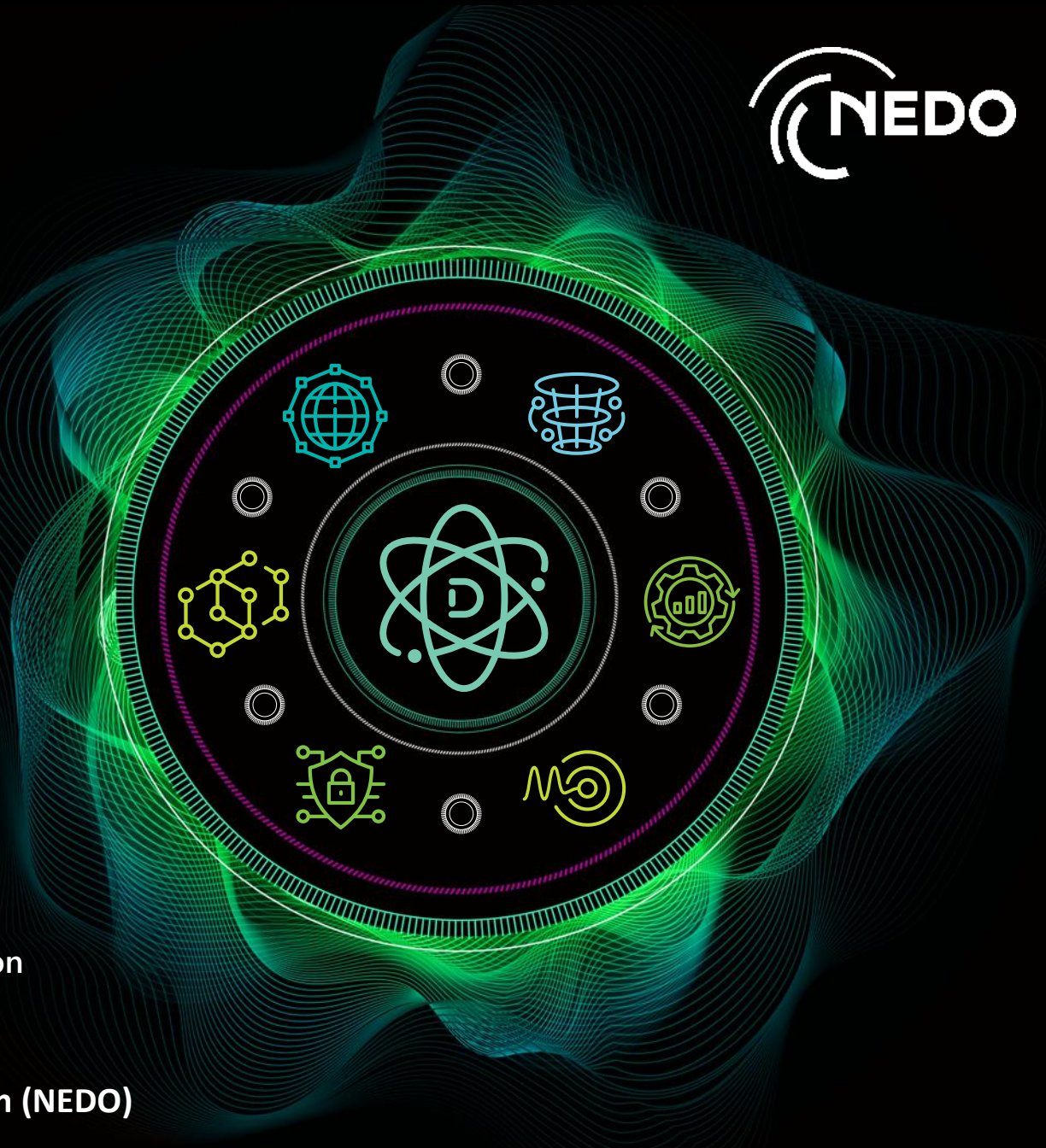
Quantum Computing Use Cases

Optimization of water equipment design

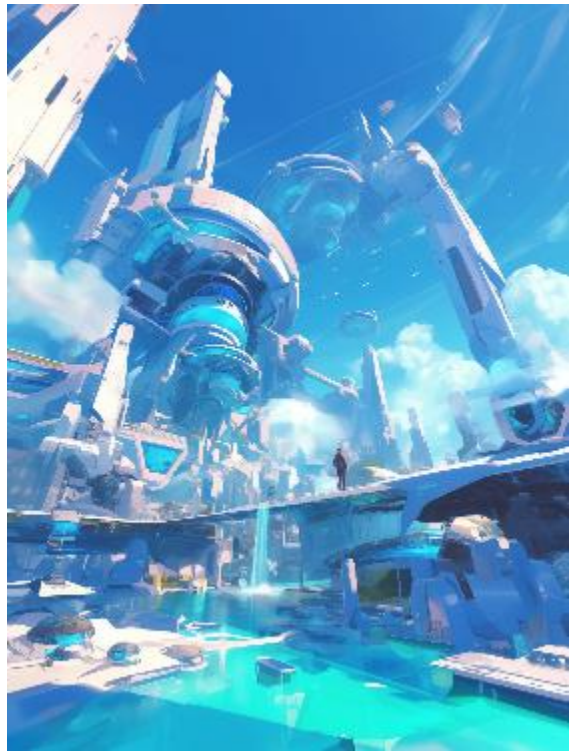


Promotion of SDGs with Quantum Technology

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New Energy and Industrial Technology Development Organization (NEDO)

水生成設備・上下水道の設計最適化
Optimization of water equipment design



ユースケース概要 **Use Case Overview**	水資源管理モデルの構築を通じた、上下水処理の最適化 Optimization of water treatment through the development of a water resource management model.
解決できる課題と効果 **Issues to be addressed and their effects**	水の安定供給を確保し、水アクセスの地理的格差を解消 Ensuring a stable supply of water and eliminating geographical disparities in water access.
量子技術の貢献 **Contributions of quantum technology**	地域の地理・気候条件や需要特徴に応じて、最適な水源ポートフォリオを提案 Propose the optimal water source based on local geography, climate, and demand conditions.

実現予想時期 **Expected realization period**	(Year)2035～2040
産業分類 **Industry classification**	ユーティリティ・通信 Utilities・Communications
関連するQRAMI階層 **Related QRAMI layers**	事業層 Business layer
関連する量子技術 **Related quantum technologies**	量子アニーリング Quantum Annealing

新規性 **Novelty**	軽微な改良 Minor improvements
達成難易度 **Difficulty of achievement**	容易 Easy
社会貢献度 **Social contribution level**	社会全体に貢献 Contributions to society as a whole
市場規模 **Market size**	5.10兆円～ 10T¥～

Detail

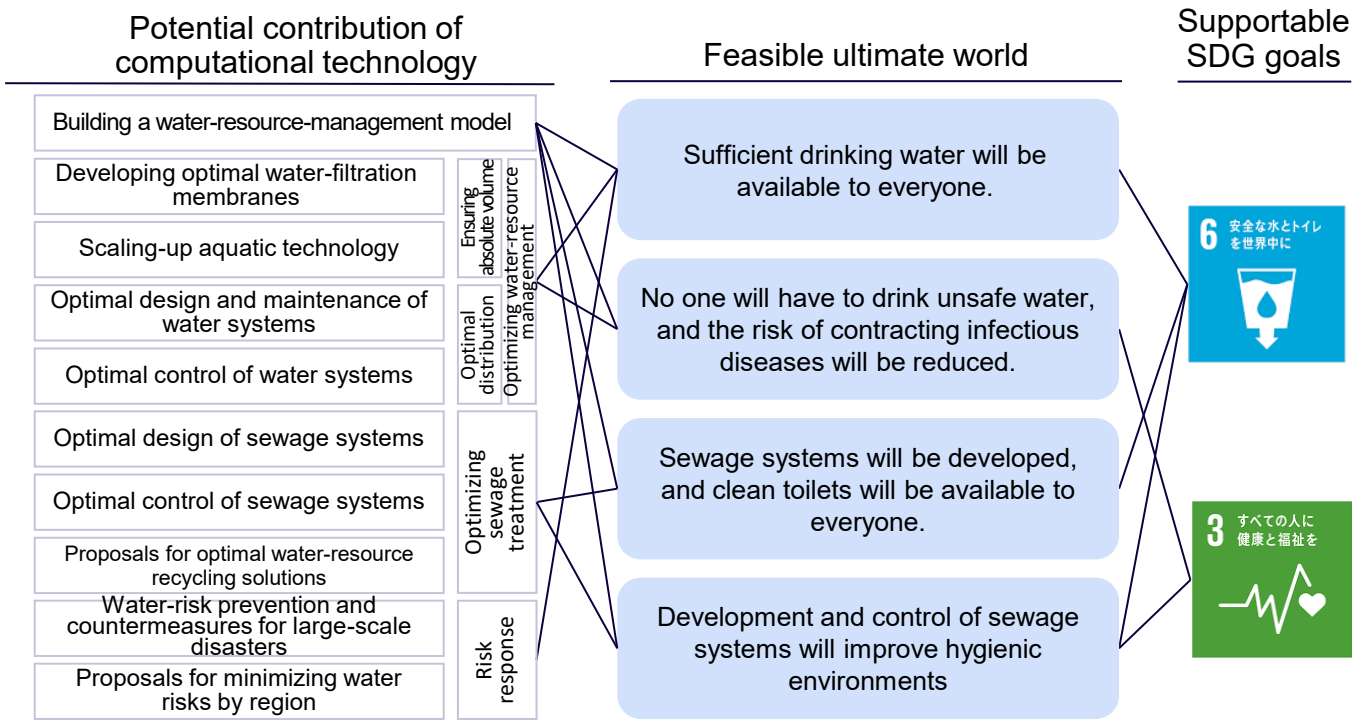
Optimization of water equipment design

- Technological innovation concerning water generation and optimal design of water-supply and sewerage systems will ensure the absolute volume of water is supplied and the eliminate geographical disparities.



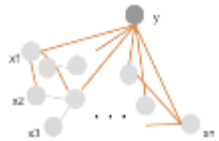
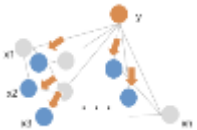
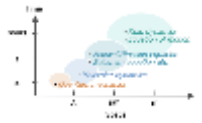
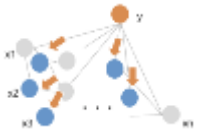
54%
Relative improvement in access to water

Conventional methods would provide safe water to an additional 82.8 million people each year; however, using QC will make it possible to provide relief to an additional 127.38 million people each year, namely, a 54% increase in the number of people who can be helped.



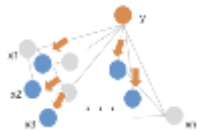
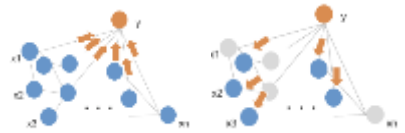
Roadmap

Optimization of water equipment design

Process (1/2)		Necessary R&D and business development	Quantum-computer scope of contribution and future development issues	
Constructing a water-resource circulation system	Establishing a water-resource-circulation model	■ A circulation-system model (water source ➡ delivery ➡ use (household/industry) ➡ disposal) was established. Specifically, a large amount of past measured values of water supply/demand and related parameters were input as a data set, and the model was formulated using linear-regression analysis.		● Expanding the scope of quantum computing for statistical analysis, e.g., linear-regression analysis (i.e., developing methods with a wider range of applications than current algorithms)
	Establish computational technology	■ Establishing forecasting simulation in consideration of global scale and real-time water resources and demand	Solve forward problems in causal models 	■ Within those models, identify computational tasks difficult to solve by a classical approach ■ Developing algorithms to efficiently solve those tasks ■ Large-scale execution of established mathematical models
Designing optimal water management	Construction of an optimal-water-source portfolio	■ According to the circulation-system model, the optimal-water-resource portfolio—based on real-time geographical and climatic conditions and demand characteristics of the region—for each region is proposed. ■ In the proposed optimal-water-source portfolio, a mechanism to support the effectiveness and necessity of new water-generation technologies and promote their introduction and dissemination is proposed. ■ Implementing new water-generation technologies in a manner that assures scalability and cost-effectiveness ➢ Seawater-desalination technology: higher water-production rate, lower energy cost, less waste and improved utilization rate of waste, etc. ➢ Water-generation technology: hygroscopic materials that can be used regardless of the specific gravity of water vapor (humidity) contained in the air ➢ Artificial rainfall: Development of lower-cost rainfall materials and rainfall-control systems for handling periods with no rainclouds → Quantum chemical calculations and fluid calculations to speed up calculation of optimal materials and synthesis/manufacturing processes	Solve the inverse problem in causal models 	■ Accelerating the search for—and expanding the scope of—optimal solutions
				■ Accelerating quantum chemical calculations ■ Developing algorithms to solve MD calculations quickly ■ Developing algorithms to solve nonlinear equations (such as the Navier-Stokes equations) quickly
	Designing optimal water-pipe infrastructure	■ Design of optimal initial placement of water pipes according to the circulation-system model ■ Simulation for predicting water-pipe maintenance and corrosion (complex predictions based on daily geographical/climatic conditions and water-supply volume)	Solve the inverse problem in causal models 	■ Accelerating the search for—and expanding the scope of—optimal solutions

Roadmap

Optimization of water equipment design

Process (2/2)		Necessary R&D and business development	Quantum-computer scope of contribution and future development issues	
Design to optimize water management	Optimizing water-distribution and water-supply operations	■ Establishing simulations that can optimally control water distribution and supply in accordance with factors like daily water volume and demand ■ Establishing technology that can remotely and automatically control water distribution and supply	-	■ None in particular
	Optimizing water-recycling systems	■ Proposals for optimizing water-resource-circulation solutions (use of water-purification agents, ion-exchange membranes, reuse, etc.) → Optimization calculations based on wastewater characteristics measured in real time	Solve inverse problem 	■ Accelerating the search for—and expanding the scope of—optimal solutions ■ Executing large-scale established mathematical models in real-time
	Predicting and preventing risks for water-resource-circulation systems	■ Simulating the effects of large-scale disasters (earthquakes, etc.) on water-resource-circulation systems, and proposals for optimal prevention and response measures in the event of a disaster ■ Using real-time data to (i) predict and evaluate the risk of drought in each country and region in real time and in the medium to long term and (ii) propose proposals for optimization of industrial placement and human relocation by region, etc.	Solve forward and inverse problems 	■ Accelerating the search for—and expanding the scope of—optimal solutions ■ Executing large-scale established mathematical models in real-time

Roadmap

Optimization of water equipment design

Process		Necessary steps	Items related to quantum computers	2024	2025-2030	2030-2040	Beyond 2040
Constructing a water-resource circulation system	Establishing a water-resource-circulation model	■ Collecting data on the current state of water resources (e.g., water supply and demand, usage patterns, water quality, distribution, and reuse)					
		■ Collecting long-term data on regional characteristics and seasonal fluctuations of water resources					
		■ Expanding scope for applying quantum computers to statistical analysis (e.g., linear-regression analysis)	■				
		■ Constructing a water-resource-circulation model	■				
	Establish computational technology	■ Reproducing processes such as water supply and demand, runoff, reuse, and purification	■				
		■ Verifying the possibility and business feasibility of accelerating calculations with quantum computers	■				
		■ Within those models, identify computational tasks difficult to solve by a classical approach	■				
		■ Establishing quantum-computing technology that enables real-time calculations on a global scale using established mathematical models	■				
		■ Establish solutions combining algorithms for predicting water supply-and-demand for each region and quantum computing	■				
Designing optimal water management	Construction of an optimal-water-source portfolio	■ Accelerating the search for—and expanding the scope of—optimal solutions	■				
		■ Establish solutions combining algorithms for optimizing water-resource portfolio for each region and quantum computing	■				
		■ Accelerating quantum chemical calculations	■				
		■ Develop algorithms to solve molecular dynamics calculations at high speed	■				
		■ Developing algorithms for solving nonlinear equations (e.g., Navier-Stokes equations) quickly	■				
		■ Establishing quantum chemical algorithms for optimization of new water-production technologies and processes (e.g., seawater desalination and air-water generation)	■				
	Designing optimal water-pipe infrastructure	■ Accelerating the search for—and expanding the scope of—optimal solutions	■				
		■ Establishing an algorithm for optimizing initial placement of water pipes	■				
		■ Establishing technology for collecting data on current water-pipe materials, age, water quality, environmental conditions, etc. in real time					
		■ Constructing an algorithm for predicting water-pipe corrosion					

Roadmap

Optimization of water equipment design

Process		Necessary steps	Items related to quantum computers	2024	2025-2030	2030-2040	Beyond 2040
Designing optimal water management	Optimizing water-distribution and water-supply operations	■ Establish solutions combining algorithms for optimizing delivery and water supply that consider factors like daily water volume and demand and quantum computing					
		■ Establishing technology that can remotely and automatically control water distribution and supply					
	Optimizing water-recycling systems	■ Defining indicators to be targeted for optimizing water recycling (energy consumption, water quality, etc.)					
		■ Accelerating the search for—and expanding the scope of—optimal solutions					
		■ Establish solutions combining algorithms for proposing optimal water-resources-circulation solutions and quantum computing					
		■ Executing large-scale established mathematical models in real-time					
	Predicting and preventing risks for water-resource-circulation systems	■ Formulating an algorithm for predicting the impact of large-scale disasters on water-resource supply by learning from past cases					
		■ Accelerating the search for—and expanding the scope of—optimal solutions					
		■ Establish solutions combining algorithms for proposing optimal countermeasures against damage from large-scale disasters and quantum computing					
		■ Establish solutions combining algorithms for predicting real-time, medium-to-long-term regional-drought risks and quantum computing					
		■ Establish solutions combining algorithms for optimized proposals for regional-drought risk prevention and quantum computing					
		■ Executing large-scale established mathematical models in real-time					

More use cases are available on our website. We invite you to explore them.
https://www.quantum-computing-use-cases.nedo.go.jp/english/

More Use Cases

New Energy and Industrial Technology Development Organization (NEDO)
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This collection of use cases was obtained as a result of the work commissioned by the New Energy and Industrial Technology Development Organization (NEDO) "Cyber-Physical Development Business of Quantum/Classical Hybrid Technology/Study of Use Case of Quantum Technology" and the “Post-5G Information and Communications System Infrastructure Reinforcement R & D Project (Quantum Industrialization)/Comprehensive Study for Promoting the Industrialization of Quantum Computers ”.