

Quantum & Quantum-Inspired Computing for Load-side Flexibility Orchestration and Optimal Facility Allocation

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OVERVIEW

GRAVITEQA develops Quantum Computing (QC) and Quantum-Inspired Computing (QIC) solutions for two combinatorial optimisation problems of modern power systems. **Load-side Management for Flexibility Provisioning (LMFP)** coordinates distributed Flexibility Power Units operating in discrete modes so that the aggregated demand realises, in real time, the active/reactive power setpoint requested at the Point of Common Coupling by the system operator. **Facility Location Allocation (FLA)** optimises the siting and configuration of RES facilities to maximise profitability under technical and financial constraints, accounting for grid hosting capacity. Both problems are cast into quantum-ready formulations and solved with QC algorithms (QAOA, Trotterized Adiabatic Evolution, Pauli Correlation Encoding) and quantum-inspired solvers; the alpha models and solution architecture have been released, with network models verified against established power-flow tools.

BENEFITS

- **Real-time orchestration:** quantum(-inspired) solvers target the combinatorial explosion of discrete-mode flexibility dispatch, improving scheduling and system stability for DSOs.
- **Faster RES deployment:** optimal siting with hosting-capacity awareness accelerates renewable integration and grid connection decisions.
- **Scalability path:** QUBO-based formulations are portable across quantum hardware, emulators and quantum-inspired cloud platforms.
- **Attractive QIC economics:** preliminary project analysis of the cloud-based QIC deployment indicates strong financial viability (positive NPV, short payback) under stated assumptions.

CURRENT ENABLERS

- Requirements, use cases (IEC 62559) and KPIs defined in the project's requirements-engineering phase (facility location allocation; load-side management for flexibility provisioning).
- Access to NISQ hardware references (e.g., IQM) and classical emulators for quantum-kernel development.
- Cloud infrastructure for quantum-inspired execution at industrially relevant problem sizes.
- Verified classical network models providing the physics baseline for the quantum formulations.

R&D NEEDS / NEXT DEVELOPMENTS

- **Qubit reduction:** current QAOA/TAE qubit requirements exceed NISQ capacity for large-scale problems; PCE reduces qubits but increases computation time.
- **Runtime compression:** warm-starting, parameter-tuning reduction and better classical optimisers to meet the 15-minute LMFP operational window.
- **Constraint integration** into the quantum formulations and scalability analysis on problem sizes matching the real final problem.
- **Complete cost picture:** The current cost analysis covers operational costs; R&D, licensing, maintenance, staffing and deployment costs remain to be estimated.
- **Validation with real data** in the project testbeds against the project KPI framework.

APPLICATIONS

- **DSOs / BRPs / aggregators:** real-time re-dispatch of distributed flexibility for congestion mitigation, voltage support and frequency control.
- **Utilities / project developers:** profit-optimal siting and configuration of RES plants.
- **Research community:** reusable QUBO formulations and QC/QIC benchmarking for power-system optimisation.

TECHNOLOGY READINESS LEVEL

1	2	3	4	5	6	7	8	9
■ Current level	■ After validation							
TRL 3 currently (alpha formulations and solvers verified on test cases and emulators); TRL 4 to be reached upon completion of the validation with real data in the project testbeds.								