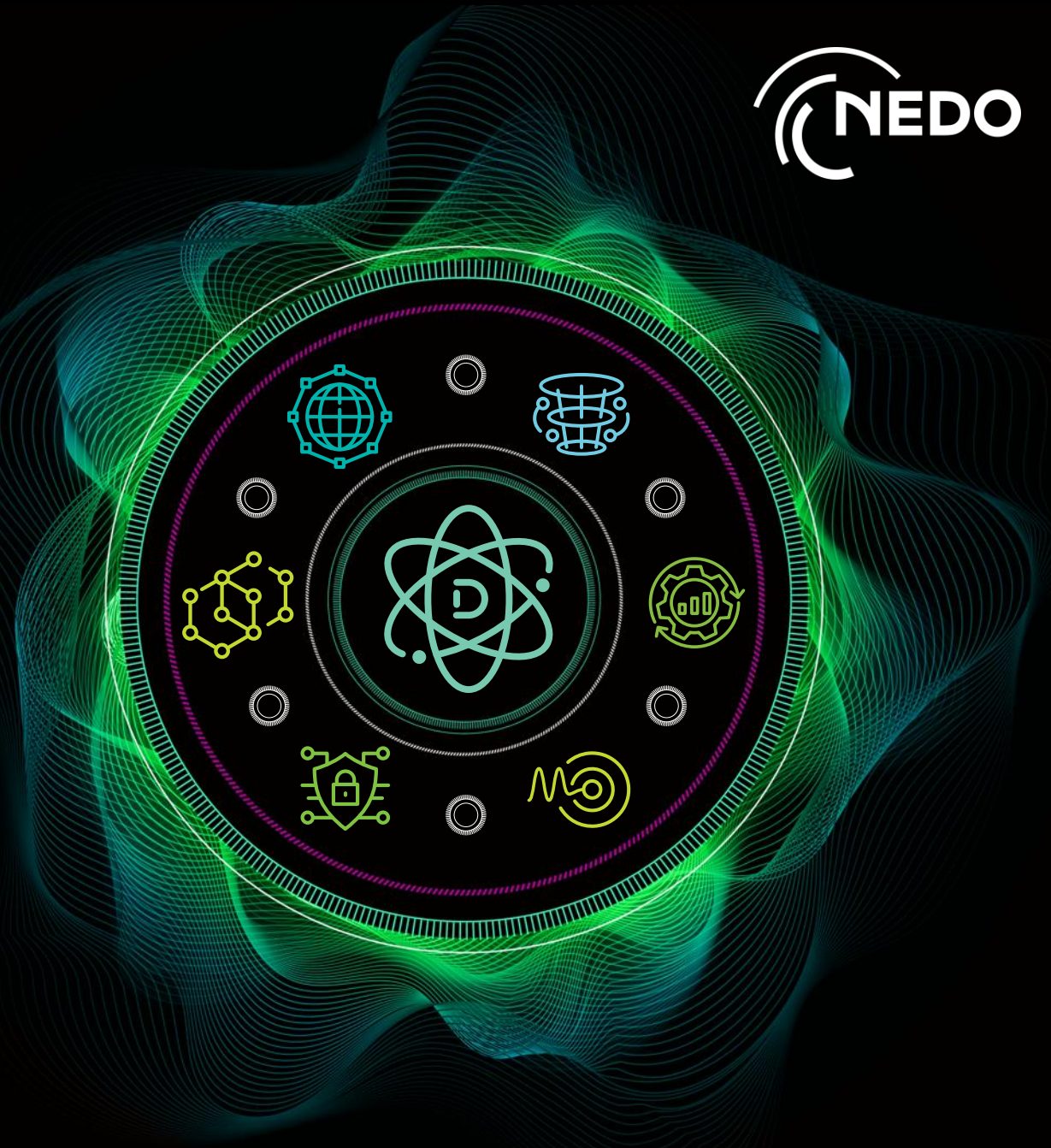
Quantum Computing Use Cases

VPP supply-demand adjustment optimization using quantum GAN and QAOA

GRID



New Energy and Industrial Technology Development Organization (NEDO)

GRID: VPP supply-demand adjustment optimization using quantum GAN and QAOA [2024/9] 1/2

Concept

Industry	Energy
Process	Power transmission and distribution, input
Method	combinatorial optimization
Category	Gate*

Background

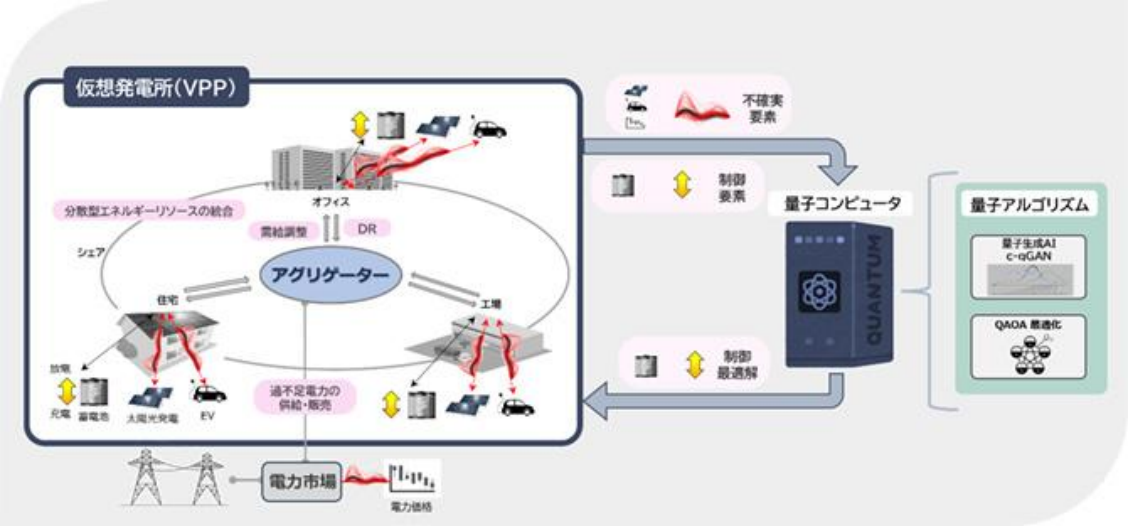
- As the introduction of renewable energy advances worldwide, the instability of electricity supply due to renewable energy, which is easily affected by weather, has become an issue.
- Virtual power plants (VPPs) are attracting attention as a solution. They treat small power plants such as offices and storage batteries as a single power plant, and use electricity without waste by managing and adjusting them in cooperation with the electricity market. **Supply and demand adjustment, which optimizes the balance between power generation and consumption in real time, plays an important role in realizing efficient and stable power supply,** based on DR (demand response) from each facility.

Issues and motivation to be solved

- Stochastic programming, which is currently used to create scenarios for supply-demand adjustment of VPPs, evaluates the risks and returns of a plan by sampling scenarios that may occur many times within a range of distributions. However, **it is difficult to put it into practical use because of the enormous computational complexity, and it has not been effective in actual supply-demand management.**
- **There has not been enough research on how to solve the highly uncertain power system problems computationally with quantum computers.**

Expected business benefits

- This initiative will be developed in three stages: (1) optimizing supply and demand adjustment of VPP for one household, (2) applying it to several households, and (3) supporting more than 100 households.
- Based on predictions that a quantum computer with error correction (FTQC) functions will be put into practical use around 2035, **we have been conducting research with an eye toward implementation for social problems since 2024.**



Realization of VPP Supply and Demand Adjustment Optimization Method

Reference: MONOist, "Optimizing supply and demand adjustment of a virtual power plant using a quantum computer" (https://monoist.itmedia.co.jp/mn/articles/2409/12/news071.html), The University of Electro-Communications, "Report: Selected as a project for cyber-physical development of quantum-classical hybrid technology invited by the New Energy and Industrial Technology Development Organization (NEDO)" (https://www.uec.ac.jp/news/announcement/2024/20240910_6472.html)
*Gate（gate-based）: A computing approach in which operations are applied sequentially to qubits to perform calculations. Similar in concept to logic circuits in classical computers, it can address a wide range of problems.

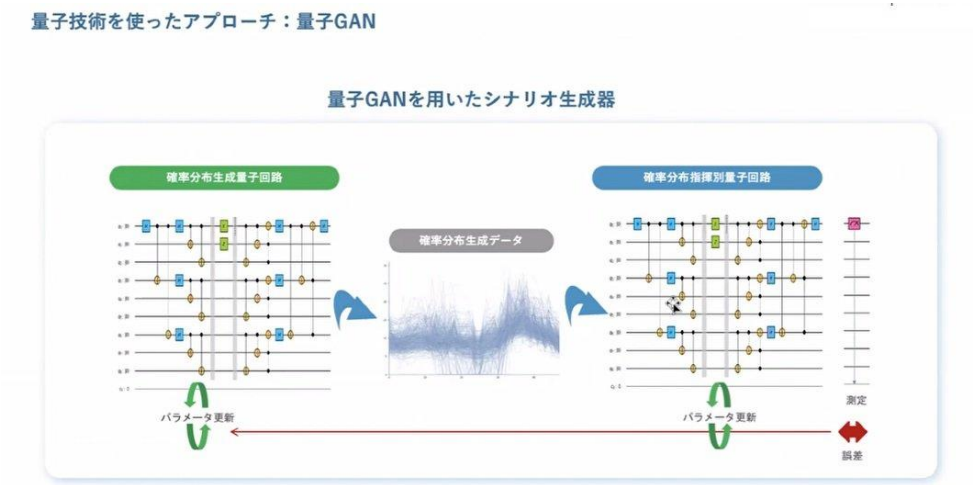
GRID: VPP supply-demand adjustment optimization using quantum GAN and QAOA [2024/9] 2/2

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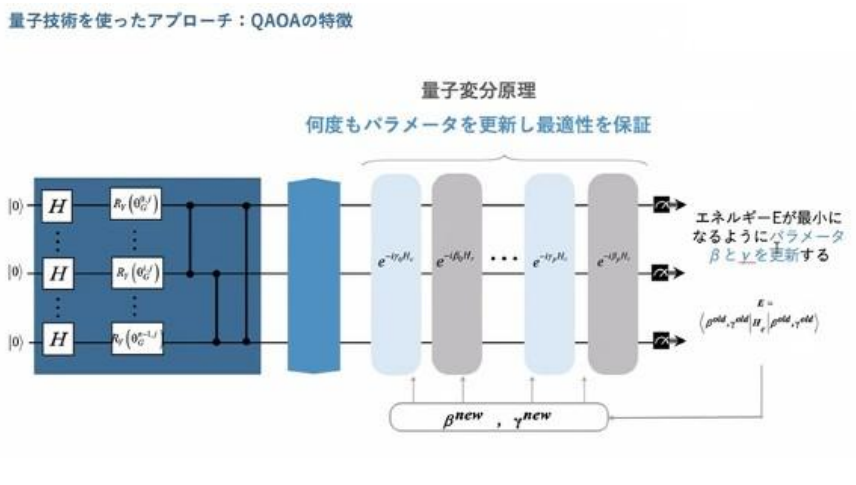
Problem setting as a quantum computer

- Research and development of a quantum classical stochastic optimization method utilizing gate type quantum technology for the purpose of eliminating and optimizing supply and demand uncertainty in VPP
- Specifically, we will conduct three studies: (1) mapping VPP uncertainties to quantum GAN *1; (2) solving VPP problems using quantum approximation optimization algorithms (QAOA *2 and); and (3) fusion of quantum GAN and QAOA.
- HW utilizes gated quantum technology



quantum GAN

*1 GAN is a network that enables the generation of data close to the real thing by learning while competing with Discriminator and Generator alternately. The classical GAN has the disadvantage that it is not good at generating discrete values due to the vanishing gradient problem.



QAQA

*(2) QAOA is called quantum approximation optimization algorithm and is an algorithm for solving combinatorial optimization problems using the quantum gate method.

Reference: MONOist "Optimizing supply and demand adjustment of a virtual power plant with a quantum computer" (https://monoist.itmedia.co.jp/mn/articles/2409/12/news071.html)
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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”.