

STABLE ENERGY SYSTEM IN VINNYTSIA

Vinnytsia, Vinnytsia Oblast, Ukraine

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1. What future urban problem needs to be addressed?

The problem lies in the lack of a stable, decentralised electricity and heat supply system that could ensure a reliable and sustainable energy supply in crisis situations (power cuts, emergencies) while reducing CO₂ emissions through the use of renewable energy sources.

Electricity distribution within the city of Vinnytsia is carried out through a private distribution network operator (PJSC Vinnytsiaoblenergo). This structure is common practice in most cities in Ukraine and around the world, making Vinnytsia's experience potentially interesting and scalable for many other cities facing similar challenges.

To overcome this dependence and increase energy sustainability, Vinnytsia plans to create an alternative distribution network owned by the municipality (similar to the existing street lighting network). This network should become the basis for the construction of local “energy islands.”

Specific issues to be addressed:

1. Optimal planning and design: includes determining optimal routes for new cable lines, locations for the construction of solar (SES) and wind (WES) power plants, selecting energy storage technologies, and integrating with existing infrastructure (cogeneration plants, lighting network).

2. Safe and efficient management in conditions of coexistence: requires the development of new organizational models, coordination procedures, data exchange, load balancing, and emergency response.

Vinnytsia, like many medium-sized Ukrainian cities, is heavily dependent on a centralised energy system that is vulnerable, inflexible and does not always provide uninterrupted energy supply. The situation is similar in the neighbouring areas of Vinnytsia City Territorial Community: old networks, low consumption efficiency, lack of local generation.

This problem falls under the category of ‘Climate-Resilient City’.

It also has elements of a ‘Safe City’, as ensuring autonomous energy supply increases the city's energy security and emergency preparedness.

For Vinnytsia, solving this problem is a key priority, because:

- It ensures a reliable energy supply in conditions of geopolitical and energy stress;
- It increases the city's energy independence by building local energy islands;
- It reduces greenhouse gas emissions through the introduction of renewable energy;
- It creates a foundation for the city's digital transformation through the integration of IoT, AI, and smart technologies;
- It opens up opportunities to attract investment in the green economy and sustainable development projects.

This fits in with the city's strategy to transition to a smart and sustainable city.

Although each city has its own specific characteristics, this problem is typical for many medium-sized cities in Ukraine and Europe, especially those with old energy systems that need to transition to sustainable energy supply. Similar challenges arise in cities such as Tartu (Estonia), which is actively developing the concept of microgrids, Kaunas (Lithuania), which is implementing decentralised energy projects, and Krakow (Poland), which is developing intelligent energy management systems. These examples demonstrate the commonality of the problem and approaches to solving it in the region.

Therefore, this challenge is pan-European, and the solution planned for implementation in Vinnytsia has the potential to be scaled up in other countries.

2. Innovations

Until February 2022, the current challenges facing Ukraine's energy system, such as rocket attacks and the destruction of the interconnected grid, could not have been foreseen, and cities, including Vinnytsia, began to seek urgent solutions. Generator sets were used to provide emergency power to critical infrastructure, and solar stations helped to partially cover electricity needs from renewable sources. Work was also underway to find innovative solutions, such as the creation of microgrids and energy islands. However, these solutions proved to be insufficiently effective: generators are dependent on expensive fuel and have limited operating time, solar stations do not have energy storage systems for use at night or in cloudy weather, and the lack of a systematic approach leads to fragmented solutions without their integration into a single network. In addition, there are legal obstacles to the introduction of new technologies, including imperfect legislation that does not provide clear rules for decentralised energy systems, complex licensing procedures for obtaining permits for construction and operation, and limited funding due to the lack of state support and investment mechanisms.

Vinnytsia community is focusing on studying the best practices of these countries in creating and managing decentralised energy systems in order to develop a comprehensive approach that takes local characteristics into account. In particular, it is analysing the technological solutions, regulatory framework and financial mechanisms that have enabled European countries to successfully integrate microgrids and energy islands into their existing energy infrastructure.

In addition, Vinnytsia is paying attention to studying methods of attracting private investment and creating joint energy cooperatives, which are actively used in Germany and Lithuania. Particular emphasis is placed on the implementation of intelligent management systems that ensure the optimisation of energy consumption and load balancing between sources.

This approach will allow Vinnytsia not only to adapt ready-made solutions, but also to develop innovative models that can become the basis for scaling similar projects in other Ukrainian cities. In the long term, this will contribute to the creation of a sustainable and energy-independent city, which is a key goal of Vinnytsia's development strategy.

The future solution is based on the use of existing resources in Vinnytsia community and the creation of a microgrid system for a full cycle of energy supply: production, balancing, distribution and supply. Main characteristics:

1. Use of existing facilities:
 - Cogeneration plants (electricity + heat).
 - Local cable lines and transformer substations.
 - Existing developed outdoor lighting network.
2. Infrastructure development:
 - Construction of new power lines, which will form the basis of the municipal distribution network.
 - Construction of new power supply lines.
 - Development of solar power plants at municipal facilities (schools, hospitals).
 - Planning of wind farms in the future.
3. Integration into a single system:
 - Combining all energy sources (cogeneration, solar power plants, wind farms).
 - Providing power to municipal, social and residential infrastructure.
4. Intelligent management:
 - IoT sensors and AI for consumption optimisation.
 - Load balancing between sources.
 - Systems for coordination with the main network operator.
5. Crisis resilience:

- Autonomous operation of the system when the main grid is disconnected.
6. Affordability:
 - Transparent tariffs and attracting investment.
 7. Scalability:
 - Adaptability for other cities.

3. Expected impact of your pilot solution.

If the microgrid system and energy islands are successfully implemented, Vinnytsia will see a significant positive impact on the environment, in particular through a reduction in CO₂ emissions due to the transition to renewable energy sources such as solar and wind power plants, which will reduce the burning of fossil fuels, while optimising the operation of cogeneration plants will help reduce energy losses.

Improvements in air quality due to reduced greenhouse gas and pollutant emissions will be particularly noticeable in winter, when the load on the system is highest.

The efficient use of local energy resources, such as biomass, and the integration of existing networks will conserve resources and reduce the need for new infrastructure projects, while a decentralised system and local networks will reduce electricity losses during transmission.

The implementation of the project will encourage residents to use energy-efficient solutions, raising environmental awareness, which in turn will contribute to the creation of a sustainable city where the integration of green technologies will make Vinnytsia more resilient to climate change and energy independent, setting an example for other cities.

The successful implementation of the microgrid system and energy islands will have a significant positive impact on the lives of Vinnytsia residents, improving their quality of life through uninterrupted power supply to critical infrastructure, including hospitals, schools, water supply stations, sewage treatment plants and public transport, which will ensure stability in everyday life and reduce power outages, increasing the comfort of residents.

Reduced utility costs will be achieved through the implementation of energy-efficient solutions and the use of renewable energy sources, which will help lower tariffs for utility providers and, accordingly, end tariffs for the population, while tariff transparency and energy consumption optimisation will make services more affordable.

Safety will be improved by autonomous energy islands, which will allow life support facilities to operate even during emergencies, significantly reducing the risks associated with power outages.

Citizens will be involved in sustainable development through the opportunity to participate in energy-saving projects, such as installing solar panels on private and multi-family homes with subsequent connection to the grid, creating energy communities (cooperatives), and raising environmental awareness through educational campaigns and practical project results.

The development of innovative technologies will stimulate the growth of the IT sector and other sectors of the economy, creating new jobs in the fields of energy, construction and system maintenance. In addition, the health of residents will improve thanks to reduced air pollution from lower fossil fuel combustion, which is especially important for people with chronic diseases.

These changes will not only improve the physical and economic well-being of citizens, but also strengthen trust in local authorities through the effective resolution of pressing issues.

The successful implementation of microgrid systems and energy islands will have the following impact on city management:

1. Improved management efficiency:
 - Intelligent systems (IoT, AI) will enable automated monitoring and optimisation of energy consumption.
 - Real-time data analysis will help make quick and informed decisions.
 - New organizational models for interaction with private network operators.

2. Reduced administrative costs:
 - Efficient use of resources will reduce the need for frequent repairs and maintenance of outdated infrastructure.
 - Fewer emergencies will reduce the burden on public utilities.
 3. Improved interaction with citizens:
 - Transparency in the functioning of the energy system will increase trust in the authorities.
 - Involving the population in energy efficiency initiatives (e.g., installing solar panels) will create a platform for cooperation.
 4. Development of digital tools:
 - The introduction of cloud platforms and mobile applications for monitoring energy consumption will provide access to information for citizens and management structures.
 5. Creating a sustainable management model:
 - Energy resource management will become more sustainable and predictable thanks to a decentralised structure.
 - Gaining experience in managing innovative projects will help the city respond effectively to new challenges.
 6. Attracting investment and partners:
 - The implementation of the project will attract investors and partners, which will strengthen the city's financial capabilities.
 - Creating a positive image of Vinnytsia as a leading city in the field of sustainable development.
- These changes will make city management more efficient, digital and citizen-centric.

4. Piloting

Vinnytsia city community is deeply interested in the status of a pilot partner, as the issue of ensuring sustainable energy supply and improving energy security is extremely relevant for the city, and the implementation of the project will help resolve critical issues related to the current crisis situation. Vinnytsia has ready-made heat supply facilities, transformer substations, local networks, an extensive outdoor lighting network and municipal buildings that can be integrated into the system, while existing cogeneration plants and plans for solar and wind power plants provide a solid foundation for a quick start. The city has experience in implementing infrastructure and innovation projects, which will ensure effective coordination of work, and the presence of partners in the form of Vinnytsia National Technical University and local energy companies will provide scientific support. Local authorities and citizens actively support the idea of transitioning to a 'smart city' and sustainable development, and are willing to cooperate with other cities and regions to scale up solutions. Participation in the project will help Vinnytsia become a leading example for other cities in Ukraine and the region, as well as gain access to innovative technologies and the experience of leading countries such as Estonia.

These factors make Vinnytsia an ideal candidate for the pilot implementation of the solution.



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