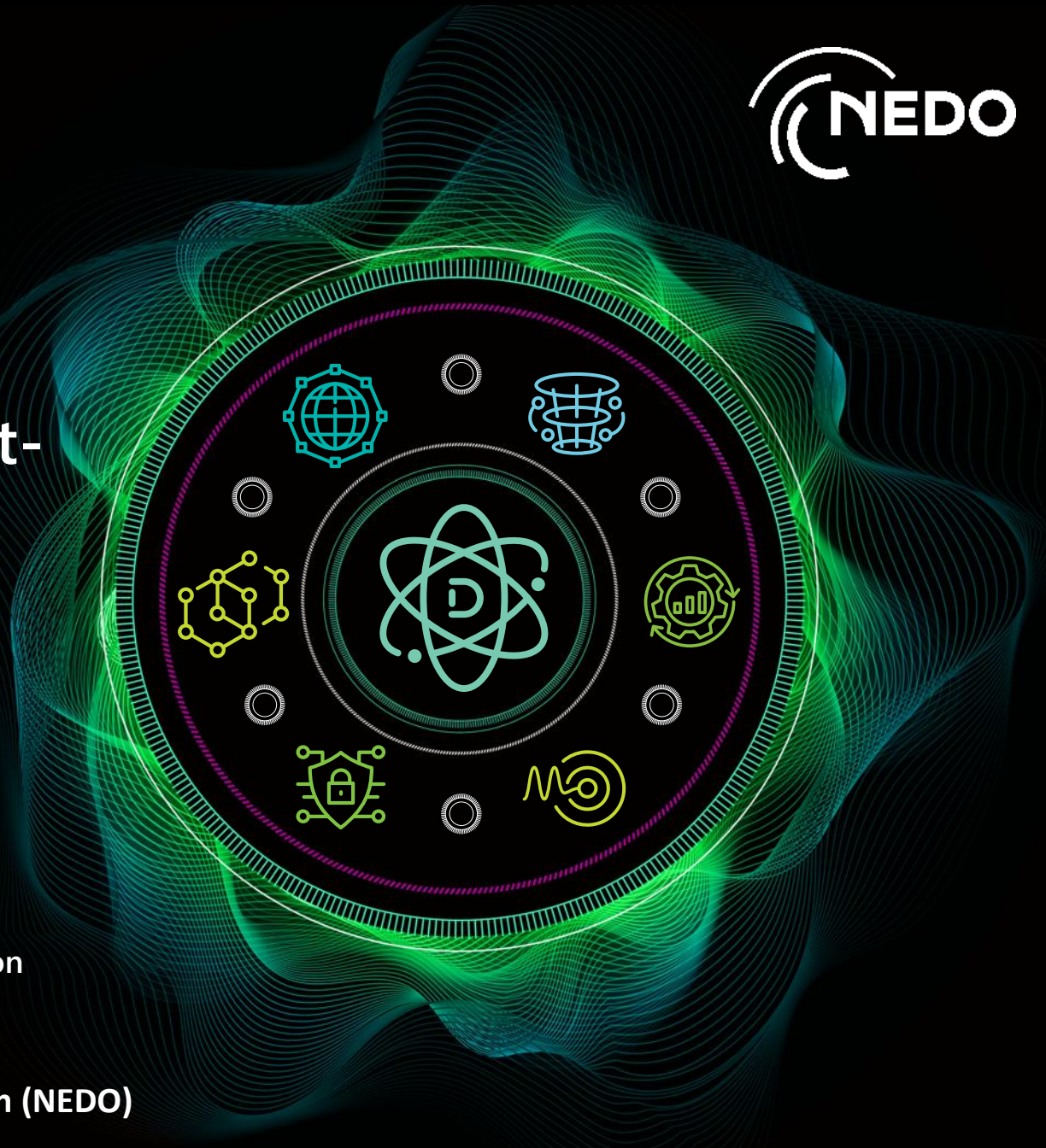
Quantum Computing Use Cases

# Optimization of the design of next-generation energy systems



Promotion of SDGs with Quantum Technology

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New Energy and Industrial Technology Development Organization (NEDO)

# 次世代エネルギーシステムの設計最適化
# Optimization of the design of next-generation energy systems



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| **ユースケース概要**<br>**Use Case Overview** | 再生可能エネルギーなどのシステム設計や設備配置を最適化<br>Optimizing the system design and equipment layout for renewable energy and other systems. |
| **解決できる課題と効果**<br>**Issues to be addressed and their effects** | 需要シーンに応じた最適な発電方法により、エネルギー問題を解消<br>Resolve energy issues through the optimal power generation methods suited to the required scenes. |
| **量子技術の貢献**<br>**Contributions of quantum technology** | エネルギーの需給予測・需給調整モデルの構築およびシミュレーション<br>Construction and simulation of energy supply and demand forecasting and adjustment models. |

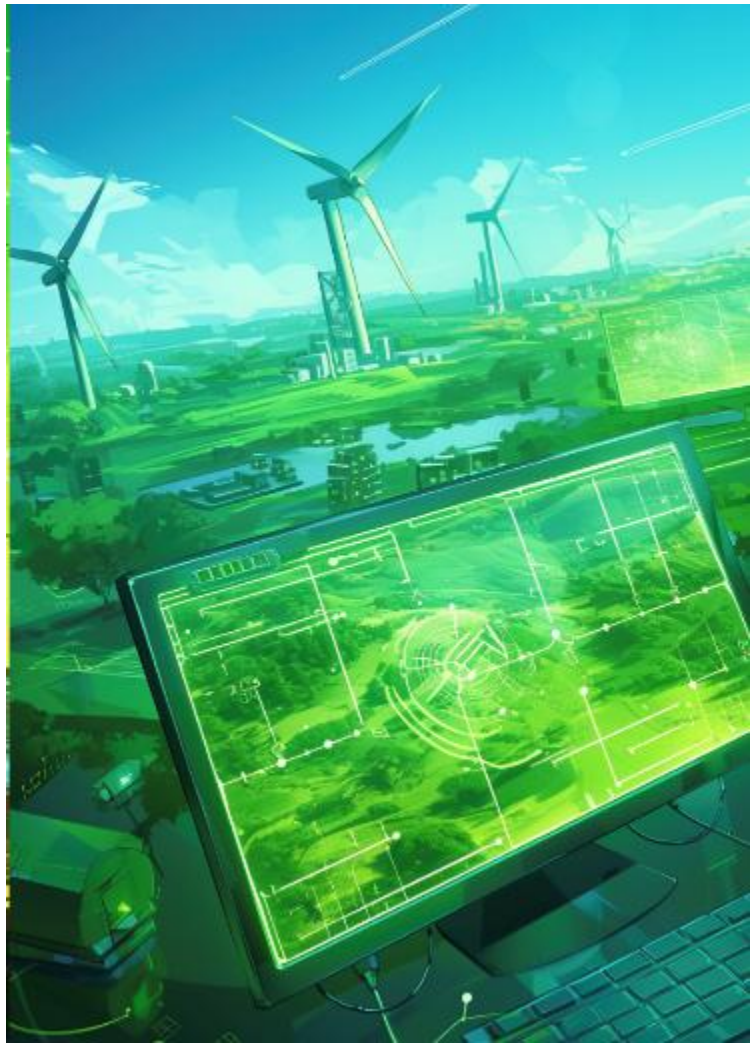
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|---|---|
| **実現予想時期**<br>**Expected realization period** | (Year)2035～2040 |
| **産業分類**<br>**Industry classification** | ユーティリティ・通信<br>Utilities・Communications |
| **関連するQRAMI階層**<br>**Related QRAMI layers** | インタフェース層<br>Interface layer |
| **関連する量子技術**<br>**Related quantum technologies** | 量子アニーリング<br>Quantum Annealing |

| | |
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| **新規性**<br>**Novelty** | 既存の模倣<br>Existing imitation |
| **達成難易度**<br>**Difficulty of achievement** | 容易<br>Easy |
| **社会貢献度**<br>**Social contribution level** | 幅広い業種に貢献<br>Contributions to a wide range of industries |
| **市場規模**<br>**Market size** | 1~10兆円<br>1～10T¥ |

Detail

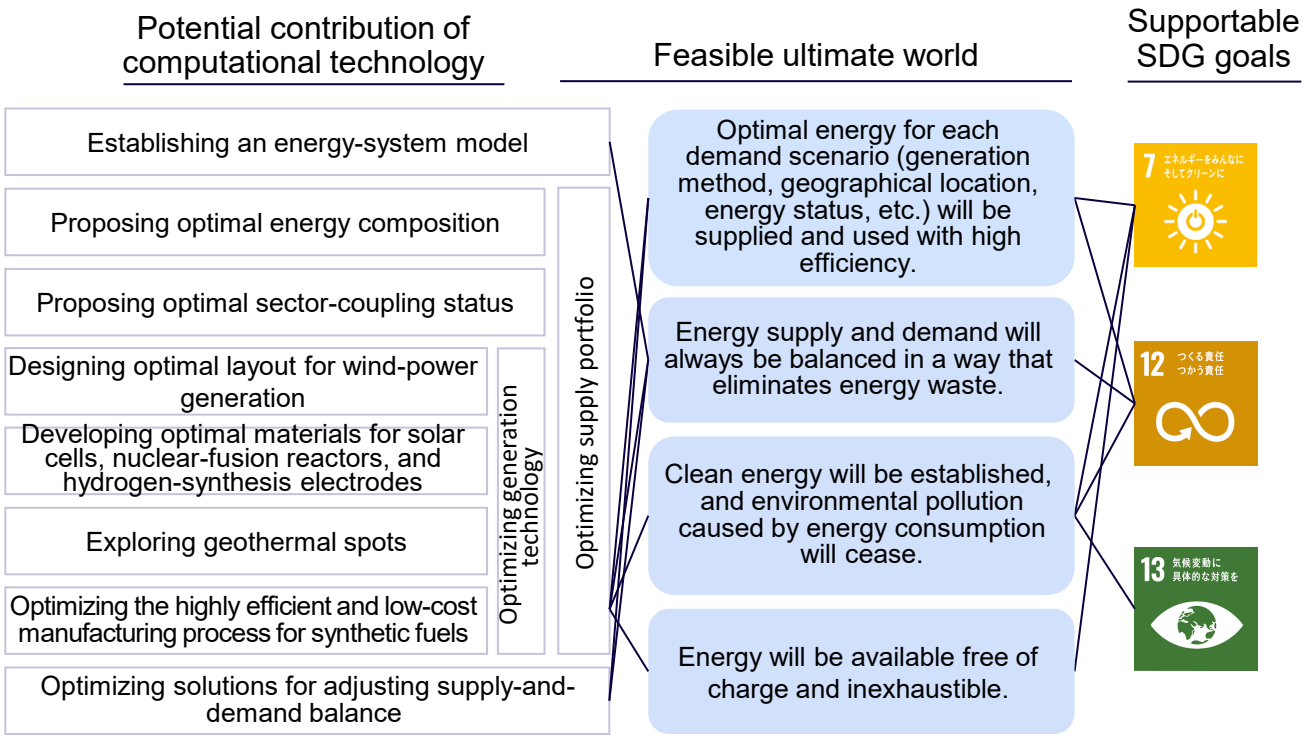
# Optimization of the design of next-generation energy systems

- By achieving optimal system design and optimal placement of next-generation energy, it will be possible to supply sufficient energy to humanity and eliminate restrictions on energy use.



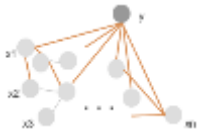
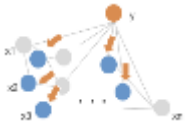
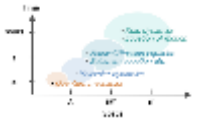
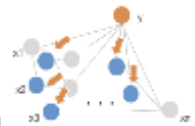
**100%**
Share of renewable energy

Currently, the need for renewable energy is urgent, but its spread is limited owing to its high cost of power generation compared to existing methods. However, technological innovation using QC could bring the acquisition cost to the same level as existing methods, and the share of renewable energy could reach 100%.



Roadmap

# Optimization of the design of next-generation energy systems

| Process | | Necessary R&D and business development | Quantum-computer scope of contribution and future development issues | |
|---|---|---|---|---|
| Building an energy-management system | Establishing an energy-system model | ■ Building an energy-system model that includes global-scale supply forecasts, supply-and-demand adjustments, and demand forecasts (including decentralization of energy generation through microgrids and conversion of energy carriers and storage of energy through sector coupling). Specifically, a large amount of past measured values of energy supply and demand and related parameters are input as a data set, and 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) |
| | Establishing computational capabilities | ■ Establishing simulations to predict supply-and-demand volumes on a global scale in real time | Solve forward problems in causal models  | ■ Within those models, identify computational tasks difficult to solve by a classical approach<br>■ Developing algorithms to efficiently solve the tasks |
| Building an optimal energy system | Building an optimal-energy-generation portfolio | ■ Proposing optimal energy mix and sector-coupling conditions on the basis of predictions of future climate and economic fluctuations Including proposals tailored to the characteristics of each region<br>■ Building next-generation energy-generation technology<br>➢ Designing optimal layout of wind-power generation<br>➢ Developing optimal materials for solar cells, nuclear-fusion reactors, and hydrogen-synthesis electrodes<br>➢ Exploring geothermal spots<br>➢ Optimization of the highly efficient, low-cost synthetic fuel manufacturing process, etc.<br>→ Quantum chemical calculations and quantum fluid calculations are used to speed up calculations concerning 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<br>■ Developing algorithms to solve MD equations quickly<br>■ Developing algorithms to solve nonlinear equations (such as the Navier-Stokes equations) quickly |
| | Establishing optimal operations | ■ Based on the supply-and-demand simulation model, solutions to adjust the energy supply and demand balance on a global scale are proposed.<br>■ Establishing grid-control technology (adjusting supply to match energy demand)<br>■ Establishing an energy-trading market based on game theory (adjusting demand to match energy supply) | Solve the inverse problem in causal models  | ■ Accelerating the search for—and expanding the scope of—optimal solutions<br>■ Performing real-time, large-scale calculations |

Roadmap

# Optimization of the design of next-generation energy systems

| Process | | Necessary steps | 2024 | 2025-2030 | 2030-2040 | Beyond 2040 |
|---|---|---|---|---|---|---|
| Building an energy-management system | Establishing an energy-system model | ■ Collecting past data on energy supply and demand (i.e., generation type, demand area, and use) | | | | |
| | | ■ Establishing a system for collecting data on various parameters that determine energy supply and demand (natural conditions, industrial activity, etc.) | | | | |
| | | ■ Expanding scope for applying quantum computers to statistical analysis, e.g., linear-regression analysis | | | | |
| | | ■ Constructing an energy-system model based on collected data. Reproducing energy supply, transportation, and demand | | | | |
| | Establishing computational capabilities | ■ Within those models, identify computational tasks difficult to solve by a classical approach | | | | |
| | | ■ Verifying the possibility and business feasibility of accelerating calculations with quantum computers | | | | |
| | | ■ Establishing quantum-computing technology that enables real-time calculations on a global scale | | | | |
| | | ■ Establishing algorithms for forecasting regional energy supply/demand and quantum-computing solutions | | | | |
| Building an optimal energy system | Building an optimal-energy-generation portfolio | ■ Accelerating the search for—and expanding the scope of—optimal solutions | | | | |
| | | ■ Establishing an algorithm for optimizing energy-generation portfolio and quantum-computing solutions for each region | | | | |
| | | ■ Accelerating quantum chemical calculations | | | | |
| | | ■ Develop algorithms to solve molecular dynamics equations at high speed | | | | |
| | | ■ Developing algorithms to solve nonlinear equations (such as the Navier-Stokes equations) quickly | | | | |
| | | ■ Constructing quantum algorithms for optimizing placement and material search for next-generation energy generation technologies (wind power, solar cells, etc.) | | | | |
| | Establishing optimal operations | ■ Accelerating the search for—and expanding the scope of—optimal solutions | | | | |
| | | ■ Establishing a quantum algorithm—based on the energy-system model—for optimizing adjustment of supply-and-demand balance. | | | | |
| | | ■ Establishing grid-control technology | | | | |
| | | ■ Establishing an energy-trading market based on game theory | | | | |
| | | ■ Performing real-time, large-scale calculations | | | | |

Items related to quantum computers

**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)**
**AI and Robotics Department (e-mail: quantum_ai@ml.nedo.go.jp)**

**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 ”.**