TRANSFORMATION OF THE ENERGY SECTOR: DIGITALISATION, SOCIAL RESPONSIBILITY AND GREEN MARKETING

Monograph

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The monograph is dedicated to studying approaches and principles of transformation of the energy sector, development of sustainable responsibility of all subjects of socio-economic relations, and features of the use of economic and marketing tools for energy greening. The authors analysed the features of implementing green energy and green marketing, key trends in developing technopolis. Peculiarities of the formation of energy security processes during military time are investigated. In studying the impact on communities and the environment, the principles of strategic management of social responsibility of energy companies are proposed. The key aspects of environmentally responsible tariff formation were investigated within the framework of the integration of renewable energy flows into a single energy system. To develop the potential of resources and energy conservation, the sectoral aspects of the decarbonisation of the economy were studied. The monograph is generally intended for government officials, entrepreneurs, researchers, graduate students, and economic, medical, and other specialities students.

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CHAPTER 2. ENERGY SECURITY IN WARTIME FOR SUSTAINABLE DEVELOPMENT

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2.1. Ukraine's energy sector in wartime conditions

The energy sector is an important and vulnerable component of any country's economy. Due to military aggression by the russian federation, Ukraine is experiencing increased challenges in this area. The loss of coal as an important source of energy is a serious challenge, as the temporarily entrenched Donbas has limited natural resources that do not provide sufficient energy sustainability. In this regard, the gas industry becomes one of the few available alternatives. However, significant dependence on natural gas imports increases risks for the country. Urgent reforms in the energy efficiency of the GDP require significant efforts in the structural restructuring of the economy, which, in turn, will significantly affect the socio-economic situation of Ukraine.

For Ukraine, the path to achieving energy independence began in 2015, when our state stopped importing Russian natural gas and switched to concluding contracts with the countries of the European Union. The next important stage was 2022. On February 24, Ukraine switched its energy system to autonomous mode after being disconnected from the power systems of Russia and Belarus. This disconnection was planned and was supposed to last three days to test how the Ukrainian system works autonomously, in order to later connect to the European system of electricity transmission operators - ENTSO-E (Zanuda, 2022) . That night, the Russian Federation began hostilities, invading the territory of Ukraine. However, the test was successfully conducted, and Ukraine finally refused to resume parallel work with the power systems of the Russian aggressor and Belarus. At the same time, Ukrenergo submitted an application for accelerated synchronization with the European energy system. Since then, for 20 days, the Ukrainian energy system has been isolated, but stable. The frequency of the network was maintained only at the level of 50 Hz. (Continental, 2022; Vatutina, 2022). The application for accelerated synchronization was supported by the energy ministers of the EU countries and the association of system operators ENTSO-E", and on March 16, 2022, Ukraine joined the energy grid of continental Europe. On January 1, 2024, Ukrenergo, the Ukrainian HTS operator, officially became a member of ENTSO-E (ENTSO-E Member, 2024). This historic step affected the country's energy strategy, strengthening the country's energy independence, its security, and expanding cooperation with European partners. This event is called obtaining "energy visa-free " with the European Union Grigorenko, (2022). Joining ENTSO-E gave Ukraine the opportunity to participate in joint projects and initiatives for the development of infrastructure and improvement of energy security in the region.

ENTSO-E (European Network of Transmission System Operators for Electricity), the European Network of Electricity Transmission System Operators, is an association for the cooperation of European Transmission System Operators (TSO). The TSO's 40 members represent 36 countries, which are responsible for the safe and coordinated operation of the European electricity system, the largest integrated electricity network in the world. ENTSO-E and its

members, as the European Community of Electricity Transmission System Operators, have a common mission: to ensure the security of the integrated energy system at all times at the pan-European level and the optimal functioning and development of the European integrated electricity markets , while enabling the integration of electricity , produced from renewable energy sources, and new technologies. ENTSO-E plays a central role in making Europe the first climate-neutral continent by 2050 by creating a system that is safe, sustainable and affordable, and which integrates the expected amount of renewable energy, thereby offering a significant contribution to development Europe's Green Deal. These efforts require sector integration and close cooperation between all actors.

Europe is moving towards a sustainable, digital, integrated and electrified energy system with a mix of centralized and distributed resources.

ENTSO-E acts to ensure that this energy system keeps consumers at the center of its operations, and is operated and developed with climate goals and social welfare in mind.

ENTSO-E's main responsibilities to perform include the following:

- Development and implementation of standards, network codes, platforms and tools to ensure a secure system and market functioning, as well as the integration of renewable energy;
- Assessment of the adequacy of the system in different terms;
- Coordination of infrastructure planning and development at the European level;
- Coordination of research and innovation activities of OSP;
- Development of platforms for transparent data exchange with market participants (ENTSO-E Mission, 2024).

2.2. Accession of Ukraine to European Network of Transmission System Operators for Electricity

Ukraine's accession to European Network of Transmission System Operators for Electricity (ENTSO-E) has a significant positive impact on the development of the country's energy system and its integration with European partners. First, joining ENTSO-E allows Ukraine to become part of the wider European energy system, which contributes to improving energy security, increasing the reliability of electricity supply and energy exchange with other countries. Second, Ukraine should adopt and implement the standards and procedures defined by ENTSO-E, which will improve the efficiency and coordination of the country's energy system. Thirdly, joining ENTSO-E gives Ukraine the opportunity to participate in the international trade exchange of electricity, which can stimulate the development of the energy market and ensure better prices for consumers.

The war that Russia has been waging against Ukraine for more than two years has a direct impact on the energy security and sustainable development of both Ukraine and the entire European energy landscape. The challenges faced by Ukraine's energy sector due to massive shelling of energy infrastructure have caused significant technological disruptions, resulting in long-term blackouts and undersupply of electricity to consumers. About 4% of the generating capacity was destroyed at the beginning of hostilities, another 35% of the capacity is located in the occupied territories. In particular, the largest nuclear power plant in Europe (Zaporizka) is under

constant pressure from the Russian occupiers. About 50% of thermal generation, 30% of solar generation, and more than 90% of wind generation were destroyed or are in the occupied territories. Gas production decreased by 10-12% during the time of the beginning of the full-scale invasion (Draft Recovery Plan, 2022)

These circumstances, as well as Ukraine's international cooperation in the energy sector, require immediate measures aimed at strengthening the safety and reliability of electrical networks and ensuring the sustainable development of the industry. We will define a system of measures that can contribute to economic security and sustainable development of the country:

- Modernization and reconstruction of existing electrical networks to increase their efficiency and resistance to failures.
- Implementation of modern systems of monitoring and management of electrical networks for timely detection and elimination of problems.
- Development and implementation of the latest technologies, such as smart grids and smart meters, which allow for greater automation and control of the energy system.
- Increasing investments in renewable energy sources and energy efficiency to reduce the burden on traditional electricity networks.
- Development and implementation of digital programs for prevention and response to accidents and disasters that may affect electrical networks.
- Increased investment in research and development of new technologies to improve the safety and reliability of electrical networks.
- Strengthening the legislation and regulatory framework that regulates the field of electricity supply and ensures appropriate safety and reliability standards.
- Protection of power grid infrastructure from possible military threats by installing barriers, protective structures and systems for detecting and deflecting attacks.
- Development of action plans and emergency response procedures for possible attacks on electrical networks, including evacuation and allocation of resources to restore power supply.
- Increasing the readiness and training of power grid personnel for the purpose of timely detection and response to possible threats.
- Development of systems for monitoring and controlling the state of electrical networks to detect abnormal situations and attacks on infrastructure.
- Cooperation with military and law enforcement agencies to ensure the protection of power grids during military operations and timely response to possible threats.
- Increasing the level of autonomy and redundancy of power networks to ensure power supply in case of damage or loss.
- Increasing attention to the cyber security of power grids and implementing measures to counter cyber attacks and other cyber threats.

This system of measures will help ensure the protection of power grids and reliable power supply during military operations, while maintaining the security and resilience of the energy infrastructure. After the end of the war in Ukraine, it is necessary to immediately move to the recovery phase, which is an important stage in the formation of a new and sustainable Ukrainian energy sector.

Below, some specific examples show the features of the formation of components for the formation of the energy security system.

2.3. Energy-efficient technologies and investments

Ensuring the stability of the energy sector becomes the key to achieving sustainable economic development and strengthening national security. The Government of Ukraine, together with the European Commission, created a broad platform for the recovery of Ukraine, which combines reforms and investments. This Platform is an open space that helps Ukrainians to recover and connects together countries, institutions, the private sector, civil society, business partners from around the world, European and international organizations, from the EBRD to the European Investment Bank, from the IMF to the World Bank. These efforts will allow Ukraine to move towards the future, in the direction of achieving climate neutrality, accelerate the digital era, build a modern and socially oriented market economy, where no person will feel abandoned (Zaryadzhai, 2024).

In order to successfully attract investments in the energy sector, it is necessary to create a favorable environment that would ensure the interest of investors and reduce the risks of their investment decisions. One of the key foundations for such an environment is the implementation of reforms, including demonopolization, ensuring transparency and improving legal and regulatory mechanisms.

First of all, the state must ensure the rule of law and the protection of investors' rights, which reduces the risks of their investments. Adaptation to European energy legislation will create uniform standards and conditions for participation in the European energy market, which will attract more investors to Ukraine.

The fight against corruption is an important step in building trust among investors. This will help reduce investment risks and ensure the stability of the economic environment.

Implementation of stimulating regulatory legislation and economically justified tariffs will create transparency and attractiveness for investors.

Conducting an active communication policy aimed at creating a positive image of the country among investors, providing them with information about advantages and opportunities in the energy sector, as well as supporting the establishment of long-term and mutually beneficial partnerships for joint development and success. Encouraging strategic and financial investors to enter the market will allow attracting additional resources and technologies for the development of the energy sector. Investment policy measures to strengthen the security and reliability of the energy sector are presented in Fig. 2.1.

The general goal of such measures is to create a stable and attractive investment climate that will contribute to the efficient functioning of the energy market and the development of the country's energy infrastructure.

The National Council for the Recovery of Ukraine from the Consequences of the War developed a draft plan of measures for the post-war recovery and development of Ukraine.

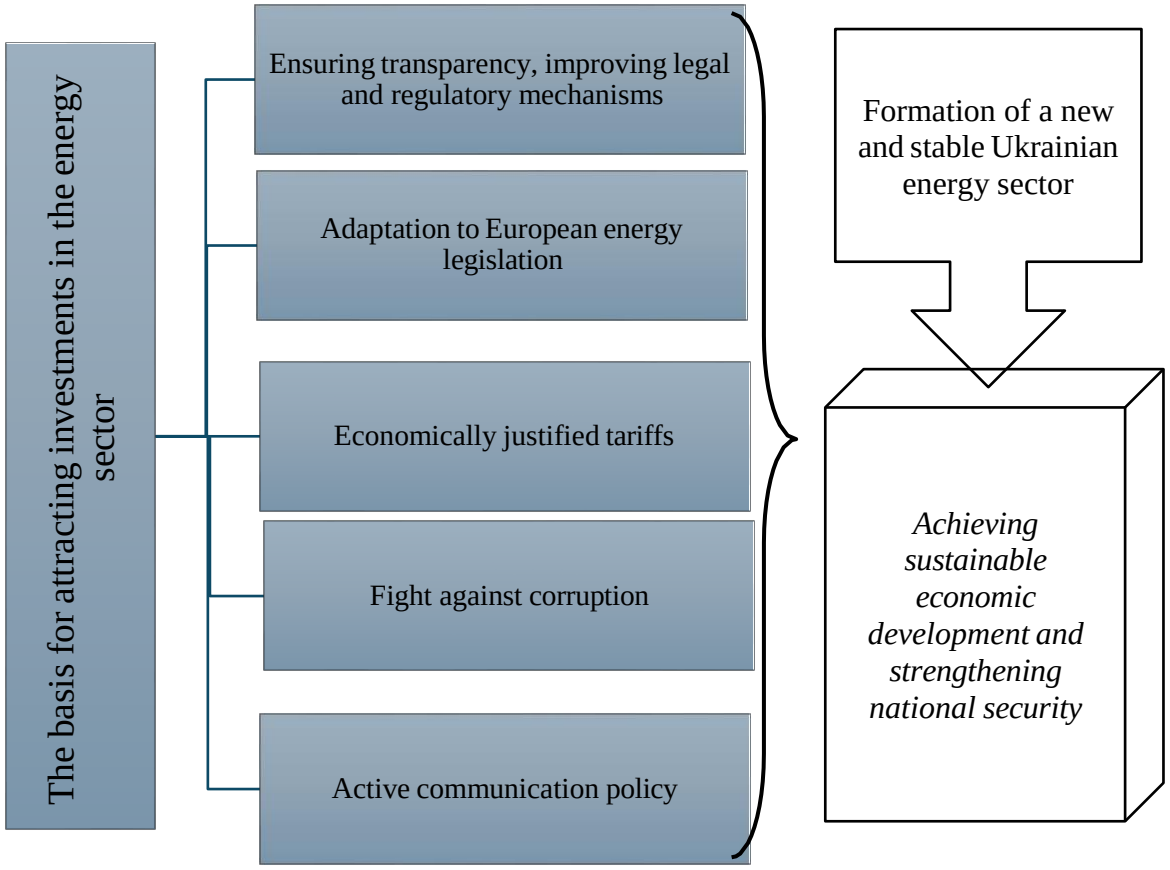

Figure 2.1. Investment policy measures to strengthen the security and reliability of the energy sector
Source: created by the authors

The vision of the Recovery of Ukraine: "A strong European country is a magnet for foreign investments" (Recovery Plan, 2022). The goals of the Recovery Plan of Ukraine are defined as:

- Ensure economic, social and environmental sustainability in the marathon to victory;
- Find effective solutions for the fastest recovery of the most important economic and social processes, and natural ecosystems;
- Develop a plan for the modernization of the country, which will ensure sustainable economic growth and the well-being of the population

The Recovery Plan of Ukraine is aimed at accelerating sustainable economic growth and is based on the following principles:

- Immediate onset and gradual development;
- Building fair welfare;
- Integration into the EU;
- Reconstruction of the better than it was, on a national and regional scale;
- Stimulation of private investments.

Within the framework of the Plan, a list of National programs for achieving key results is defined. The "Energy Independence and Green Course" program is aimed at strengthening energy security and sustainable development of the country (Projects national programs, 2022). The

restored energy sector of Ukraine should embody the most modern energy technologies and meet European energy efficiency standards.

The main directions of the Energy Restoration Program can be classified as follows:

1. Expansion of energy infrastructure based on:

- application of innovative electrical engineering technologies and IT to make the power grid more intelligent and efficient;

- construction of peak capacities and batteries;

- restoration of damaged energy facilities and modernization of the gas transportation system;

- construction of smart networks **(** smart grids).

2. Development of alternative energy sources based on:

- construction and development of renewable energy (wind, solar and hydroelectric power);

- development of infrastructure for hydrogen production.

3. Ensuring energy independence, which means the ability of a country to provide its own energy needs without dependence on external suppliers or political circumstances. To achieve this goal, it is important to take the following measures:

- an increase in nuclear power, which will increase domestic energy production and ensure the stability of energy supply in the country;

- formation of strategic reserves of oil and oil products that can be used in case of emergencies (interruptions in the supply of oil from abroad; negative changes in the world oil market);

- development and development of own gas fields, which contributes to reducing dependence on gas imports.

4. Sustainability and reliability of the energy system based on:

- modernization and optimization of the gas transport system;

- development and testing of transport infrastructure for the use of hydrogen;

- creation of reserves of oil and oil products.

Let's consider *the measures of technological reform* .

The application of the latest technologies for the modernization of the gas transportation system involves the introduction of innovative solutions and technologies to optimize and improve its operation. This covers a wide range of technologies that are used in various aspects of the functioning of the gas transportation system. Table 2.1 shows which technologies can be used.

The outdated energy system of Ukraine cannot withstand the loads of the new era. The high level of wear and tear of the main and auxiliary equipment of the power system and the uneven distribution of the load in the network often lead to emergency situations and outages of power supply to consumers. At the same time, Ukraine has one of the highest duration of emergency power outages in Europe: 696 minutes per year on average across the country. For comparison, this figure is 180 minutes in Poland, 104 minutes in Latvia, and 13 minutes in Germany. An effective mechanism for the development of the electric power system of Ukraine is the application of "smart grid" technologies (Smart Grid).

Table 2.1. Innovative technologies for optimizing the operation of the gas transportation system

Technologies	Description	Examples
Digital monitoring systems and management	The implementation of modern data collection, processing and analysis systems allows collecting large volumes of information about the state of the gas transportation system, receiving real-time data on pressure, temperature, gas consumption, etc., which helps to promptly identify and eliminate any problems	Siemens offers the SICAM system, which is used to collect data from sensors at various points in the gas pipeline and provides system operators with real-time information on pressure, temperature, gas flow and other parameters. This allows operators to quickly respond to any changes and identify possible problems.
Using drones for inspections of gas pipelines	The application of IoT in the gas transportation system allows connecting various sensors, devices and equipment to the network for data collection and process automation. This can be used to monitor the condition of gas pipelines, detect gas leaks or automatically regulate pressure.	Flyability company offers the Elios drone , which can inspect gas pipelines in hard-to-reach places (pipelines of complex construction). The use of drones makes it possible to effectively assess the condition of gas pipelines without the use of complex equipment and human resources
Intelligent management algorithms	The use of AI and data analytics allows analyzing large volumes of information collected from sensors and other sources to predict problems, detect anomalies, optimize service processes and manage resources.	General company Electric develops gas transportation system management systems based on artificial intelligence and machine learning. These systems can analyze large volumes of data and predict possible leaks, accidents or malfunctions in gas pipelines, allowing system operators to warn of events and take effective measures to avoid them.
Virtualization and cloud technologies	The application of virtualization and cloud technologies allows storing, processing and analyzing large amounts of data in real time without the need for large computing power on site. This facilitates data access and facilitates the implementation of additional analytical tools.	Schneider company Electric offers the EcoStruxure solution Gas , which allows remote monitoring and management of the gas transportation system. With the help of this system, operators can remotely control the operating modes of the equipment, as well as monitor the level of energy consumption and efficiency of the system.
Energy efficiency management systems	Implementation of energy efficiency management systems allows optimizing energy consumption and reducing losses, which is important for increasing productivity and reducing operating costs.	Honeywell manufactures smart sensors that are installed in various sections of gas pipelines to collect data on their condition and efficiency. These sensors are used to automatically control pressure, gas flow and detect any anomalies, which helps operators to respond in time to possible problems.

Source: created by the author based on (Siemens, 2024; FLYABILITY, 2024; Schneider Electric, 2024; EcoStruxure Geo SCADA Expert, 2024; Honeywell, 2024 *).*

In the Law of Ukraine On Energy Efficiency (On Energy Efficiency, 2021), smart networks, defined as electric networks that connect in an economically expedient way the participants of the electric energy market and allow to manage the transmission of energy and its consumption in order to increase the reliability of the electricity supply and the uninterrupted operation of the energy system. In general, a smart network is a set of technologies that transform an old-style energy infrastructure into a modern digital system using innovative IT solutions. The network

integrates communication technologies, as well as technologies for collecting information on the production, transmission and consumption of electricity, effective control and management of the network. Smart networks are the basis of the development of modern energy. The goal of smart grids is to increase efficiency, reliability and economic benefit in the electric power industry.

The construction of such networks is based on the use of advanced technologies of data collection, analysis and transmission. Smart networks use automation systems that allow remote control of the electric network, remote disconnection and connection of consumers, control of substation and power grid operation modes to ensure optimal use of resources.

Monitoring and diagnostic systems, equipped with various sensors and sensors, ensure constant monitoring of the network condition. This data is used to detect and eliminate problems, predict energy consumption and optimize its distribution. Smart networks make it possible to effectively integrate renewable energy sources (solar, wind) into the general electric network, which ensures the stability of energy supply and helps reduce dependence on traditional energy sources, which contributes to environmental protection. Smart grids allow consumers to reduce energy costs and save money by monitoring energy consumption in real time and optimizing it according to needs. Such approaches in the power industry make it possible to create more stable, reliable and cost-effective power supply systems that correspond to the modern sustainable approach to the development of society (Fig. 2.2). Thus, the introduction of "smart networks" contributes to:

- development of the national electric power industry;
- improving opportunities for integration of renewable energy sources and distributed generation;
- increasing the efficiency of electric energy transmission and distribution networks,
- the creation of an electric grid as an intelligent system of transmission, distribution and supply of electric energy from electric energy producers to consumers, integrated with communications and information technologies, and one that ensures improved functioning of the energy system with high-quality service to its users (Concept, 2022).

Today, the largest programs regarding Smart Grid technologies and projects are implemented in the USA, Canada and all the countries of the European Union, especially in Latvia, Italy, France, and Germany. Implementation of similar projects in developing countries: India, Brazil, Mexico. Equipped with 100% smart meters in the USA, China, Brazil, and Japan.

The war has had a significant impact on the energy sector of Ukraine. The recovery of Ukraine from the consequences of the war requires bringing the energy complex to a fundamentally new, high-quality level of development. New approaches to energy regulation should be based on the basic principles adopted by the EU countries, taking into account the risks of external aggression, informational and hybrid methods of warfare, and non-military influences.

Figure 2.2. The results of the implementation of the "smart grid" technology
Source: created by the authors based on (Concept, 2022).

2.4. Bioenergetics development

Despite the fairly intensive *development of biomethane production* in EU countries, this direction is not developing properly in Ukraine. Ukraine has the largest area of agricultural land in Europe, and one of the best potentials of agricultural raw materials for the production of biomethane in the world. Ukraine can offer the cheapest raw materials for the production of biomethane, a developed system of gas networks (HTS and GRS) and compete with any countries on the biomethane market. The structure of agricultural enterprises is favorable for the production of biomethane (a large share of large and medium-sized enterprises). However, currently biomethane production in Ukraine is not competitive with the market price of natural gas and needs support. The figure 2.3 shows the barriers to the development of the biogas and biomethane sector and recommendations for the development of the biogas and biomethane sector in Ukraine (Biogaz, 2024).

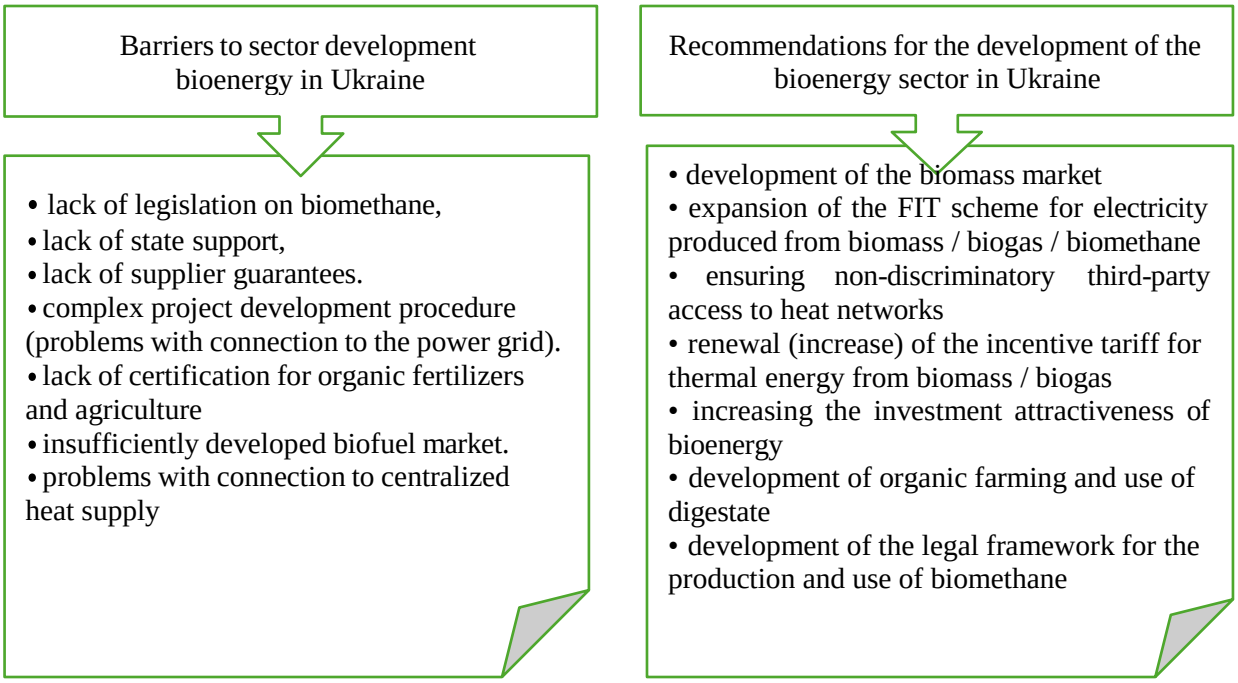

Figure 2.3. Development barriers and recommendations for the development of the bioenergy sector in Ukraine

Source: created by the authors based on (Biogaz, 2024)

Ensuring the supply of electricity to consumers, enterprises and objects of critical infrastructure with the help of small energy sources and the construction of small generation and cogeneration facilities corresponds to the strategy of decentralization of the energy system. This approach ensures greater stability and reliability of the system as a whole. In case of accidents or interruptions in operation of one source, others can continue to supply energy. Local production of electricity helps reduce dependence on imported energy and improve the energy independence of a country or region. Also, a decentralized system with small energy sources allows to reduce energy losses during transportation through the network. The construction of a large number of

small generation and cogeneration facilities is the basis of the decentralization of the energy system.

In response to the russian shelling, a system of distributed generation is being created in Ukraine, which should consist of hundreds of small power plants in order to diversify generation and protect energy facilities from large-scale damage. The scaling of such projects of distributed generation throughout Ukraine will increase the stability and flexibility of the United Energy System and will be a step towards European standards of work in the energy sector (Roshchyna, 2023).

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