

AI-based Breakthroughs for T&D Grid Operation and Maritime Electrification

Date: July 2026 | **Type:** Digital – Artificial Intelligence | **Partners:** FENTECH (lead), SC, NKUA, UOWM, PPC, ESO, EDG

OVERVIEW

GRAVITEQA develops an AI innovation layer for (i) planning and operation of T&D grids with high DER penetration and (ii) the electrification of the maritime sector. The tool set comprises the **Nodal Flexibility Envelope (NOFE) estimator**, a Trustworthy-AI, predict-and-optimize algorithm quantifying in real time the flexibility distribution grids can procure from DERs; a **conformal prediction forecaster** of cold-ironing demand delivering prediction intervals with statistically guaranteed coverage; a **port-asset scheduler** minimising energy cost while providing demand response; an AIS-data-driven **seaport electrification planning tool** (demand, emissions, cost-benefit and grid-impact analysis); and a reference design for **edge AI inference** in smart grids. The tools have been released in their alpha version, followed by the first release of the software application (backend and dashboard) for the planning and operational scheduling tools.

BENEFITS

- **Grid flexibility & data-driven operation:** fast, reliable nodal flexibility estimation enables congestion management and flexibility-market participation for DSOs and aggregators.
- **Uncertainty treatment:** coverage-guaranteed forecasts let port and grid operators plan against quantified risk instead of point estimates.
- **Lower port energy costs & emissions:** optimised scheduling of cold ironing, DERs and port assets reduces at-berth fuel burn and unlocks demand-response revenues.
- **Investment de-risking:** AIS-based planning quantifies onshore-power demand, emissions savings and grid impacts before capital is committed.
- **Scalability:** the planning methodology is port-agnostic, requiring a single primary input (the AIS dataset).

CURRENT ENABLERS

- Requirements, use cases (IEC 62559) and KPIs defined in the project's requirements-engineering phase, with SGAM positioning across the energy value chain.
- Availability of AIS vessel-traffic data (open and commercial); open data of the Port of Piraeus used for demonstration.
- Pilot engagement in the Bulgarian region (SC, ESO, EDG) securing case-study data for the Port of Varna.
- EU policy momentum: AI Act, Fit-for-55, Alternative Fuels Infrastructure Regulation (shore-side electricity obligations).
- Emerging edge ecosystems (Linux Foundation GEISA) for deploying AI services on distributed grid infrastructure.

R&D NEEDS / NEXT DEVELOPMENTS

- **Explainability & robustness:** XAI mechanisms and robust formulations for the NOFE algorithm, addressing trust requirements of safety-critical grid operation.
- **Richer port modelling:** control functionalities of cranes and electric logistics assets integrated into the EMS to extend demand-response capability.
- **Forecasting trade-offs:** alternative feature configurations assessed against training time and computational cost.
- **Full-scale validation:** Port of Varna case study and testbed validation against the project KPI framework.
- **Integration:** a unified Seaport Planning & Operation platform connecting all tools in one pipeline; edge architecture aligned with GEISA.

APPLICATIONS

- **DSOs / aggregators:** real-time flexibility services procurement from distributed RES in active distribution grids.
- **Port authorities & operators:** electrification investment planning and sequencing; day-to-day energy scheduling and market participation.
- **Energy planners / policy makers:** scenario analysis of onshore-power-supply rollout, emissions and grid impact.
- **Technology providers:** reference edge-inference design for low-latency smart-grid AI services.

TECHNOLOGY READINESS LEVEL

1	2	3	4	5	6	7	8	9
■ Current level	■ After validation							
TRL 3 currently (experimental proof of concept of the alpha tools; first application release); TRL 4 to be reached upon completion of the validation in the project testbeds (Port of Varna and distribution-grid pilots).								