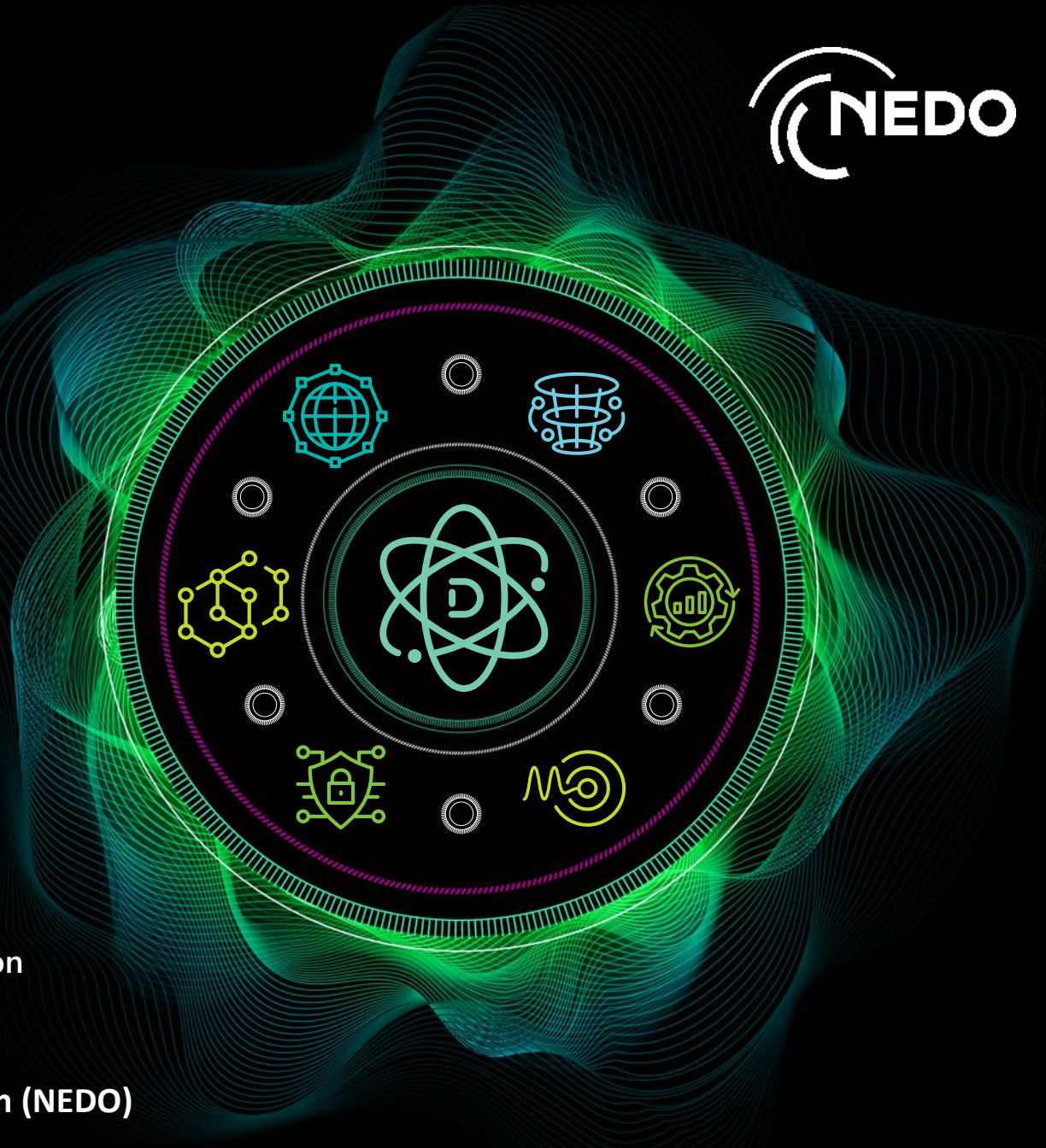
Quantum Computing Use Cases

Climate prediction simulation



Promotion of SDGs with Quantum Technology

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New Energy and Industrial Technology Development Organization (NEDO)

気候予測シミュレーション
Climate prediction simulation



ユースケース概要 **Use Case Overview**	地球規模の気候シミュレーションや気候制御技術による気候変動対策 Global climate simulations and climate control technologies for addressing climate change.
解決できる課題と効果 **Issues to be addressed and their effects**	気候変動脅威や天災リスクの大幅な低減により、経済損失を回避 Avoiding economic losses through significant reduction of climate change threats and disaster risks.
量子技術の貢献 **Contributions of quantum technology**	既存の地球規模の気象予測モデルの精緻化およびシミュレーション Refinement and simulation of existing global weather prediction models.

実現予想時期 **Expected realization period**	(Year)2035～2040
産業分類 **Industry classification**	情報・金融・その他サービス Information・Financial・Other services
関連するQRAMI階層 **Related QRAMI layers**	機能層 Functional layer
関連する量子技術 **Related quantum technologies**	量子コンピュータ(NISQ) Quantum Computer(NISQ)

新規性 **Novelty**	既存の模倣 Existing imitation
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**	1,000億～1兆円 100B～1T¥

Detail

Climate prediction simulation

- By implementing global-climate simulation and climate-control technology, the threat of climate change and the risk of natural disasters can be significantly reduced.



178 trillion dollars

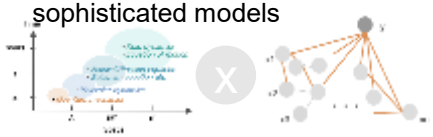
Avoiding economic losses due to climate change

If climate change measures are not taken, the world economy could lose 178 trillion dollars by 2070. By utilizing QC and cooperating with other countries, it is possible to avoid economic losses and boost GDP.

Potential contribution of computational technology	Feasible ultimate world	Supportable SDG goals
Explaining the causes of climate change and interactions between factors	Climate problems will be solved while maintaining economic growth.	13, 8
High-resolution climate-prediction simulation	Stable production of crops of choice will be possible anywhere.	2
Proposing solutions to prevent natural disasters	Rainfall will be possible anywhere and at any time in a way that solves water shortages	6
Simulating effects of artificial climate control	Energy use will be reduced because temperatures can be controlled.	7
Quantifying effects of introducing artificial-climate-control technology	Long-term safety of cities will be increased by limiting climate-related disasters	11

Roadmap

Climate prediction simulation

Process		Necessary R&D and business development	Quantum-computer scope of contribution and future development issues	
Global climate simulation	Establishing and refining global-weather and atmospheric-environment models	■ Since existing global-climate models give results that deviate from past measurements, they will be refined by verifying their validity and reproducibility. ■ Constructing a model that includes past data to reflect the life cycle of the entire Earth (including past crustal changes, geology, and meteorological changes of the Earth) →Input a large amount of past measurements of climate phenomena and related parameters as a data set, and formulate them using linear-regression analysis ■ Integration with ecological models, social models, etc.	Combining theoretical models and causal analysis to build sophisticated models 	■ Developing algorithms to solve nonlinear equations (such as the Navier-Stokes equations) quickly ■ Expanding the scope of linear-regression analysis (i.e., developing methods with a wider range of applications than current algorithms)
	Developing sensing technology	■ Developing sensing technology for real-time temperature, topography, airflow, etc. (e.g., visualization of wind using sound waves, lasers, etc.)	-	■ None in particular
	Establish computational technology	■ Global-scale prediction calculations → High-spatial-resolution simulations improve prediction accuracy (even supercomputers lack the computing power to reproduce localized precipitation characteristics)	Solve union of a theoretical model and causal model 	■ Develop techniques that enable an integrated approach combining theoretical and causal models instead of solving individual models separately
Implementation of climate-control technology	Proposing natural-disaster-prevention solutions	■ Based on these simulations, optimal measures for preventing damage from natural disasters in advance and evacuation plans (e.g., optimizing the placement of trees and water to lower urban temperatures by simulating the distribution of heat storage in urban environments) are proposed.	-	■ None in particular
	Human-climate-control solutions	■ Many efforts to control torrential rains and typhoons are being made.	-	■ None in particular
	Simulating climate-control effects	■ Since care must be taken to ensure that incorrect operation of weather control does not cause problems such as droughts and long-term changes in climate, a model that can simulate the effects of climate control will be established ■ Quantification of the negative impact of technology introduction and reliability of predictions		■ Developing methods that can be approached as a whole, combining theoretical models and causal models, rather than solving each model individually
	Establishing infrastructure to provide the above solutions	■ Determining the subject to deal with and constructing a countermeasure scheme that transcends national borders ■ Constructing guidelines for negative effects	-	■ None in particular

Roadmap

Climate prediction simulation

Process		Necessary steps	Items related to quantum computers	2024	2025-2030	2030-2040	Beyond 2040
Global climate simulation	Establishing and refining global-weather and atmospheric-environment models	■ Collecting and analyzing existing climate models					
		■ Collecting and standardizing past climate data to create clean data sets					
		■ Developing algorithms to solve nonlinear equations (such as the Navier-Stokes equations) quickly	■				
		■ Expanding the scope of linear-regression analysis (i.e., developing methods with a wider range of applications than current algorithms)	■				
		■ Building and refining models that mathematically represent the physical processes of weather and climate	■				
	Developing sensing technology	■ Developing sensing technology for real-time temperature, topography, airflow, etc.					
	Establish computational technology	■ Verifying the feasibility and business viability of accelerating calculations by using quantum computers	■				
		■ Develop techniques that enable an integrated approach combining theoretical and causal models	■				
		■ Establish solutions combining algorithms for climate-change risk and extreme-weather-measurement for each region and quantum computing	■				
Implementation of climate-control technology	Proposing natural-disaster-prevention solutions	■ Collecting data on regional disaster-damage effects (frequency of damage, extent of damage, population density) from past case studies					
		■ Establishing disaster-risk-assessment algorithms based on characteristics of each region					
		■ Establishing algorithms for optimizing preventive measures before disasters occur and evacuation plans when disasters occur					
	Human-climate-control solutions	■ Establishing an algorithm for optimizing technology for controlling torrential rains and typhoons					
	Simulating climate-control effects	■ Develop techniques that enable an integrated approach combining theoretical and causal models	■				
		■ Establishing an algorithm for predicting the impact of human intervention via climate-control technology on the natural world (including the biosphere, climate, and water resources)	■				
		■ Quantifying the negative effects of human climate-control technology and proof of prediction reliability					
	Establishing infrastructure to provide the above solutions	■ Satisfying legal regulations for introduction of technology and constructing an international cooperation scheme					
		■ Constructing guidelines for dealing with the negative effects of introducing technologies					

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

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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 ”.