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SMART CITY CHALLENGE 2025
Solution idea for the city challenges

Solution Idea Title HydroTwin Energy Islands for Cities

Planned pilot project duration – 24 months

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● Which urban challenge or problem are you planning to provide a solution to?

The challenge we are planning to provide a solution to is "Stable Energy System in Crisis." The HydroTwin solution will be piloted in Valga, Kohtla-Järve, Saaremaa, and TalTech Campus (Estonia), Vantaa (Finland), and Vinnytsia (Ukraine) to validate its adaptability to different urban, geographic, and energy resilience conditions.

Using renewable energy sources is essential for reducing GHG emissions, creating a green economy and sustaining a stable energy system. However, renewable energy sources might not be enough to overcome a high and urgent demand, for example, during the winter, and an energy crisis. . In this situation, if the required energy cannot be supplied locally, it can be transported from remote energy sources; but this requires infrastructure, such as power line grids, substations, and local distribution networks.

● The solution you are proposing:

In order to ensure renewable energy supply, three pillars of sustainable solutions need to be addressed: social-economic, environmental, and robustness. Here, a localized, cost-effective, environmentally friendly, feature-proof solution is proposed utilizing a decentralised microgrid ("energy island"). This holistic approach includes:

- H2 generation from renewable sources and e-fuel storage
- Mobile micro power plants with an emergency islanding mode to support critical facilities during outages
- IoT-based monitoring of key energy assets
- AI and Digital Twin

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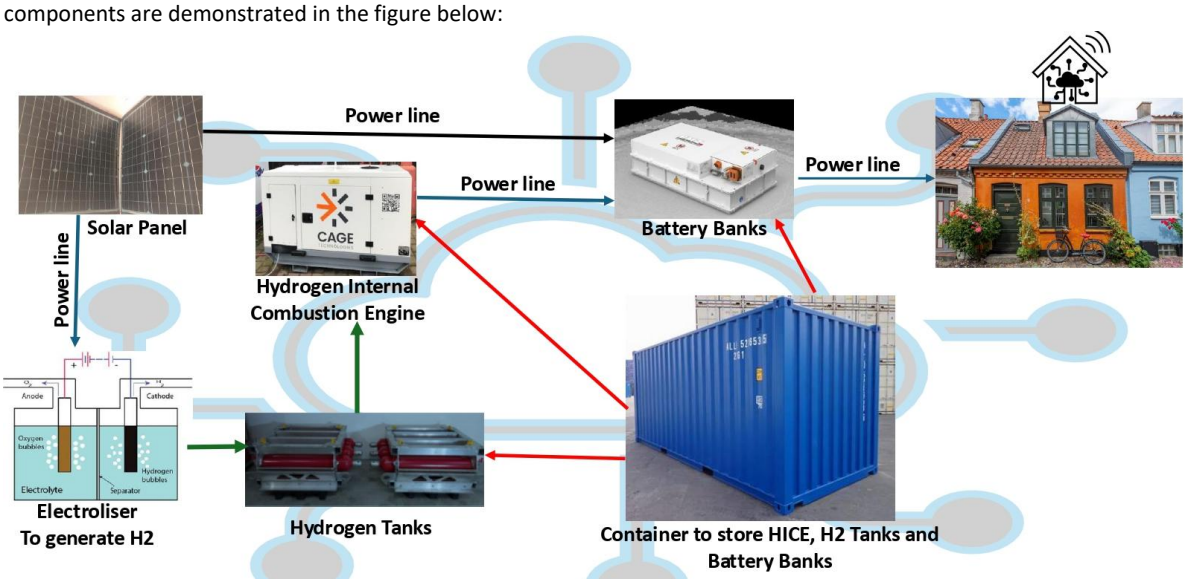
- **Innovation and piloting of your pilot solution:**

The proposed pilot solution (HydroTwin Energy Islands) is based on the outcomes of a recent Innovate UK project (2025) called “Restore” that Prof Turkmen was the Principal Investigator. The overall aim of the *Restore*-project was to produce and use green hydrogen on a crew transfer vessel to demonstrate a zero-emission system in marine transport. In the current Smart City Challenge, the main fuel, green hydrogen, will be produced using renewable energy and stored in gas form. The innovation of the proposed project is the integration of an internal hydrogen combustion engine (HICE) and batteries. HICE generated electricity will charge batteries to provide high energy. The batteries can be charged using the land grid system as well as HICE. The Internet of Things (IoT) based smart monitoring will be provided for broadcasting the energy generation, consumption and data science.

Generating energy by using renewable energy sources (solar panels or other renewables) is very important to reduce GHG emissions. However, it might not be enough to overcome the energy demand during winter, which can cause interruptions. To overcome this, stored hydrogen will be provided during high energy demand (e.g., winter, crisis) while still reducing emissions. The total system can fit in a standard ship container. It can be located anywhere on the land and is transferrable in the case of an emergency. It can even be located on a floating structure, as demonstrated in the *Restore* project. Therefore, it is relatively easy to determine optimal routes for new cable lines as well. The remote monitoring system and collected data will support the building of digital twins, and the use of AI will help to improve safe and efficient management. All of the components are demonstrated in the figure below:



- **What do the cities need for piloting:**

The challenges of ensuring energy security, achieving zero-emission targets, and sustaining a green economy are shared by many cities. However, successful implementation requires bespoke solutions due to local conditions. Therefore, the pilot

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solution should be discussed and modified with the city governance in question. The city should provide information and their future plans including:

- existing infrastructure,
- geographical and climatic characteristics,
- supply chain constraints, energy storage conditions, safety and regulatory requirements,
- availability and management of local facilities,
- opportunities for scaling, skills development, and workforce readiness,
- and engagement of the local community.

• Capabilities of the proposed research and development team:

Our team combines expertise in hydrogen energy systems, AI-based Digital Twins, and power electronics for smart microgrids. Prof. Serkan Turkmen (TalTech) brings 20+ years of experience in hydrogen-based propulsion and renewable maritime energy, with EU FP7, Horizon, EPSRC, and Innovate UK projects. Dr. Mahtab Shahin (TalTech) specializes in AI-enabled Digital Twin simulation and energy resilience prediction. Dr. Noman Shabir (TalTech) contributes expertise in power electronics, hybrid storage control, and smart energy management systems. Together, this team integrates hydrogen engineering, AI governance, and smart microgrid technologies to deliver resilient Energy Islands for cities. The team also includes two industry partners supporting technology readiness and commercialization: Cage Technologies Ltd (UK), specializing in hydrogen combustion power units and zero-emission mobile energy platforms; and Aceon Battery Solar Technology Ltd (UK), providing battery storage, hybrid hydrogen–battery integration, and containerized microgrid systems for scalable Energy Islands.

• Expected impact of your pilot solution:

The *HydroTwin Energy Islands* -pilot solution creates a fit-to-place energy governance model, where locally produced and stored green hydrogen is intelligently managed, converted to electrical form, and continuously monitored for performance, emissions, and resilience. The proposed solution enables energy sovereignty, reduces reliance on central power grids, enhances emergency preparedness, and builds long-term city-level resilience. By integrating data science, AI models, and real-time Digital Twin simulations, the system can predict energy generation and demand fluctuations, optimize hydrogen storage and distribution, and automatically prioritize critical facilities such as hospitals, emergency shelters, and mobility hubs during crises. Its deployment is expected to stimulate green economic growth, attract new investments, improve public awareness, and generate new local jobs in hydrogen technologies, AI-based energy management, Digital Twins, and smart city innovation.

In conclusion, in an era with increasing energy instability, *HydroTwin Energy Islands* is not just a technical solution; it is an enabler of energy independency. By combining hydrogen storage, smart microgrid deployment, and AI-driven predictive energy governance, the prosed pilot empowers cities not only to withstand energy crises but to anticipate, absorb, and recover from them. Consequently, the expected impact is seen to develop energy management from reactive to proactive, from dependent to sovereign, and from vulnerable to future-ready.