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SMART CITY CHALLENGE 2025
Solution idea for the city challenges

Max 3 pages
send to smartcity@taltech.ee by Nov 30, 2025

Solution Idea Title (max 5 words, no acronyms) - **Resilient Urban Energy Hub**
Planned pilot project duration – 24 months
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1. Which urban challenge or problem are you planning to provide a solution to?

Vinnytsia (Ukraine) needs a crisis-resilient energy system capable of supporting both critical municipal services during extended outages caused by military attacks, cyber incidents, extreme weather events, and infrastructure failures, while also being suitable for use by ordinary consumers during peacetime.

The city needs: local energy islands; an alternative municipal distribution network; reliable integration of renewables and heat pumps; fire-safe energy storages; and protected supply for shelters, critical infrastructure (water and heat supply networks, communications) and key public buildings. The system must meet modern requirements, supporting sustainable urban development (including environmental sustainability) and being economically efficient.

Kohtla-Järve (Estonia), the second pilot city, located in a region of potential geopolitical threats, faces ageing infrastructure and dependency on centralized supply, creating similar vulnerabilities.

2. The solution you are proposing

We propose an integrated solution at the intersection of 'Safe City' and 'Climate Resilient City' priorities, namely the development and piloting of a **Resilient Urban Energy Hub (R-UEH)** — an autonomous, modular, scalable, and resilient energy supply system designed as a **"cellular network"**. Each base module is formed around one or several buildings (residential blocks, schools, shopping centers, etc.). The solution thus implements the microgrid concept, facilitating decentralization of energy production, storage and distribution, and is fully capable of operating in off-grid mode.

Main components:

- **Distributed local renewable generation** based on solar panels installed on roofs, facades, and ground-mounted systems, vertical-axis wind turbines (VAWTs), and heat pumps.
- **External energy sources** - integration of heat and electricity supply from central networks and neighboring cells of **"cellular network"**.

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- **Safe storage:** battery-based Energy Storage System (ESS), if necessary, on the basis of non-flammable materials (for example, salt battery technology).
- **Smart microgrid backbone** based on a scalable, highly efficient hybrid AC/DC topology built on modular technology, allowing the consumer load to be divided into priorities into normal and critical.
- **Centralized management and control based on artificial intelligence**, which should provide: predictive balancing, autonomous islanding, black-start capability, cyber-secure monitoring and critical-load prioritization.
- **Crisis resilience equipment placement:** fire-safe design, reinforced housings, bunker placement option and autonomous operation for 72-120 hours.

To ensure **technological sovereignty** (supply independence and secure remote access) by utilizing software, controllers, inverters, and key components from **EU and allied suppliers**, the involvement of European partners (such as CE+T Power, Efore, Eltek, Enersys) is being considered to use their components, solutions, and engineering support.

3. Innovation and piloting of your pilot solution.

Existing solutions lack comprehensive survivability, sufficient **fire and explosion safety**, and fail to address the critical need for shelter integration. In addition to the benefits of the microgrid concept, the **R-UEH's Innovation provides Integrated 3D Resilience through:**

- **Chemical Resilience (Explosion and fire safety):** Achieved via safe components (e.g., salt batteries) and decentralized placement to mitigate explosion/fire risks.
- **Network Resilience** (Cellular Modularity) - the architecture eliminates single points of failure, ensuring rapid recovery thanks to the interchangeability of modules and the **"cellular network"** architecture.
- **Cyber-Physical Verification** - The developed solution will be verified using the **TalTech Power Hardware-in-the-Loop simulator (Kohtla-Järve)**.

To implement the **R-UEH**, cities must designate hub facilities, assist with laying communications, and help navigate the regulatory landscape.

Piloting Plan (24 months):
1. Coordination & Site Selection (0–3 months) - Engagement with municipal authorities, selection of pilot buildings, preliminary analysis, clarification of technical requirements.
2. Design & Technical Validation (3–9 months) - Detailed smart-microgrid design, system modelling and simulation, alignment of the final technical solution with both cities.
3. System Implementation (9–16 months) - Installation of generation, storage and microgrid components; deployment of control systems; construction of protected infrastructure.
4. Testing & Optimization (16–22 months) - Functional tests, crisis simulations, AI-EMS optimization, and adjustments based on real performance data.

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5. Finalization & Handover (22–24 months) - Documentation, training, municipal replication roadmap, and final technical-economic conclusions.

The core team consists of the staff of the **Virumaa College Centre for Innovation in Digitalization and Green Technologies** (VIDRIK). To ensure scientific and technical credibility and conduct high-precision tests, we engage the Microgrid and Metrology Research Group **of TalTech as a strategic partner**.

Unique resources are being developed in **Kohtla-Järve** as part of a research consortium jointly established by the Tallinn University of Technology and the University of Tartu within the framework of the Just Transition Fund:

- Physical Demonstration Lab: The laboratory, ready by early 2026, allows us to test the safety and efficiency of ESS (salt and LFP batteries) and integrated generation, including a **hydrogen storage unit with a capacity of 200 kWh.**
- Virtual Lab: The unique **Power Hardware-in-the-Loop complex** based on the OPAL RT Real-Time Simulator and CINERGIA power amplifiers will be used for **Cyber-Physical Development and Verification** of the technical solution.

Project success in high-risk environments requires interdisciplinary expertise: **Legal Expertise** (TalTech Law School) for harmonizing decentralized energy legislation, and **Civil Engineering** (TalTech School of Engineering) for designing and integrating the **R-UEH** solution into conventional and reinforced, buried protective structures.

4. Expected impact of your pilot solution.

- The **project will establish a ready for replication, field-tested standard** for crisis-resilient urban energy infrastructure.
- **Resilience of the urban environment**: ensuring the uninterrupted operation of critical infrastructure — electricity, heating, water supply, and communication systems — in the event of external power outages, with autonomous functionality maintained for 72–120 hours.
- **Sustainable development of urban infrastructure**: 20–40% reduced grid dependence (in addition to this: reducing the requirements for distribution networks and reducing losses in them); 15–35% CO_2 reduction; increased share of local renewables.
- **Scalability & replication**: transferable smart-microgrid blueprint for Eastern European cities; supports long-term decarbonization and reduced energy poverty.
- **Accuracy of AI forecasting and balancing** (between generation, storage, and consumption): >85%

Disclaimer: by submitting this form you will give the FinEst Centre for Smart Cities the right to share this idea with cities and other researchers, companies through FinEst Centre homepage. If this idea is selected, the FinEst Centre for Smart Cities has the right to implement this idea with offering you an active role in conducting the pilot. If this pilot is selected then the financing is an investment by the FinEst Centre for Smart Cities.