Q-Tumi: Code the currents, Light the Land

Optimising Hydroelectric Energy Supply Using Quantum Algorithms

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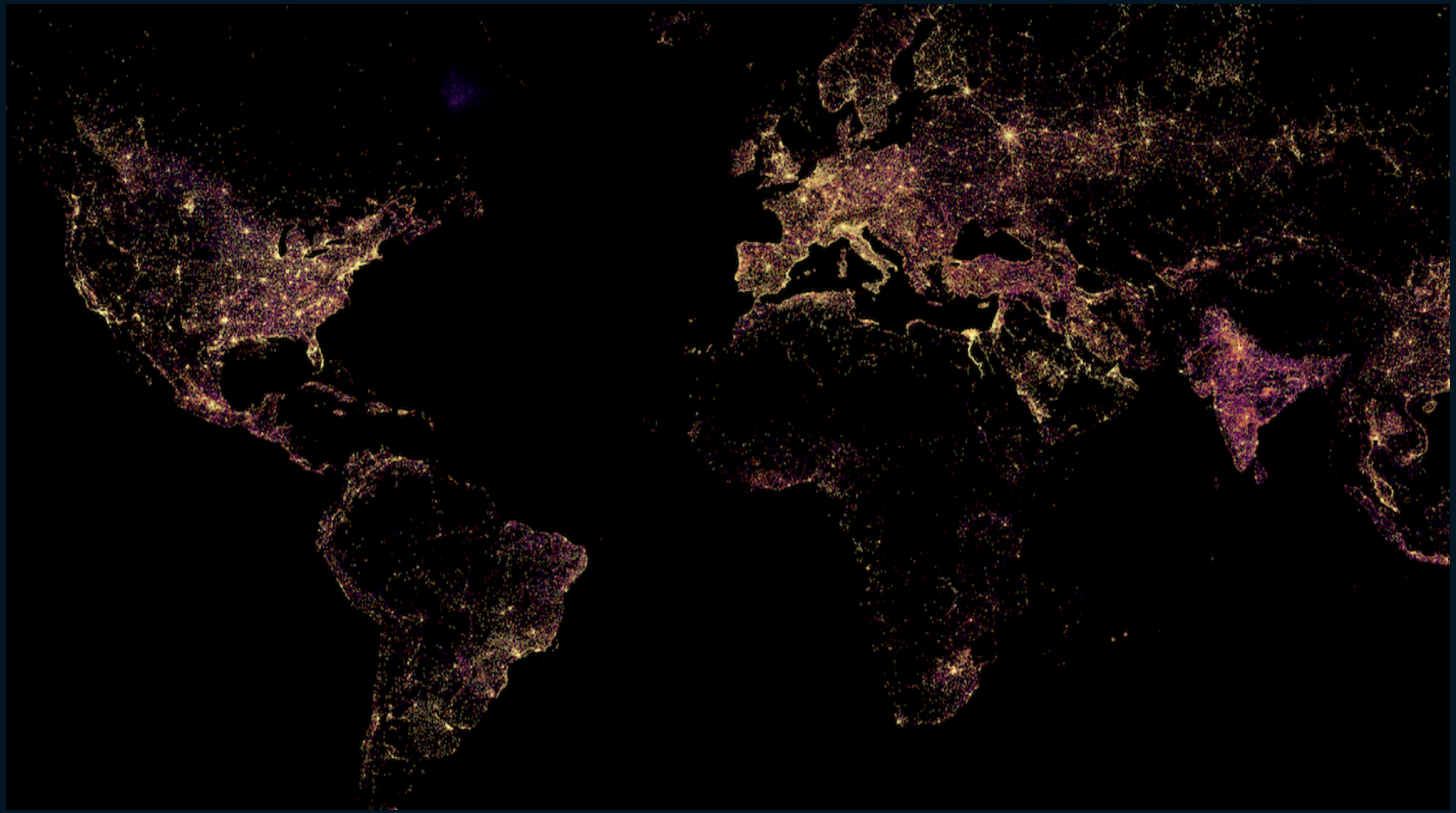

600 million people in Africa lack access to electricity

Sub-Saharan Africa avarage 56 days of outages annually.

African firms lose up to 31% of sales due to outages

“DUMSOR” led to about $1 billion in economic loss in Ghana

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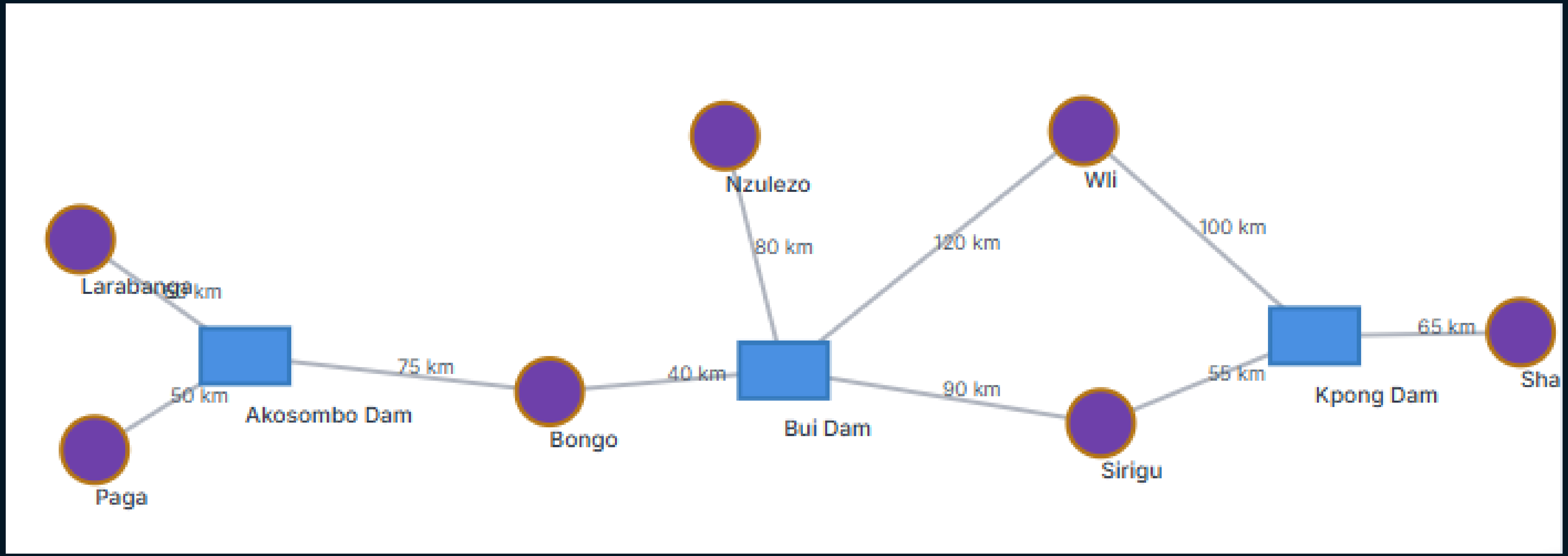
SDGs and Value Proposition

QTumi Optimises energy distribution from renewable energy sources using Quantum algorithms to minimise blackouts in rural areas in Africa.

Problem Formulation



- **Sources**: small hydro-plants (estimated supply)
- **Towns**: villages & towns (estimated demand)
- **Edges**: routes with distance–cost trade-offs

3	7	1,580 MW
Hydropower Plants	Cities/Communities	Total Capacity

Goal: minimize transport cost + unmet demand (Blackout)

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Mathematical Formulation

We model the energy distribution from hydroelectric sources to towns as a discrete network flow problem. The graph is defined as a bipartite network with:

- $\mathcal{S}$: Set of energy sources (e.g., hydro plants),
- $\mathcal{T}$: Set of demand nodes (e.g., rural towns),
- Each source $i \in \mathcal{S}$ has a limited daily energy capacity E_i (in energy units),
- Each town $j \in \mathcal{T}$ has a fixed daily energy demand D_j,
- The distance between node i and j is denoted d_{ij}.

To discretize the energy allocation, we define the binary decision variables:

$$x_{ij}^k = \begin{cases} 1 & \text{if source } i \text{ sends at least } k \text{ units of energy to town } j, \\ 0 & \text{otherwise} \end{cases} \quad \text{for } k = 1, \ldots, F_{\max}.$$

Total Cost Function (Objective)

$$H(x) = \underbrace{\alpha \sum_{i,j,k} d_{ij} x_{ij}^k}_{\text{linear transport cost}} + \underbrace{\beta \sum_{j} \left(D_j - \sum_{i,k} x_{ij}^k \right)^2}_{\text{quadratic unmet demand penalty}}$$

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Quantum Optimisation

Quantum Algorithms

Quantum Approximate Optimisation Algorithm (QAOA)

Why QAOA?

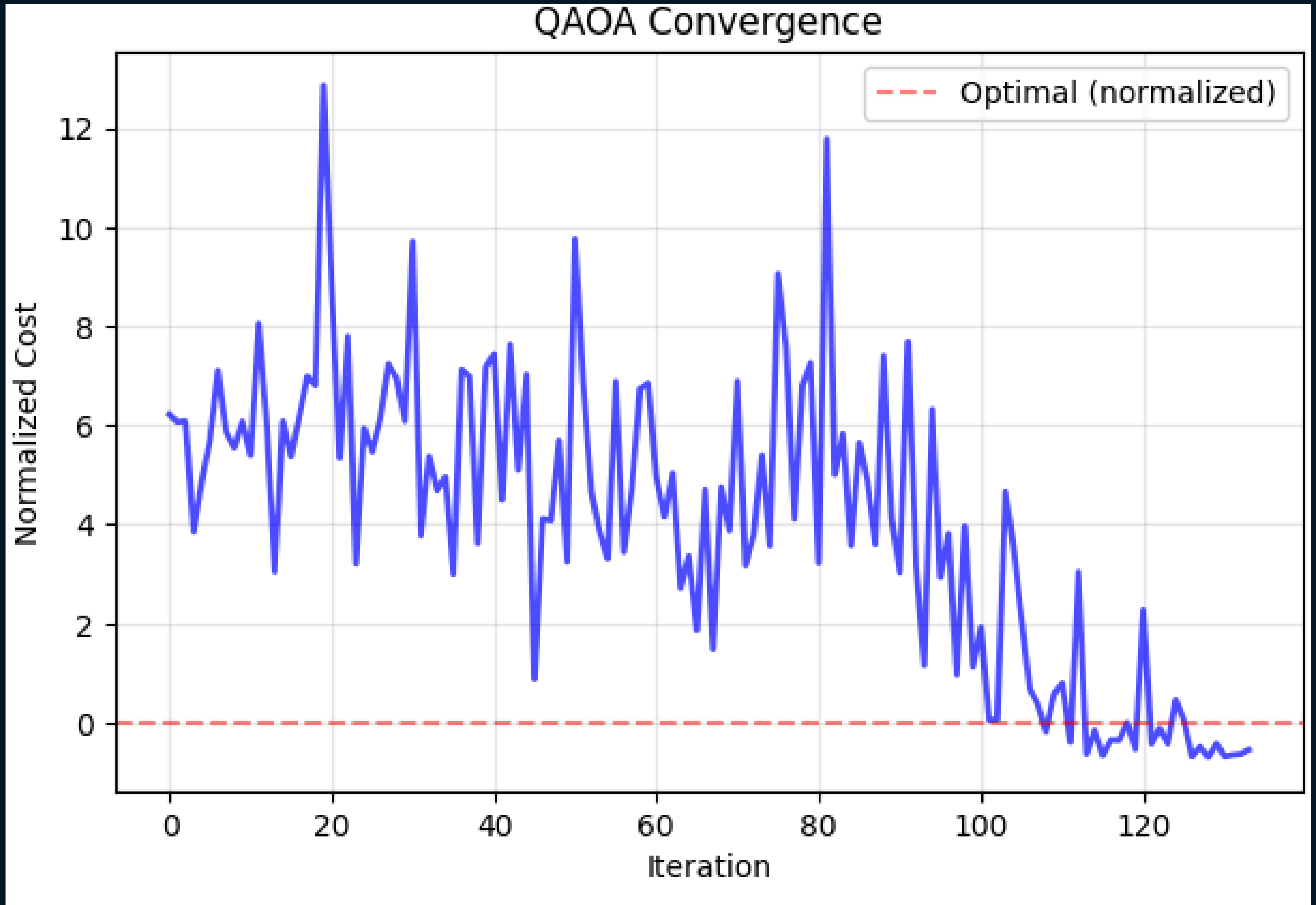
- **Handles large, discrete combinatorial spaces**
- **Natural fit for the QUBO structure**

Quadratic Unconstrained Binary Optimisation (QUBO)

Workflow

1. **Map problem→QuadraticProgram**
2. **Convert→QUBO**
3. **Run QAOA (reps=2) on Aer / Qbraid**
4. **Decode bitstring→flows**

Tests and results



Scaling projection

- **Classical runtime grows exponentially**
- **QAOA circuit depth & node count scale polynomially**
- **Potential for 10× speed-up at 20+ nodes (simulation)**

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Quantum advantage

	Quantum Computing	Classical Computing
Computational Complexity	**Polynomial**	**NP-hard**
Cost to customers	**$K**	**$K**
Service time	**Seconds**	**Hours**

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Business

Business Scalability

Starts in Ghana → expands to West Africa → adapts globally to other small hydro and hybrid mini-grid systems.

Monetization Model

- SaaS subscription to utilities & municipalities
- Pay-per-use API for developers & partner platforms

Target Users

- Municipalities
- Rural mini-grid operators
- Ghanaian communities needing stable optimized power

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Product Roadmap

3 Months

Build Minimum Viable Product(MVP), Conduct field research, Prepare data collection plan and Seek funding.

3–12 Months

Deploy MVP, develop user dashboard for operators & municipalities, pay-per-use API endpoints and commercial launch.

3+ Years

Expand to other African countries, Adapt platform to other renewables form partnerships with banks and an-African energy NGOs.

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THANK YOU!

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