the feasibility of a proof of concept clearly detailed (with computing resource requirements clearly estimated and benchmarking strategy against state-of-the-art classical computing solutions detailed)?<br><br>2.e To what extent could a small-scale proof of concept be tested on small-scale devices (NISQ) with potentially meaningful results, and be realistically executed within the indicated timeframe? |
| **3. Impact relevance** (evaluation done by Impact Experts) (25% total weight) | 3.a To what extent does the quantum solution meet a "business" need (i.e. challenge validated or prioritized by an IGO)?<br><br>3.b At a local level, to what extent is impact assessed on people, planet, and prosperity conducted across short-, medium-, and long-term timeframes?<br><br>3.c At a global level, how transposable is the use case project to other contexts?<br><br>3.d At a macro-level, to what extent have the interlinkages between SDGs been clearly assessed (benefits vs risks to negatively impact other SDGs)? |
| **4. Team composition** (evaluation done by all Experts) (10% total weight) | 4.a To what extent does the team have the necessary expertise and means to achieve the project?<br><br>4.b How diverse and inclusive is the team, in terms of geography and demography? |

| **Table 3 - Evaluation criteria of PoC reports (Phase 3)** | |
|---|---|
| **1. Implementation strategy** (evaluation done by Scientific Experts) (20% total weight) | To what extent does the implementation strategy and methodology clearly articulate the simulation approach, identify bottlenecks encountered, and describe the refinements or mitigation strategies implemented to address the bottlenecks? |
| **2. Results and benchmark** (evaluation done by Scientific Experts) (20% total weight) | To what extent are the main simulation results clearly presented and rigorously compared against classical state-of-the-art benchmarks? |
| **3. Scaling and performance** (evaluation done by Scientific Experts) (20% total weight) | To what extent are the quantitative performance metrics (runtime, accuracy, resource usage, etc.) comprehensively reported, and compared to classical baselines, with uncertainties quantified and robustness adequately assessed? |
| **4. Discussion of impact** (evaluation done by Impact Experts) (20% total weight) | Drawing on the simulation results, to what extent does the analysis provide a realistic and well-reasoned assessment of the solution's anticipated impact in a future real-world deployment? |

| | |
|---|---|
| **5. Justifications for implementation on QPUs** (evaluation done by Scientific Experts) (20% total weight) | To what extent does the team provide convincing justification for the feasibility and readiness of implementation on quantum processing units, which would imply to advance into Phase 4 with OQI support? |

| **Table 4 - Evaluation criteria of PoC Reports (Phase 4)** | |
|---|---|
| **1. QPU Implementation strategy** (evaluation done by Scientific Experts) (25% total weight) | To what extent does the report clearly describe the problem-to-hardware mapping, preprocessing, and error mitigation schemes? |
| **2. Results and benchmark** (evaluation done by Scientific Experts) (25% total weight) | To what extent are the main QPU implementation results clearly presented and rigorously compared against classical state-of-the-art benchmarks? |
| **3. Scaling and Performance** (evaluation done by Scientific Experts) (25% total weight) | To what extent does the discussion clearly assess quantum hardware performance, identify concrete improvements and credibly project future performance on larger/fault-tolerant devices (FTQC)? |
| **4. Discussion of impact** (evaluation done by Impact Experts) (25% total weight) | Drawing on the report results, to what extent does the analysis provide a realistic path from proof-of-concept to deployment, with well-reasoned impact assessment and key stakeholders identified? |

# 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 marginalised from 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<br>— Inject innovation for future solutions of existing/projected real-world issues<br>— Think out of the box through exposure to quantum and domain expert networks<br>— Foster interdisciplinary collaboration |
| Domain experts | — Exposure to quantum and UN networks<br>— Apply their expertise on solutions to validated real-world issues<br>— Access new funding streams<br>— Access classical HPC resources<br>— Access new datasets |
| Quantum experts | — Access UN and domain expert networks<br>— Apply their quantum expertise on solutions to validated real-world issues<br>— Access free quantum computing resources for proof of concepts<br>— Access new funding streams<br>— Publish high impact publications with OQI affiliation |
| Quantum industry | — Access talent (new hires)<br>— Showcase their technology capability, with validated real-world issues and benchmark against other providers<br>— Participate in global sustainability effort<br>— Access UN and domain expert networks |
| Countries | — Build local capacity - related to OQI’s educational pillar (A3)<br>— 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 maximise 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 Openness, 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.

During the PoC proposal development and its implementation (Phase 2-4), all details provided, shared, or generated within the project, including the submissions to OQI, remain confidential. Further, participants retain ownership of the intellectual property (IP) they contribute to the use case projects, as well as any developed during the project. In addition, in the spirit of open science, to contribute learnings to collective community knowledge and to ensure reproducibility, use case teams are committed to share their Results openly under an appropriate open license.

The detailed principles of how OQI applies openness across use cases in practice can be found in the Guidelines for Openness (Annex 7). They are inspired by the CERN's Open Science Policy and legally based on the OQI Framework Agreement that every party signs as they enter Phase 2. To enable a transparent conversation and support teams in increasing the openness of their use case, OQI provides a questionnaire that clarifies openness and ownership of provided and created IP within the project (Annex 7).

## 4.5 Terms and Conditions

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 PoC proposal development and its implementation (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. |
| 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.<br><br>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).<br><br>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. |

# Bibliography


| | |
|---|---|
| [1] | Open Quantum Institute [Online]. Available: https://open-quantum-institute.cern/use-cases/. |
| [2] | F. Arute, et al., "Quantum supremacy using a programmable superconducting processor," *Nature*, vol. 574, p. 505, 2019. [Online]. Available: https://www.nature.com/articles/s41586-019-1666-5 |
| [3] | M. Reiher, et al., "Elucidating reaction mechanisms on quantum computers," *PNAS*, vol. 114, pp. 7555-7560, 2016. [Online]. Available: https://www.pnas.org/doi/10.1073/pnas.1619152114 |
| [4] | J. Biamonte, et al., "Quantum Machine Learning," Nature, vol. 549, p. 195–202 , 201. [Online]. Available: https://www.nature.com/articles/nature23474 |
| [5] | A. Farhi, J. Goldstone, "Quantum Approximate Optimization Algorithm," *arXiv*, vol. 1411.4028, 2014. [Online]. Available: https://arxiv.org/abs/1411.4028 |
| [6] | A. W. Harrow, A. Hassidim S. Lloyd, "Quantum Algorithm for Linear Systems of Equations," *Phys. Rev. Lett.* , vol. 103, p. 150502, 2009. [Online]. Available: https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.103.150502 |
| [7] | P. W. Shor, "Algorithms for quantum computation: discrete logarithms and factoring," Proceedings 35th Annual Symposium on Foundations of Computer Science, Santa Fe, NM, USA, pp. 124-134, 1994.[Online]. Available: https://ieeexplore.ieee.org/document/365700 |
| [8] | A. Gilyén, S. Lloyd, E. Tang, “Quantum-inspired low-rank stochastic regression with logarithmic dependence on the dimension,” *arXiv*, vol. 1811.04909, 2018. [Online]. Available: https://arxiv.org/abs/1811.04909 |
| [9] | N.H. Chia, H.H. Lin, C. Wang, “Quantum-inspired sublinear classical algorithms for solving low-rank linear systems,” *arXiv*, vol. 1811.04852, 2018.[Online]. Available: https://arxiv.org/abs/1811.04852 |
| [10] | Quantum Algorithm Zoo [Online]. Available: https://quantumalgorithmzoo.org/ |
| [11] | United Nations Sustainable Development Goals [Online]. Available: https://sdgs.un.org/goals. |
| [12] | United Nations Summit of the Future [Online]. Available: https://www.un.org/en/summit-of-the-future. |
| [13] | OQI Use Case White Paper 2025 [Online]. https://doi.org/10.17181/n8xbe-nqt80 |
| [14] | OQI Use Case White Paper 2024 [Online].https://doi.org/10.17181/t5b0z-9p474 Available: https://repository.cern/records/t5b0z-9p474 . |
| [15] | OQI Use Case White Paper 2023 [Online]. Available: https://repository.cern/records/rwj5q-ch468 . |
| [16] | OQI Use Case White Paper 2022 [Online]. Available: https://repository.cern/records/s2kmk-2nw51 . |
| [17] | OQI Use Case Idea Submission Form [Online]. Available: https://docs.google.com/forms/d/e/1FAIpQLScPUcgUFzctux6W7udyNwspGYgNkHJwNn3rFGYd2a15sMesWQ/viewform |
| [18] | CERN-OQI Privacy Policy [Online]. Available: https://open-quantum-institute.cern/wp-content/uploads/2025/11/Open-Quantum-Institute-Privacy-Policy.pdf |

# Annex 1 - Use Case Outline Template

## OQI Use Case Outline Title

Authors | Date

Scan to download the document

### 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.

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

## 7. Presentation of the use case team

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

Scan to download the document

### 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 optimising 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

# Annex 3 - Use Case Phase 3 Report Template

# OQI Use Case Phase 3 Report Title

Authors | Date

Scan to download the document

## 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? Strategise techniques to improve the performance (error mitigation techniques, circuit construction and depth reduction, data pre-processing, code optimisation, 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. optimising 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.

# Annex 4 - Use Case Phase 4 Report Template

## OQI Use Case Phase 4 Report Title

Authors | Date

Scan to download the document

### Abstract

Please add a short summary of what has been achieved in Phase 4 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 QPU Implementation

Describe and discuss what has been done in this phase in terms of running the proposed quantum algorithm on quantum hardware, how the problem was mapped to the QPU, data pre-processing, hyper-parameter tuning (if applicable), classical postprocessing, any error mitigation or corrections schemes etc. This section should include a specification of the quantum hardware used for the simulation. It also includes describing the small scale (if applicable) and real-world data used and linked above, its source and its relevance in the targeted context.

If there are significant updates on the technical approach compared to its description and planning in the full proposal (from phase 2) or the Phase 3 Report, please clearly state and discuss these updates in the first section, too.

### 2 Results

Present the results of the implementation on the QPU. That includes: explain the rationale behind the choice of the problem sizes and if they were related to the limits of the hardware; compare the results to classical benchmarks (refer to the benchmarking strategy stated in the Full Proposal from Phase 2) and the simulations obtained in Phase 3. Discuss how the results scale in terms of runtime, accuracy, and/or energy efficiency etc. and extrapolate findings to larger scales. Also present observations and findings about the effect of noise and errors on the quantum hardware. Use graphs and tables where possible to aid in the description of the results.

### 3 Discussion and Conclusions

Discuss all relevant aspects and learnings from the implementation on quantum hardware. How was the performance with different embeddings / transpilation techniques (if applicable), what could be improved, etc. Explain if other techniques could be used to improve the performance of the algorithm with today's quantum hardware. This could include error mitigation/correction techniques, circuit construction and depth reduction, data pre-processing, code optimisation, etc. Also compare the results and the resources used to obtain them with those estimated in Phases 2 and 3. Finally, please assess a possible future implementation on larger and fault-tolerant devices: What would be the projected performance? What resources would be needed? This includes discussing problems that will become relevant when scaling up the proposed solution, and how it would be addressed (e.g. optimising transpilation on the specific quantum processor, classical pre- and postprocessing steps that may lead to issues when scaling up, etc.)

### 4 Anticipating a Real-World Implementation

Given the results of the implementation on quantum hardware please provide an assessment of the impact of the Use Case when/if deployed in a real-world scenario. Revisiting the Impact Design from Phases 2 and 3, please provide an honest (re-)assessment on how the proposed quantum solution would really make a difference when/if deployed in the real world.

What would it realistically take to move from a successful proof of concept to an implementation that creates real-world impact (both in terms of impact translation and technical readiness)? What is the anticipated timescale and what could be done today to prepare for future deployment? Who are key-stakeholders to be involved in the path to a real-world implementation?

## 5 Supplementary Materials

Supplementary materials relevant to the methodology or details on the implementation that do not need to be discussed and presented in detail in the main text.

## 6 References

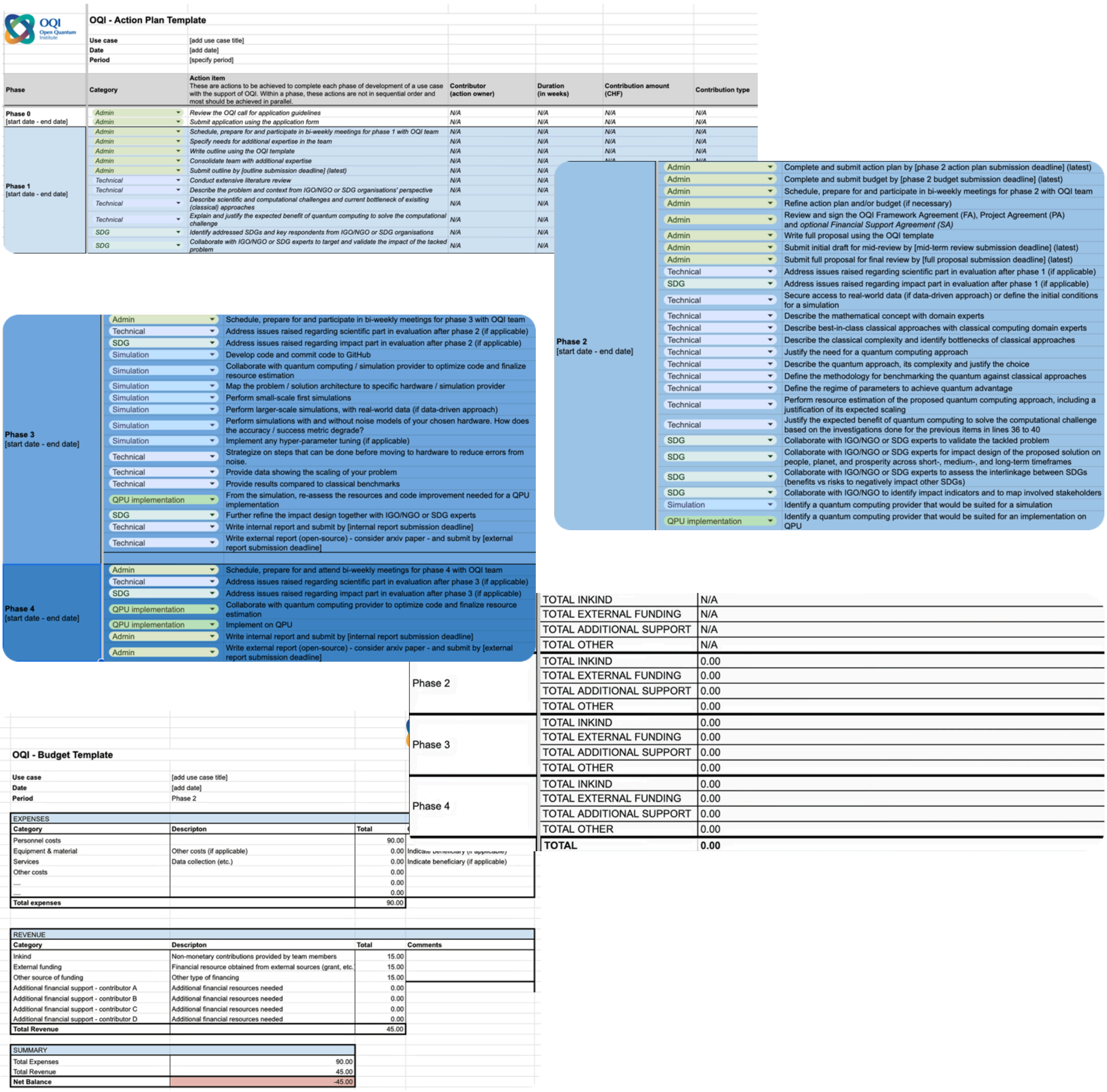
How to add Citations and a References List: You can upload a .bib file containing your BibTeX entries, created with JabRef; or import your Mendeley, CiteULike or Zotero library as a .bib file. You can then cite entries from it, like this: [?]. Just remember to specify a bibliography style, as well as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

# Annex 5 - Use Case Journey and Action Plan Template

## OQI Use Case Journey & Action Plan

Scan to download the document

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.



**OQI - Action Plan Template**

Use case: [add use case title]
Date: [add date]
Period: [specify period]

| Phase | Category | Action item<br>These are actions to be achieved to complete each phase of development of a use case with the support of OQI. Within a phase, these actions are not in sequential order and most should be achieved in parallel. | Contributor (action owner) | Duration (in weeks) | Contribution amount (CHF) | Contribution type |
|---|---|---|---|---|---|---|
| Phase 0 [start date - end date] | Admin | Review the OQI call for application guidelines | N/A | N/A | N/A | N/A |
| | Admin | Submit application using the application form | N/A | N/A | N/A | N/A |
| Phase 1 [start date - end date] | Admin | Schedule, prepare for and participate in bi-weekly meetings for phase 1 with OQI team | N/A | N/A | N/A | N/A |
| | Admin | Specify needs for additional expertise in the team | N/A | N/A | N/A | N/A |
| | Admin | Write outline using the OQI template | N/A | N/A | N/A | N/A |
| | Admin | Consolidate team with additional expertise | N/A | N/A | N/A | N/A |
| | Admin | Submit outline by [outline submission deadline] (latest) | N/A | N/A | | |
| | Technical | Conduct extensive literature review | N/A | N/A | | |
| | Technical | Describe the problem and context from IGO/NGO or SDG organisations' perspective | N/A | N/A | | |
| | Technical | Describe scientific and computational challenges and current bottleneck of exisiting (classical) approaches | N/A | N/A | | |
| | Technical | Explain and justify the expected benefit of quantum computing to solve the computational challenge | N/A | N/A | | |
| | SDG | Identify addressed SDGs and key respondents from IGO/NGO or SDG organisations | N/A | N/A | | |
| | SDG | Collaborate with IGO/NGO or SDG experts to target and validate the impact of the tacked problem | N/A | N/A | | |

| Phase | Category | Action item |
|---|---|---|
| Phase 2 [start date - end date] | Admin | Complete and submit action plan by [phase 2 action plan submission deadline] (latest) |
| | Admin | Complete and submit budget by [phase 2 budget submission deadline] (latest) |
| | Admin | Schedule, prepare for and participate in bi-weekly meetings for phase 2 with OQI team |
| | Admin | Refine action plan and/or budget (if necessary) |
| | Admin | Review and sign the OQI Framework Agreement (FA), Project Agreement (PA) and *optional Financial Support Agreement (SA)* |
| | Admin | Write full proposal using the OQI template |
| | Admin | Submit initial draft for mid-review by [mid-term review submission deadline] (latest) |
| | Admin | Submit full proposal for final review by [full proposal submission deadline] (latest) |
| | Technical | Address issues raised regarding scientific part in evaluation after phase 1 (if applicable) |
| | SDG | Address issues raised regarding impact part in evaluation after phase 1 (if applicable) |
| | Technical | Secure access to real-world data (if data-driven approach) or define the initial conditions for a simulation |
| | Technical | Describe the mathematical concept with domain experts |
| | Technical | Describe best-in-class classical approaches with classical computing domain experts |
| | Technical | Describe the classical complexity and identify bottlenecks of classical approaches |
| | Technical | Justify the need for a quantum computing approach |
| | Technical | Describe the quantum approach, its complexity and justify the choice |
| | Technical | Define the methodology for benchmarking the quantum against classical approaches |
| | Technical | Define the regime of parameters to achieve quantum advantage |
| | Technical | Perform resource estimation of the proposed quantum computing approach, including a justification of its expected scaling |
| | Technical | Justify the expected benefit of quantum computing to solve the computational challenge based on the investigations done for the previous items in lines 36 to 40 |
| | SDG | Collaborate with IGO/NGO or SDG experts to validate the tackled problem |
| | SDG | Collaborate with IGO/NGO or SDG experts for impact design of the proposed solution on people, planet, and prosperity across short-, medium-, and long-term timeframes |
| | SDG | Collaborate with IGO/NGO or SDG experts to assess the interlinkage between SDGs (benefits vs risks to negatively impact other SDGs) |
| | SDG | Collaborate with IGO/NGO to identify impact indicators and to map involved stakeholders |
| | Simulation | Identify a quantum computing provider that would be suited for a simulation |
| | QPU implementation | Identify a quantum computing provider that would be suited for an implementation on QPU |
| Phase 3 [start date - end date] | Admin | Schedule, prepare for and participate in bi-weekly meetings for phase 3 with OQI team |
| | Technical | Address issues raised regarding scientific part in evaluation after phase 2 (if applicable) |
| | SDG | Address issues raised regarding impact part in evaluation after phase 2 (if applicable) |
| | Simulation | Develop code and commit code to GitHub |
| | Simulation | Collaborate with quantum computing / simulation provider to optimize code and finalize resource estimation |
| | Simulation | Map the problem / solution architecture to specific hardware / simulation provider |
| | Simulation | Perform small-scale first simulations |
| | Simulation | Perform larger-scale simulations, with real-world data (if data-driven approach) |
| | Simulation | Perform simulations with and without noise models of your chosen hardware. How does the accuracy / success metric degrade? |
| | Simulation | Implement any hyper-parameter tuning (if applicable) |
| | Technical | Strategize on steps that can be done before moving to hardware to reduce errors from noise. |
| | Technical | Provide data showing the scaling of your problem |
| | Technical | Provide results compared to classical benchmarks |
| | QPU implementation | From the simulation, re-assess the resources and code improvement needed for a QPU implementation |
| | SDG | Further refine the impact design together with IGO/NGO or SDG experts |
| | Technical | Write internal report and submit by [internal report submission deadline] |
| | Technical | Write external report (open-source) - consider arxiv paper - and submit by [external report submission deadline] |
| Phase 4 [start date - end date] | Admin | Schedule, prepare for and attend bi-weekly meetings for phase 4 with OQI team |
| | Technical | Address issues raised regarding scientific part in evaluation after phase 3 (if applicable) |
| | SDG | Address issues raised regarding impact part in evaluation after phase 3 (if applicable) |
| | QPU implementation | Collaborate with quantum computing provider to optimize code and finalize resource estimation |
| | QPU implementation | Implement on QPU |
| | Admin | Write internal report and submit by [internal report submission deadline] |
| | Admin | Write external report (open-source) - consider arxiv paper - and submit by [external report submission deadline] |

| | | |
|---|---|---|
| | TOTAL INKIND | N/A |
| | TOTAL EXTERNAL FUNDING | N/A |
| | TOTAL ADDITIONAL SUPPORT | N/A |
| | TOTAL OTHER | N/A |
| Phase 2 | TOTAL INKIND | 0.00 |
| | TOTAL EXTERNAL FUNDING | 0.00 |
| | TOTAL ADDITIONAL SUPPORT | 0.00 |
| | TOTAL OTHER | 0.00 |
| Phase 3 | TOTAL INKIND | 0.00 |
| | TOTAL EXTERNAL FUNDING | 0.00 |
| | TOTAL ADDITIONAL SUPPORT | 0.00 |
| | TOTAL OTHER | 0.00 |
| Phase 4 | TOTAL INKIND | 0.00 |
| | TOTAL EXTERNAL FUNDING | 0.00 |
| | TOTAL ADDITIONAL SUPPORT | 0.00 |
| | TOTAL OTHER | 0.00 |
| | **TOTAL** | **0.00** |

**OQI - Budget Template**

Use case: [add use case title]
Date: [add date]
Period: Phase 2

| EXPENSES<br>Category | Descripton | Total | |
|---|---|---|---|
| Personnel costs | | 90.00 | |
| Equipment & material | Other costs (if applicable) | 0.00 | Indicate beneficiary (if applicable) |
| Services | Data collection (etc.) | 0.00 | Indicate beneficiary (if applicable) |
| Other costs | | 0.00 | |
| .... | | 0.00 | |
| .... | | 0.00 | |
| **Total expenses** | | 90.00 | |

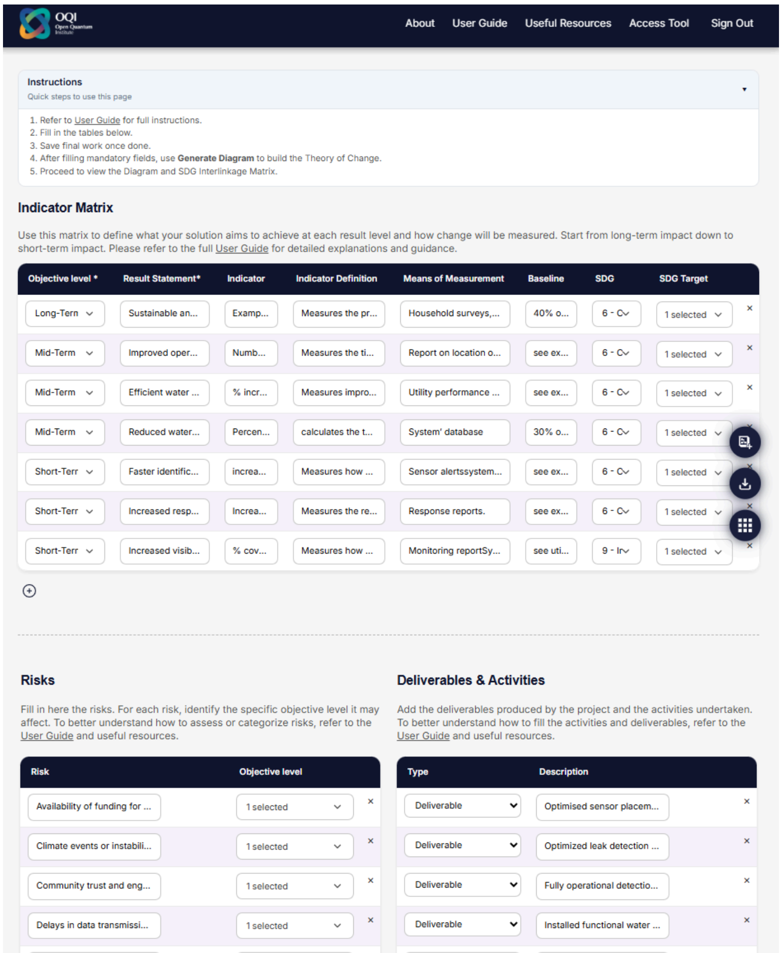
| REVENUE<br>Category | Descripton | Total | Comments |
|---|---|---|---|
| Inkind | Non-monetary contributions provided by team members | 15.00 | |
| External funding | Financial resource obtained from external sources (grant, etc. | 15.00 | |
| Other source of funding | Other type of financing | 15.00 | |
| Additional financial support - contributor A | Additional financial resources needed | 0.00 | |
| Additional financial support - contributor B | Additional financial resources needed | 0.00 | |
| Additional financial support - contributor C | Additional financial resources needed | 0.00 | |
| Additional financial support - contributor D | Additional financial resources needed | 0.00 | |
| **Total Revenue** | | 45.00 | |

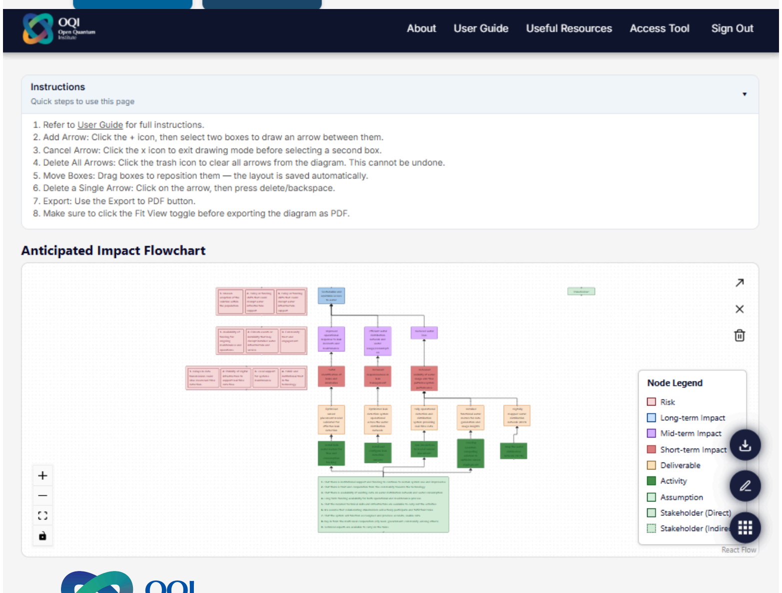
| SUMMARY | |
|---|---|
| Total Expenses | 90.00 |
| Total Revenue | 45.00 |
| **Net Balance** | -45.00 |

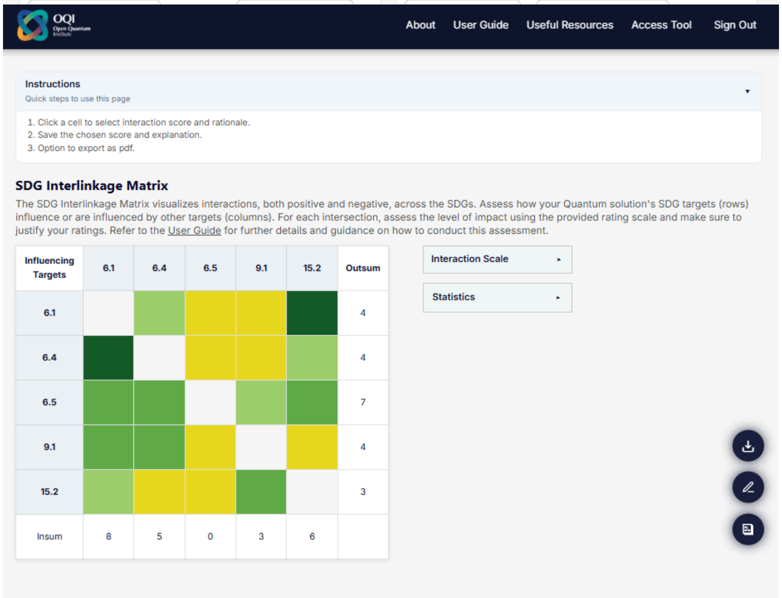
# Annex 6 - Snapshot of the Impact Tool

**OQI Impact Tool**

Scan to access the tool:

# Annex 7 - Open Guidelines and Questionnaire

OQI Use Case Open Guidelines
& Questionnaire

## A. Guidelines for Openness of OQI Use Cases

### 1. Purpose

Part of OQI's multidimensional commitment to 'open' is building quantum computing use cases that benefit humanity and support the UN 2030 Agenda and beyond. Developed through open, multi-stakeholder collaborations among quantum experts, domain and impact experts, and quantum providers, these use cases create knowledge, methods and best practices, which are shared openly to maximize benefits for all.

This document explains how the principle of openness is applied across OQI use cases in practice and, namely in terms of publications, data and software. This aligns with the central value of OQI to make Results openly accessible. This approach is based on Article 5 and 6 of the OQI Framework Agreement and inspired by the CERN's Open Science Policy.

The development of all OQI use cases is governed by the Quantum Application Framework, which offers practical guidelines and a methodology to support the global community in developing robust quantum computing use cases that address global challenges. This document complements the Framework by specifying how the principle of openness is applied in practice across these use cases.

### 2. Key Concepts and Definitions

Openness applied in the context of OQI use cases builds on the definitions and principles set out in the OQI Framework and Project Agreements as well as the Quantum Application Framework. The Framework and Project Agreements remain the legally binding references.

#### 2.1 Core Definitions from Framework

The following core terms are defined in the OQI Framework Agreement and underpin the interpretation of openness in OQI use cases:

**"Intellectual Property"** shall mean all intellectual property, including Know-How, in forms such as drawings, designs, documents, inventions, software programmes, technology, reports, processes, and protocols, and protected by means such as secrecy, patents, copyrights, and trademarks.

**"Results"** shall mean all information and Intellectual Property created in the execution of the Project.

**"Background"** shall mean all Intellectual Property (regardless of the form or medium in which it is disclosed or stored) owned or controlled by a Party at the commencement of a Project, and any Intellectual Property developed independently of that Project (whether before or after the date of this Agreement), provided by a Party for use in that Project;

Additionally, we will refer to **"third-party resources"** for data, software, tools, or other inputs that are not owned by the Project Parties but are used within a use case. Their use is subject to the respective licensing terms and conditions, which may impose constraints on openness, reuse, and dissemination.

### 2.2 Governance and Ownership model

The governance and ownership of Results in OQI use cases follow the principles established in the OQI Framework and Project Agreements.

- **Ownership remains with the creator.** Each Party retains ownership of its Background and the Results it generates. Joint Results are jointly owned, with specific arrangements established separately.
- **Access is purpose-bound.** Parties grant each other non-exclusive, royalty-free access to Background and Results for the execution of the Project and to enable the use of the Results.
- **Openness is balanced with protection.** Results are initially treated as confidential and may be protected where appropriate before being shared openly, in line with OQI's open science objectives.
- **Use is subject to rights and obligations.** The use of Background and Results must respect ownership, licensing conditions, third-party rights, and prior obligations, which may impose constraints on sharing and openness.

## 3. Intellectual Property

In line with the OQI Framework Agreement, Intellectual Property (IP) in OQI use cases is managed with a focus on balancing protection and openness. Guiding principles are detailed below.

### 3.1 Patents

While OQI use cases primarily focus on applying and integrating existing technologies, they may in some cases lead to novel technical solutions that are eligible for patent protection. In general, patentability depends on jurisdiction, but typically requires that an invention is novel, involves an inventive step, and is industrially applicable.

A key consideration in OQI use cases is the timing of publication. Public disclosure of Results (e.g. through papers, open repositories, or presentations) before filing a patent may compromise the ability to obtain patent protection in many jurisdictions. Therefore, Parties should:

- Assess the patentability of Results at an early stage
- Coordinate internally and with other Parties before public disclosure
- Ensure that any intended patent filings are completed prior to publication where relevant

At the same time, patents and openness are not mutually exclusive. OQI promotes approaches where patented technologies can be made available through open or royalty-free licensing models.

### 3.2 Categories of IP

Different categories of IP require different approaches to openness, protection, and reuse. Distinguishing between categories is important to ensure appropriate handling, as different legal regimes may apply (such as copyright, data rights, or patents), different licensing models may be required, and the degree of openness achievable can vary depending on the nature of the Result.

- **Data**. Data refers to structured or unstructured information generated, collected, or used within a use case, including but not limited to raw and processed datasets, simulation outputs, benchmarks, and associated metadata.

  Data and associated data services apply open and FAIR (Findable, Accessible, Interoperable and Reusable) principles.

— **Software**. Software refers to executable or interpretable code developed or used within a use case, including source code, algorithms, models, scripts, and workflows, as well as related documentation.

— **Other.** Other IP refers to non-code and non-data IP produced or used within a use case, including publications, reports, methodologies, visualizations, and digital tools (e.g. dashboards or platforms).

### 3.3 Licensing and Platform

The following table suggests licenses and publishing platforms.

| | **License** | **Platform** |
|---|---|---|
| Data | Creative Commons licences with CC-BY as default standard. | Zenodo, CERN document server |
| Software | Licenses approved by the Open Source Initiative. | OQI provides GitHub repository |
| Other (where not patentable*)<br><br>*for patentable, refer to Section 3.a | Creative Commons licences with CC-BY as default standard. | Website, peer-reviewed journal or in the format of the CERN Yellow Report |

## 4. Documentation, Publication and Dissemination of Results

### 4.1 Principles

The documentation and dissemination of Results in OQI use cases are guided by the following principles:

— **Sharing of learnings**. OQI encourages the dissemination of both positive and negative Results, as well as lessons learned throughout the use case, to support collective progress and avoid duplication of effort.

— **Reproducibility**. Results are documented so others can understand, assess, and, where possible, reproduce the Results, by using the use case teams' submitted artifacts including their code, data and environment alongside the clear descriptions of methods, data, assumptions, and limitations.

The term Reproducibility is meant to reflect and follow the guidelines and standards set out by HPC communities like ACM and Super Computing conferences. The phrase 'where possible' highlights that even though the use case teams may submit all of the information needed to reproduce an experiment, the complete set of Results may not be re-achievable, given the unstable and noisy standard of current quantum hardware.

### 4.2 Documenting the Results during project

As outlined in the Quantum Application Framework, use case teams produce structured documentation throughout the development process. Such documentation have internal and external reporting purposes:

— Shareable with external stakeholders: Phase 1 Outline, Phase 2 extract of Full Proposal, Phase 3 extract of Report, Phase 4 extract of Report (extract approved by the use case teams)

— Internal reporting: Phase 2 Full Proposal, Phase 3 Report, Phase 4 Report

### 4.3 Scientific Publications

OQI encourages the publication of Results that are deemed to be at the level of scientific publications to be done through open access channels in order to maximize dissemination, visibility and reuse. Once published, all OQI publications are to be made immediately openly available and reusable. The following routes are supported:

— **Diamond Open Access.** Publication in community-driven journals that do not charge article processing fees (APCs) (e.g. Quantum journal).

- **Gold Open Access.** Articles made openly available by the publisher, typically with APCs covered by the authors, CERN, or OQI. In such cases, authors who are CERN members of personnel can use the CERN Open Access fund to waive the publication fees. For other authors of the use case team, OQI can support this process, following CERN guidelines and up to a reasonable open access article processing charge. Please submit an official request to oqi.usecases@cern.ch.
- **Green Open Access.** Authors deposit the accepted manuscript in an open repository (e.g. arXiv, CERN Document Server), in parallel with peer-reviewed journal publication.

Additionally, OQI supports the dissemination of non-peer reviewed manuscripts on an open repository (e.g. arXiv, CERN Document Server).

### 4.4 Program-Level Outputs

OQI also compiles Results and learnings from all use cases led during its pilot. This compilation takes the form of the OQI Use Case White Papers (based on the Phase 1 Outlines), as well as a final pilot phase compilation through a CERN Yellow Report (based on the Results that have been approved for open dissemination).

### 4.5 Further Dissemination of Completed Use Cases.

OQI encourages and supports use case teams to identify and pursue further opportunities for disseminating their Results once OQI's support for the use case is completed, including future translation into real-world deployment.

# B. Open Collaboration Questionnaire

This questionnaire is based on the Open Guidelines for OQI Use Cases and provides use case teams with a framework to reflect on how openness is embedded in the work supported by OQI. The questionnaire aims to identify strengths and uncover opportunities to increase openness in the development of use cases.

The output of this questionnaire should be updated continuously, especially before each evaluation prior to transitioning to a new phase. In Phase 2, the output should outline expected Results. In Phase 3 and 4, the output should be updated with the most recent findings.

## 1. Results

Please fill out Table 1 following the instructions below.

1.1 List all created and expected Results from the execution of the use case. For each Result, identify the party or parties who created them and specify the category (Data, Code, Other). Such Results include, but not limited to methodology and outputs of the methodology related to algorithms, resource estimation, benchmarking, etc, as well as generated data, produced software, impact discussions, etc.

1.2 Specify if any of the Results should be protected by new patents.

1.3 Comment any concerns in regard to making Results openly available with clear reasoning.

1.4 For each Result specify the preferred platforms/means of open publication. See Guidelines for details.

1.5 For foreseeable peer-reviewed publications, identify the journal, the list of authors and the open-access strategy.

1.6 Describe the relevant licenses: See Guidelines for details.

### Table 1: List of Results

| Result (see 1.1) | Owning Party(ies) (see 1.1) | Category (see 1.1) | Patentable (see 1.2) | Open Access (see 1.3) | Comment (see 1.2, 1.3) | Publication Platform (list of authors) (see 1.4, 1.5) | License (see 1.6) |
|---|---|---|---|---|---|---|---|
| | | Neit... | | Please ... | | | |
| | | Neit... | | Please ... | | | |

## 2. Background and third-party resources

Please fill out Table 2 following the instructions below.

2.1 In accordance with Annex 1 of the Project Agreement, list all relevant Background made available for use in the project. This should include a confirmation and, where necessary, an update or completion of the information provided in Annex 1.

In addition, list all third-party resources used in the project (e.g. external datasets, software, or other materials not owned or controlled by the Parties).

For each item, identify the providing party or parties and specify its category (Data, Software or Other).

2.2 Indicate whether the Background or third-party resource is or will be openly accessible. If it is not, provide a justification for the restricted access.

2.3 Describe how and where the Background or third-party resource can be accessed (or will be made accessible), and describe the conditions for its use, including any licenses or intellectual property protections (e.g. patents). For data, also explain how interoperability and reusability are ensured (e.g. formats, standards, documentation).

### Table 2: List of Background and third-party resources

| Background (see 2.1) | Providing Party(ies) (see 2.1) | Category (see 2.1) | Open Access (see 2.2) | Comment (see 2.2) | Access Method and Location (see 2.3) | Usage Conditions (licenses, IP rights, patents) (see 2.3) | For Data only: Interoperability and Reusability Details (see 2.3) |
|---|---|---|---|---|---|---|---|
| | | Neit... | Pl... | | | | |
| | | Neit... | Pl... | | | | |

## 3. Other Considerations

3.1 What potential challenges might be encountered when attempting to reproduce the Results of this use case?

3.2 Dissemination of Results is an important aspect of Openness. Discuss other potential ways, if any, of disseminating the use case Results.