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Use Case Description: Wind Farm Siting

Facility location and allocation problems are essential components of strategic design and planning for energy systems. Examples of this type of energy systems optimization problems include determining the optimal location for wind farms to maximize energy capture while accounting for electrical grid constraints. Locations of facilities such as solar or wind power generation systems or hydro power plant can also be determined based on minimization of facility opening costs, energy transportation costs subject to satisfying energy demand subject to resource availability constraints. [1] [2]

To this end you are being asked to utilize a quantum computer in order to find the ideal placement of a wind farm with several turbines, taking into account prevalent wind conditions and the wake effect between turbines.

Sources

[1] Hale Cetinay, Fernando A. Kuipers, A. Nezih Guven: 'Optimal siting and sizing of wind farms', https://doi.org/10.1016/j.renene.2016.08.008

[2] Akshay Ajagekar, Fengqi You: ‘Quantum computing for energy systems optimization: Challenges and opportunities’, https://arxiv.org/pdf/2003.00254

1. Challenge Overview

In this challenge, participants are tasked with optimizing wind farm layout using a 2D grid-based abstraction of the wind farm and wind conditions. Wind farms are represented as a coordinate in the grid.

The quantum solution should demonstrate if and how quantum computing—running on Pasqal's platform—can provide a solution to this problem.

The challenge includes creating a project that:

- Proposes a business idea with a clear business plan for wind farm layout or similar optimization problems.
- Implements a quantum algorithm to enhance power output, with potential extensions to include more realistic models and forecasts.

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2. Problem Statement

- How can quantum computing be used to optimize wind farm layouts or similar problems?
- Which details of the environmental conditions and consumers locations should be considered for the algorithm?
- Can you come up with metrics (classical and quantum) to assess the quality and scalability of your solution?
- What advantages can quantum technology provide to future customers and citizens in this context?

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3. Use Case Details

a. Model the wind farm as a grid:
    - Represent the wind farm, wind conditions, wake effect, etc. on a 2D-grid. You can start with smaller grid and increase its size once you are more familiar with the problem.

b. Quantum Computing's Role:
    - Investigate and choose the optimization approach to model the power output with a fixed number of windfarms to be placed.
    - Leverage a suitable quantum algorithm to solve the chosen approach.

- Test your solution under real conditions on the Pasqal cold atom platform, adjusting the solution accordingly.

c. Target Users:
- Identify the target users of your solution. Would it be solely for energy providers, or could it also be applied to other sectors?
- How does your solution help them deliver better services to their customers or target audience?

d. Business Potential:
- How can your solution be used in traditional or new business models? Is it transferable to other optimization problems?

e. SDG Impact:
- How does your solution contribute to SDG 7: Affordable and clean energy, and which other Sustainable Development Goals (SDGs) might it impact?

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4. Expected Deliverables

a. Optimizing Algorithm:
- A working prototype demonstrating how quantum computing can improve wind farm layouts.

b. Technical Documentation:
- A detailed explanation of the quantum algorithms used

c. Business Case:
- A clear business plan demonstrating the commercial viability of the solution, identifying target users, interaction models, and potential regions for deployment.
- A strategy for turning the algorithm into a product that can reach real institutions, energy providers, etc.
- Distribution models for bringing the platform to market, whether through partnerships, SaaS models, or direct-to-consumer platforms.

d. Impact Case:
- An analysis showing how the solution contributes to supporting SDG 7.

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5. Judging Criteria

a. Innovation:
- Novel use of quantum computing to optimize wind farm placement.
- Distribution models and ideas for integrating these algorithms into new platforms and business models that optimize energy infrastructure or other applicable projects.

b. Impact:
   - The solution’s potential to significantly enhance energy infrastructure and positively impact SDG 7.

c. Feasibility:
   - The practicality and potential for real-world implementation of the algorithm.

d. Technical Merit:
   - The level of quantum computing skill and sophistication demonstrated.

e. Presentation:
   - The clarity and effectiveness of the final pitch, explaining the solution, its impact, and its technical details.

Appendix:

Modelling constraints like number of wind farms in QUBO:

https://www.nature.com/articles/s41598-020-60022-5

Pasqal’s Pulser platform tutorial:

https://pulser.readthedocs.io/en/stable/index.html

Solving a QUBO problem with QAOA on Pasqal:

https://pulser.readthedocs.io/en/stable/tutorials/qubo.html