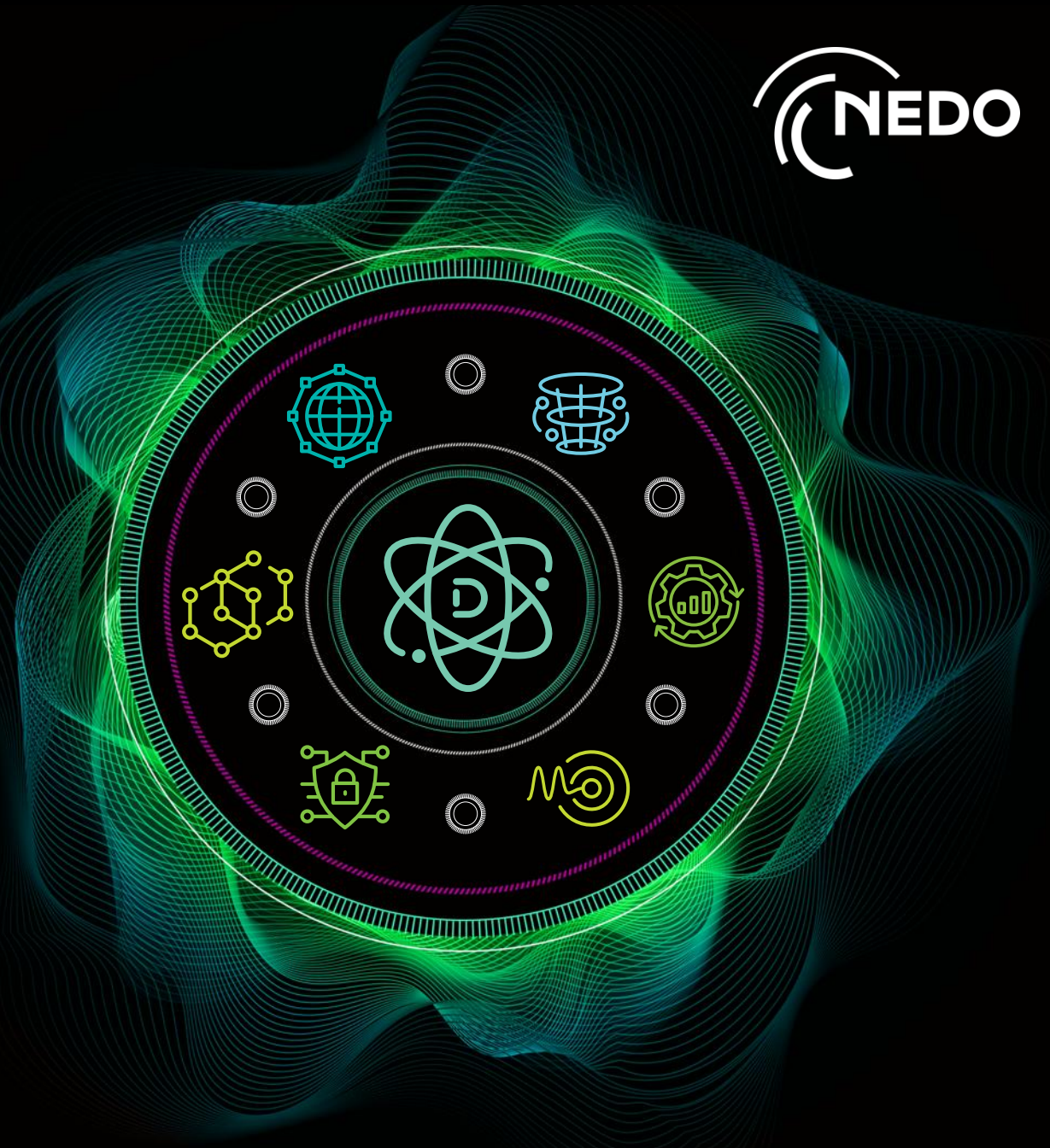
Quantum Computing Use Cases

Estimation of unstable renewable power output

EDF (French power company)



New Energy and Industrial Technology Development Organization (NEDO)

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Validation

Industry	Energy
Process	power generation
Method	AI
Category	Gate*

Background

- Renewable energy sources that extract energy from the natural environment, such as solar and wind power, offer great potential for decarbonization to combat climate change, but **the output of renewable energy sources is unstable.**
  - ✓ Unlike other energy sources, which can be turned on and off as energy consumption changes, **the management of renewable energy sources needs to be fully optimized to meet demand** for grid stabilization.
- Thus, **there is a need to establish models to predict power output from unstable renewable sources.**
  - ✓ Unreliable forecasting models would require energy suppliers to use sources such as fossil fuels and other non-sustainable alternatives, which would add significantly to the environmental burden

Issues and motivation to be solved

- **Predictive models for renewable power output, which exhibit unstable and complex behavior, can be difficult to train and require large amounts of energy and data**
  - ✓ Predictive simulations rely on chaotic and difficult-to-model weather and climate conditions, requiring high-performance computing resources such as HPC
- **PASQAL, in collaboration with EDF, a French power company, has developed a model that uses quantum computer technology to reduce CO2 emissions in power prediction simulations and achieve high-precision power prediction.**
- In addition, after winning the 2023 PASQAL hackathon on sustainable solutions using quantum computers, the company plans to work toward demonstration.

Problem setting as a quantum computer

- **Models complex physical systems, such as renewable power sources, and compares the accuracy of classical and quantum computer models**
  - ✓ A **14 qubit emulator (assumed to be a gate)** was used as the quantum computer.
- We also conducted **a comparison of CO2 emissions using a classical computer and a quantum computer as a benchmark for energy consumption**
  - ✓ The quantum computer used was **Fresnel (gate), PASQAL's current commercial device.**

Reference: pasqal"Three Winning Quantum Projects Announced for the Blaise Pascal [re] Generative Quantum Challenge" (https://www.pasqal.com/news/winners-of-the-blaise-pascal-regenerative-quantum-challenge/), RTE"Le transport d'électricité, comment ça fonctionne?" (https://www.rte-france.com/wiki-energie/transport-electricite-comment-ca-fonctionne), Pasqal "The Blaise Pascal [re] Generative Quantum Challenge" (https://www.pasqal.com/news/the-blaise-pascal-regenerative-quantum-challenge-the-journey-winning-projects-and-lessons-drawn/), Microsoft PASQAL Provider (https://learn.microsoft.com/ja-jp/azure/quantum/provider-pasqal#fresnel1)
*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.

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Expected business benefits

- **High prediction accuracy exceeding that of classical reservoir based on neural network using classical computer with small data size**
- **When the data size is large, the quantum computer emits less CO2.**
  - ✓ Classical computers consume more energy as data size increases, but **quantum computers have constant CO2 emissions.**
  - ✓ **Around 105~106 for industrial use on the dataset, quantum computers emit less CO2 than classical computers.**

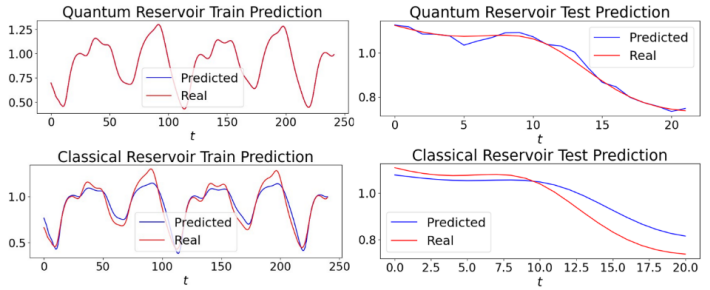


Figure 7.

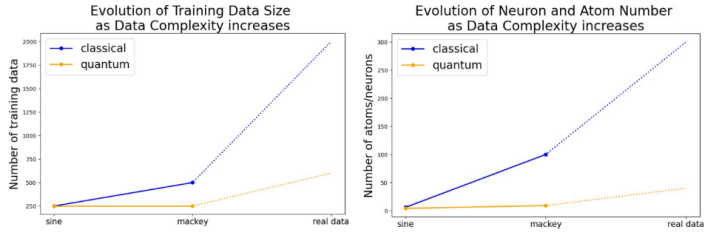
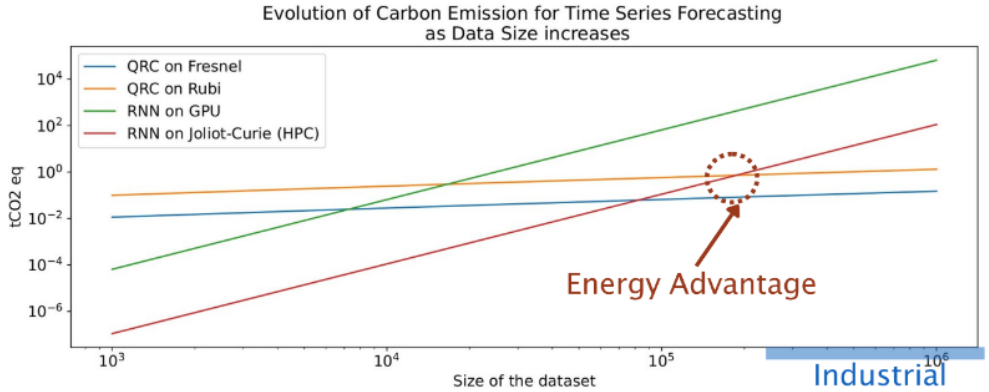


Figure 8.



Pasqal"The Blaise Pascal [re] Generative Quantum Challenge" (https://www.pasqal.com/news/the-blaise-pascal-regenerative-quantum-challenge-the-journey-winning-projects-and-lessons-drawn/)
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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”.