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ENERGY MANAGEMENT: STATE AND PROSPECTS OF DEVELOPMENT IN UKRAINE

Zarządzanie Energią: Stan i Perspektywy Rozwoju na Ukrainie

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Streszczenie

Artykuł poświęcony jest badaniu stanu i perspektyw rozwoju zarządzania energetycznego w Ukrainie, której system energetyczny od dłuższego czasu znajduje się pod zmasowanym atakiem ze strony Rosji. Przeanalizowano straty poniesione przez sektor energetyczny Ukrainy w wyniku rosyjskiej inwazji na pełną skalę. Ustalono, że w obecnych warunkach system energetyczny Ukrainy nie jest w stanie funkcjonować tak stabilnie, jak przed wojną. Omówiono rolę, znaczenie i zadania zarządzania energetycznego w odbudowie i rozwoju sektora energetycznego kraju. Uzasadniono stopniowe tworzenie systemu zarządzania energetycznego na trzech poziomach rozwoju. Zbadano aktualny stan zarządzania energetycznego w ukraińskich miastach i zjednoczonych wspólnotach terytorialnych. W artykule przedstawiono wyzwania i możliwości, z jakimi borykają się organizacje podczas wdrażania systemu zarządzania energetycznego. Przedstawiono propozycje możliwych rozwiązań problemów wskazanych w analizie. Podkreślono znaczenie strategicznych inwestycji w energetykę odnawialną i współpracę międzynarodową na rzecz wsparcia bezpieczeństwa energetycznego i wzrostu gospodarczego Ukrainy. Zwrócono uwagę na konieczność reformy polityki energetycznej, aby dostosować ją do nowych wyzwań, co przyczyni się do zrównoważonego rozwoju infrastruktury i wzmocnienia relacji partnerskich z międzynarodowymi darczyńcami i inwestorami.

***Słowa kluczowe**: zarządzanie energetyczne, system zarządzania energetycznego, monitoring energetyczny, efektywność energetyczna.*

Summary

The article is dedicated to the research of the current state and development prospects of energy management in Ukraine, whose energy system has been under massive attack by the Russian Federation for an extended period. It analyzes the damage inflicted on Ukraine's energy

sector by the Russian full-scale invasion. It is determined that, under current conditions, Ukraine's energy system cannot function as stably as it did before the war. The role, significance, and tasks of energy management in the recovery and development of the country's energy sector are elucidated. The article justifies a step-by-step approach to forming an energy management system across three levels of development. It examines the current state of energy management in Ukrainian cities and amalgamated territorial communities. The article highlights the challenges and opportunities organizations face when implementing energy management systems. It offers suggestions for potential solutions to the problems identified in the analysis. The importance of strategic investments in renewable energy and international cooperation for supporting energy security and economic growth in Ukraine is emphasized. The necessity of reforming energy policy to adapt to new challenges, which will contribute to sustainable infrastructure development and strengthen partnerships with international donors and investors, is underscored.

Key words: energy management, energy management system, energy monitoring, energy efficiency.

Introduction

In the context of Russia's military aggression, the energy management system in Ukraine is a crucial aspect for ensuring the stability and effectiveness of the country's energy sector.

Its functioning, development, and improvement require a comprehensive approach and coordinated efforts from all stakeholders, including government bodies, businesses, non-governmental organizations, and citizens. To achieve success in this area, it is essential to implement modern technologies and energy management practices, promote the development of renewable energy sources, reduce energy losses, and enhance energy efficiency. Furthermore, it is important to ensure transparency and openness in decision-making and create favorable conditions for investment in the energy sector.

Analysis of the Damage from Russian Aggression in Ukraine's Energy Sector

Energy efficiency and a resource-conserving approach have always been crucial for Ukrainians, and they are particularly significant during the ongoing war. The energy infrastructure of Ukraine has been under targeted attack from the enemy for an extended period. As a result of these strikes, a significant portion of generating facilities that produce electricity

has been rendered inoperative. Over 50% of Ukraine's energy infrastructure has been affected by Russian shelling.

According to the KSE Institute, the analytical center at the Kyiv School of Economics, as of early 2024, the direct damages inflicted on Ukraine's energy sector amounted to $9 billion [13]. Following public statements made by the Prime Minister of Ukraine after the massive attack in March 2024, 80% of thermal power plant units were damaged. The total damages to the energy sector reached $12.5 billion [18].

The sector suffering the most is electricity generation and transmission (Fig.1). The estimated total damages for these assets exceed $7.4 billion [17].

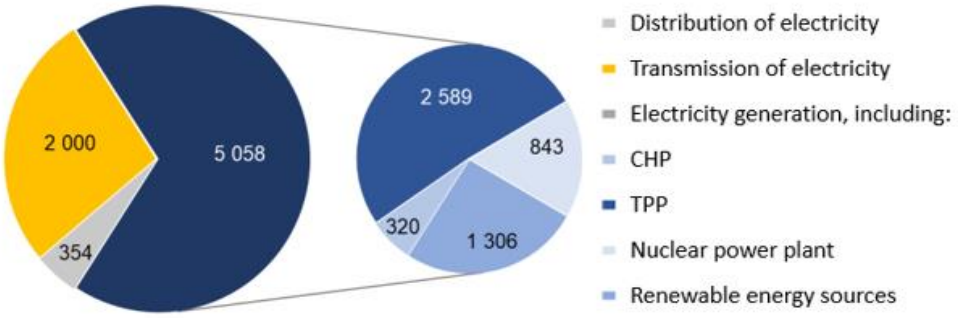

Figure 1. Direct infrastructure damage to power generation facilities, million USD.
Source: data from the Ministry of Energy of Ukraine [17].

A significant portion of the damage has affected large power generation facilities. During one of the massive missile strikes in the 2022-2023 heating season, according to the Prime Minister of Ukraine, 9 thermal power plant units were damaged, and at least one was completely destroyed due to a direct missile hit [18]. Overall, current direct damages to thermal power generation are estimated at $2.6 billion for thermal power plants (TPP) and $320 million for combined heat and power plants (CHP). Direct damages to hydroelectric power plants and pumped storage power plants (PSPP) are estimated at $1.1 billion [17].

Producers of renewable energy (RES) have also suffered significant losses. According to the Energy Charter Secretariat, 13% of solar generation capacity is located in occupied territories, and 8% has been damaged or destroyed; around 80% of wind generation is under occupation, with part of it damaged due to shelling; 2% of bioenergy facilities are under occupation, and at least 4 biogas plants are known to have been destroyed (Fig.2) [13].

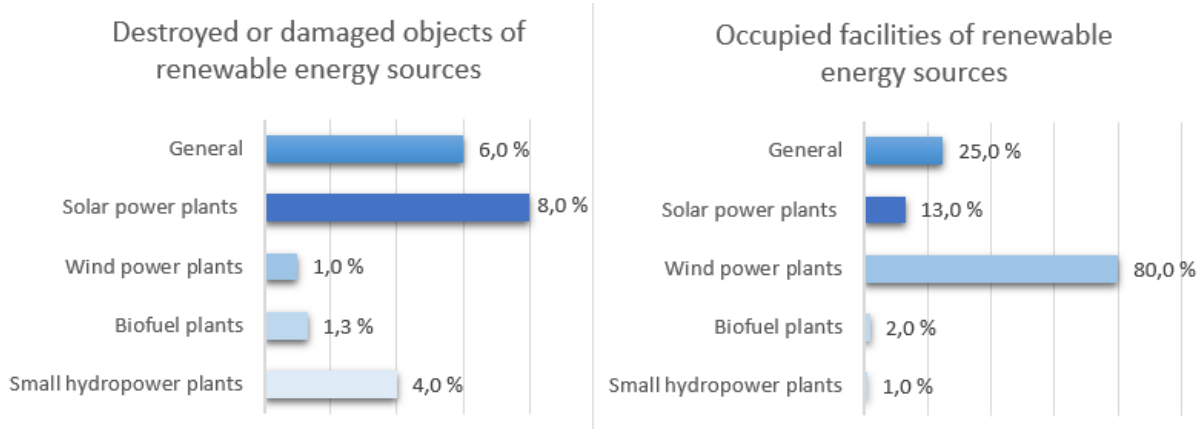

Figure 2. Destroyed, damaged and occupied renewable energy facilities as of January 2024.

Source: Energy Charter International based on public data [13].

The KSE Institute team estimates the direct damages to renewable energy producers (excluding large hydropower plants and pumped storage plants) at $220 million [13]. This sector is also experiencing significant indirect financial losses (Table 1).

Table 1. Assessment of Direct Losses to Ukraine's Energy Sector Due to the War as of January 2024

Sector	Assessment of losses, $ billion
Electric Power Industry, including:	7,41
Electricity Generation, including:	5,06
TPP	2,59
CHP	0,32
NPP	0,84
RES	1,31
Electricity Transmission	2,00
Electricity Distribution	0,35
Oil and Gas Sector, including:	1,20
Gas Transportation	0,78
Gas Distribution	0,15
Oil and Petroleum Storage	0,27
Coal Mining Industry	0,41
Total Direct Infrastructure Damage	9,0

Source: Kyiv School of Economics, based on data from the Ministry of Energy of Ukraine, energy companies, and open data [13].

The continuation of active hostilities across a significant portion of Ukraine and targeted massive shelling by the Russian Federation have led to damage and destruction of electricity

transmission and distribution assets. Preliminary estimates indicate that the direct damages to the electricity transmission system operator amount to over $2 billion, while the distribution system operators have incurred damages exceeding $350 million [17].

Since the first days of the full-scale Russian invasion, targeted attacks have been directed at oil and petroleum storage and processing facilities. Since February 24, 2022, at least 32 oil depots of various sizes and modernization levels, as well as the fuel stored at these facilities, have been damaged or completely destroyed. Current estimates indicate that direct damages to the fuel storage sector amount to nearly $266 million [13].

Assessing the current situation is challenging due to the lack of precise information on damage to facilities that are under occupation or inaccessible due to ongoing shelling and risks of landmines.

Under these conditions, Ukraine's energy system cannot operate as stably as it did before the war. Therefore, all consumers, including both the public and businesses, must adopt a conscious approach to energy use. The energy war that Russia is waging against Ukraine has highlighted the urgent need to accelerate the implementation of an energy management system for the restoration and economic development of Ukraine.

Implementation of Energy Management Systems in Ukraine

The path to energy efficiency begins with energy management – a practice aimed at ensuring the rational use of fuel and energy resources within an enterprise or municipality, significantly optimizing energy consumption.

An energy management system (EMS) is part of a broader management system that includes a set of measures aimed at conserving energy resources. This primarily concerns the public sector and municipal utilities, where financial resources are limited, and the material and technical base is outdated both morally and physically.

Implementing an energy management system involves monitoring energy consumption, developing an energy policy, planning new energy-efficient measures, calculating baseline energy consumption levels, identifying energy savings potential, and more [19]. However, an EMS is not merely a tool for reducing energy consumption; it is a strategic initiative aimed at creating a sustainable, competitive, and responsible energy system for any facility. An energy management system is a set of management decisions that defines energy policy and goals, sets energy tasks, and ensures the achievement of these goals and tasks [12].

The energy management system can be presented as a series of steps forming three levels of development. Research has shown that the level of municipal energy management in cities and united territorial communities (UTC) is in the development stage (Fig. 3).

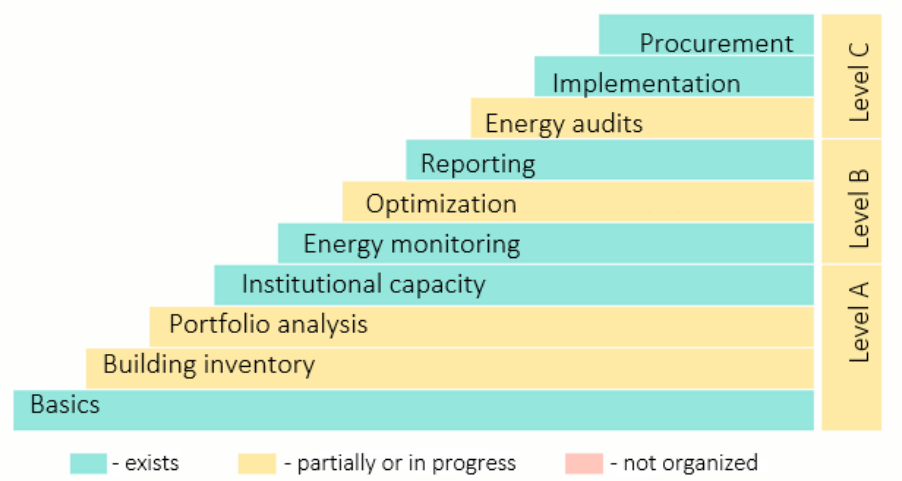

Figure 3. The level of municipal energy management in cities and united territorial communities in Ukraine.

Source: according to our own research [15].

Level A serves as the foundation upon which the further efficiency of the energy management system is built. This requires addressing a range of administrative and organizational tasks, primarily the appointment of a responsible person to perform energy management tasks. One option is to assign these duties to an employee who is willing and able to take on the role of energy manager. Another approach is to create a new position and hire a new specialist. Ideally, the candidate should have technical or construction experience, although this is not essential. The most important qualities are communication skills and motivation to work in this field. It is also necessary to develop a job description for the energy manager and allocate time resources and a budget [14].

To determine the potential for improving energy efficiency and implementing modern technologies, a building inventory is required. The main task of the inventory is to define the scope of work for the energy manager. A tool for identifying buildings with the greatest savings potential is portfolio analysis. It is conducted to achieve maximum savings and further assess modernization measures. The development of institutional capacity is a constant need for the energy manager to improve their skills and competencies in energy management.

Level B requires thorough monitoring of the energy consumption of facilities to accurately identify and correct problems. This involves scaling data, tracking changes in

consumer behavior, planning energy resource purchases, creating reports, and building a foundation for further optimization [11].

Global practice shows that improving energy efficiency is largely achieved through organizational changes in the energy management system of an enterprise or city [7]. By implementing an energy management system, significant energy savings of 3-5% can be achieved over 1–2 years without substantial financial losses [20].

Level C includes key components that ensure a comprehensive approach to energy management. This level covers regular, comprehensive energy audits of the condition of engineering systems and building elements, as well as analyzing energy consumption by consumers [19].

The results of energy audits are used to develop detailed energy-saving plans and improve infrastructure. Comprehensive programs are implemented that support environmental and energy standards, ensuring compliance with international energy regulations and standards. Additionally, sustainable procurement practices are introduced, which involve selecting energy-efficient equipment and technologies during tenders and purchases [8].

Energy management ensures a high degree of transparency and accountability in energy management processes, including detailed reporting and monitoring of results.

To assess the current state of energy management in Ukrainian cities and municipalities, energy monitoring, data analysis, and planning are carried out on an ongoing basis. A study conducted among AEMU members and signatories of the Covenant of Mayors, through an electronic survey of officials responsible for the municipal energy sector, showed that 88% of the cities surveyed assign a decisive role to the energy sector for the normal functioning of urban infrastructure and, in one form or another, set corresponding goals and monitor their achievement [6].

68% of the surveyed cities have programs supporting energy efficiency in the residential sector, but one in five lacks appropriate financial support. In cases where budgetary funds are allocated, the effectiveness of these programs is primarily assessed formally, based on the amount of funding and the number of beneficiaries, rather than on the actual savings achieved.

Only 50% of cities have a dedicated energy manager position or an energy management department, and in 30% of these, energy management has been added to the responsibilities of officials responsible for other matters. However, 85% of cities expressed support for the mandatory introduction of a dedicated energy manager position within local government bodies and the need for legislative regulation of this issue.

93% of the cities surveyed conduct energy monitoring, while the remaining 7% are in the process of preparing for its implementation. Monitoring mainly focuses on energy consumption based on meter readings, rather than the microclimate within buildings. Only one-third of cities have a basic set of equipment for conducting rapid building inspections. In 83% of cities, energy audits are conducted for public buildings, and 50% have started the energy certification of public buildings [6].

Projects and programs, while beneficial to specific communities, must also be supported by a long-term and systematic vision of energy efficiency development on a national scale.

Energy Management in the Restoration and Development of Ukraine's Energy Sector

Energy management is the first essential step toward smart energy consumption management. Government authorities, communities, and enterprises aiming to be prepared for any energy challenges, stop wasting energy and money, and become more energy-efficient and competitive should start their work with energy management [19].

In the USAID project "Improving the Efficiency and Accountability of Local Government Bodies," a step-by-step algorithm for implementing an energy management system is recommended (Figure 4).

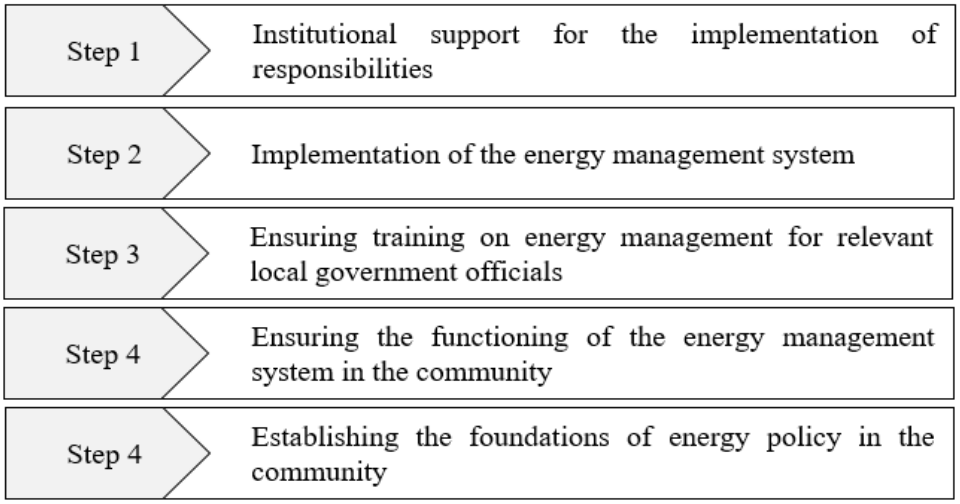

Figure 4. Algorithm for Implementing an Energy Management System.
Source: according to the USAID HOVERLA project [20].

This approach will ensure a systematic and comprehensive approach to the implementation of energy-saving measures within the community. At each stage of implementation, a foundation is created for the effective management of energy resources,

which, in turn, will contribute to improving energy efficiency and reducing energy resource costs. Moreover, the involvement of specialists and the training of officials will ensure the sustainable operation of the energy management system at the local level, while the formation of the community's energy policy will promote long-term energy stability and sustainable development.

Energy management allows for the consideration of various energy efficiency measures and the selection of those that will be most appropriate and bring the greatest effect. These measures do not necessarily have to be expensive. Even without significant financial investments, simply by setting up an energy management system, energy consumption can be reduced by 5-15% [19].

As of today, several important steps have been taken in Ukraine to implement energy management systems, particularly in the context of enhancing energy efficiency and energy independence.

1. Legislative foundation established**.** A number of laws have been adopted, including the Law of Ukraine "On Energy Efficiency" [1] and the CMU Resolution "On the Implementation of Energy Management Systems" [3]. They provide the legal basis for energy-saving measures at the local and national levels.

2. State programs. Programs supporting energy conservation have been introduced, such as the Government's "Warm Loans" program for homeowner associations, private households, and businesses. Additionally, EU and USAID programs aimed at improving energy efficiency are actively operating. In line with the EU Directive on Energy Efficiency of Buildings, long-term plans are being developed to promote the concept of zero-emission buildings. These buildings will require minimal energy, and all of it will be produced from renewable energy sources. While this involves significant investment, it is expected to save about 50% of energy costs in the long term [10].

According to the Law of Ukraine "On Energy Efficiency" [1], the Ministry of Regional Development has developed the Building Thermal Modernization Strategy through 2050 [16]. It outlines the country's goals for building modernization and how they will be achieved. In the coming years, an action plan will also be developed as part of this strategy.

To enhance energy efficiency, Ukraine plans to implement the construction of nearly zero-energy buildings [5]. Additionally, most of this energy should come from renewable sources, ideally generated directly on or near the buildings.

The National Recovery Plan of Ukraine, developed by the Ukrainian government in collaboration with hundreds of experts, already includes housing modernization projects. These

projects cover energy-efficient reconstruction of housing, the introduction of heat pumps, and even pilot construction of nearly zero-energy buildings [4].

3. Energy management system established. To ensure compliance with item 5 of the Resolution, the State Energy Efficiency Agency has mandated that government authorities and local self-governance bodies provide information on the status and results of energy management systems to the agency. Many communities are already implementing energy management systems. Local governments, with the support of international programs, are learning to implement tools for monitoring and managing energy consumption [2; 3].

4. Partnership with international organizations. With the involvement of organizations such as GIZ, USAID, and the European Bank for Reconstruction and Development (EBRD), projects are being implemented to modernize infrastructure and train specialists in energy efficiency.

As a potential EU member, Ukraine aligns its goals with European standards. Within the framework of the European Green Deal, the EU aims to achieve full decarbonization (i.e., reducing greenhouse gas emissions to levels that can be fully absorbed by ecosystems or other methods) of the building sector by 2050 [9].

5. Information and awareness-raising activities. Training sessions, seminars, and consultations are conducted for local government and business representatives on energy management and efficiency [7].

6. Energy efficiency in the public sector. Projects are being implemented to modernize public facilities, such as schools, hospitals, and kindergartens. Local governments are increasingly introducing systems for accounting and optimizing energy consumption.

Energy management plays a critically important role in the recovery and development of Ukraine’s energy sector, ensuring efficiency, sustainability, and the optimal use of energy resources.

Conclusions

Overall, Ukraine is gradually moving towards increased energy efficiency, but full implementation of energy management systems still requires more active support at all levels, as well as additional investments and technical resources.

In wartime conditions, energy management in Ukraine becomes critically important, as the country faces infrastructure destruction, disruptions in energy resource supply, and a growing threat of an energy crisis. Military actions significantly complicate the effective management of energy systems while increasing dependence on external energy sources. This

presents Ukraine with the challenge not only of maintaining the operation of the energy sector under emergency conditions but also of finding ways to optimize and develop it.

We believe that the primary tasks of energy management in wartime should be:

- increasing security measures for energy infrastructure objects;
- transitioning to more resilient and renewable energy sources, which will reduce the country's vulnerability to external threats and ensure energy independence;
- reducing energy costs and ensuring the uninterrupted operation of energy infrastructure in crisis situations, maximizing efficient and rational energy consumption is an additional weapon in countering the energy terror perpetrated by Russia;
- meeting the energy needs of the civilian population during armed conflict;
- collaborating with international partners to secure support and assistance in the energy sector.

Future reconstruction of Ukraine must be based on energy management, as the sustainable development of the country after the war requires effective use of energy resources and a shift to more ecological and modern technologies. Implementing energy management will allow for optimized energy consumption, reduced dependence on fossil fuels, and enhanced energy independence.

Specifically, focusing on renewable energy sources such as solar, wind, and bioenergy will help reduce carbon emissions, which is a key factor in combating climate change. Energy efficiency across all sectors, from construction and infrastructure to industry, will result in cost reductions and increased competitiveness in the international market.

Investments in modernizing the country's energy system will not only drive economic growth but also improve the quality of life for its population. Utilizing modern monitoring and energy management technologies will ensure stability and security of the energy system amid a volatile global economy and potential new challenges.

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