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ANALYSIS OF APPROACHES TO THE FORMATION OF ENERGY EFFICIENCY MANAGEMENT STRATEGY AND INNOVATIVE ENERGY TECHNOLOGIES WITH THE PURPOSE OF ENVIRONMENTAL PROTECTION ACTIVITIES

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Key words:
energy efficiency management, energy resources, strategy, energy saving, environment, energy efficiency indicator, innovations, method of targeted energy monitoring, war, agricultural enterprise, cogeneration.

The article examines the impact of irrational use of energy resources and the possibility of reducing energy consumption. The main consumers of energy resources in Ukraine and the percentage of their consumption have been established. The total number of processing industry enterprises is almost 35.2 thousand. At the same time, the main consumers of energy resources in Ukraine are industry (30.2% of total energy consumption), household (32.8%) and transport sectors (19.5%). The level of energy intensity of Ukrainian industry is given and it is determined that over the last 5 years, the total energy intensity level of Ukrainian industry has decreased by only 4%, with a decrease in total added value by 37% and a decrease in energy consumption by 39%. The weak dynamics of the decrease in energy intensity indicates a low level of modernization of production as a whole. The author's definition of the essence of «energy efficiency management» is given, which is proposed to be considered as a component of the general system of enterprise management and energy management, especially that which is aimed at realizing the energy potential of the company for the purpose of significantly improving the energy processes of this company, with the aim of its transition to energy independence, sustainability, energy security and implementation of innovative approaches, energy-saving technologies, and optimal use of energy resources at its disposal. Functions of energy efficiency management of an industrial enterprise according to M. Meskon are given. The concept of the energy efficiency indicator and the method of targeted energy monitoring are characterized. The international experience of the implementation of innovative energy technologies by companies is indicated. The energy strategy of Ukraine for the period until 2035 was studied and its key tasks in the field of energy efficiency were established. The growing importance of the issue of energy efficiency for a country in a state of war and measures that contribute to increasing the level of economic efficiency are demonstrated on the example of an agro-industrial enterprise.

АНАЛІЗ ПІДХОДІВ ДО ФОРМУВАННЯ СТРАТЕГІЇ УПРАВЛІННЯ ЕНЕРГОЕФЕКТИВНІСТЮ ТА ІННОВАЦІЙНИХ ЕНЕРГОТЕХНОЛОГІЙ З МЕТОЮ ПРИРОДООХОРОННОЇ ДІЯЛЬНОСТІ

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Ключові слова:
управління енергоефективністю, енергоресурси, стратегія, енергозбереження, навколишнє середовище, показник енергетичної ефективності, інновації, метод цільового енергетичного моніторингу, війна, агропідприємство, когенерація.

У статті досліджено вплив нераціонального користування енергоресурсами та можливість скорочення споживання енергії. Встановлено основних споживачів енергоресурсів в Україні та відсоток їх споживання. Загальна кількість підприємств переробної промисловості становить майже 35,2 тисячі. При цьому основними споживачами енергоресурсів в Україні є промисловість (30,2% від сукупного енергоспоживання), побутовий (32,8%) та транспортний сектори (19,5%). Наведено рівень енергоємності промисловості України та визначено, що за останні 5 років сукупний рівень енергоємності промисловості України скоротився лише на 4%, при скороченні сукупної доданої вартості на 37 % та скороченні обсягів споживання енергії на 39 %. Слабка динаміка

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зниження обсягів енергоємності свідчить про низький рівень модернізації виробництва в цілому. Надано авторське визначення сутності «управління енергоефективністю», яку запропоновано розглядати як складову загальної системи управління підприємством та енергетичного менеджменту, особливо ту, яка спрямована на реалізацію енергетичного потенціалу компанії заради суттєвого покращення енергопроцесів цієї компанії, з метою її переходу до енергонезалежності, стійкості, енергобезпеки та впровадження інноваційних підходів, енергозберігаючих технологій, та оптимального використання наявних у її розпорядженні енергоресурсів. Наведено функції управління енергоефективністю промислового підприємства за М. Месконом. Охарактеризовано поняття показника енергетичної ефективності та методу цільового енергетичного моніторингу. Зазначено міжнародний досвід імплементації інноваційних енерготехнологій компаніями. Досліджено енергетичну стратегію України на період до 2035 року та встановлено її ключові завдання у сфері енергоефективності. Продемонстровано зростання вагомості питання енергоефективності для країни у стані війни та заходи, що сприяють підвищенню рівня економічної ефективності на прикладі агропромислового підприємства.

Statement of the problem

Today, an urgent issue for society is the preservation of natural resources that are extracted for energy. One of the problems is the discrepancy between the volumes of these sources and the needs of humanity. An urgent task for scientists, not only of an energy nature, but also of an economic nature, because energy is the basis, is the development and effective use of both traditional and the involvement of non-traditional and renewable energy sources in public production. Despite this, the level of energy efficiency is quite low, due to its improper use, which in turn leads to aggravation of environmental problems. Also, the lack of modernization of industrial enterprises and the presence of weak dynamics of reducing energy intensity slows down positive changes, which negatively affects the trend of balanced environmental management throughout the world. The importance of the energy monitoring system for evaluating and reducing the use of energy resources is significant. In addition to the above, the dependence on the supply of energy resources, especially from countries with unstable political relations, and the lack of a sufficient number of renewable energy sources threaten the stability of the economy. The need to implement the key tasks defined in the Energy Strategy of Ukraine for the period up to 2035 in the field of energy efficiency. Also, the war became another reason for accelerating the process of introducing advanced energy-saving technologies.

Analysis of recent studies and publications

Many scientists were engaged in research in the field of energy efficiency management, in particular with the purpose of environmental protection, which undoubtedly influenced its development. Important factors of this process are not only innovations, but also the systematization of various approaches, which will allow to build an individual approach for enterprises with different specialization from others.

For example, L. M. Ganushchak-Efimenko and O. O. Yershova [4], who are experts in the field of scientific and innovative economic activity, investigated the main modern innovative directions for energy efficiency management in three sectors of energy management: optimization, distribution and storage of energy, demonstrated successful examples of their practical implementation.

M. Meskon [7] identified four main functions of management, namely planning, organization, motivation, control, and two compatible processes: the communication process and the decision-making process, which allow us to better understand its mechanism and successfully use the advantages.

The method of increasing the energy efficiency of the enterprise by implementing the international standard ISO 50001, which was presented in the work of E.V. Myronenko, V.O. Shashko, I.O. Trembach [6], is one of the examples of attracting foreign experience that will contribute to the development of the state and the preservation of ecology.

Thanks to such research, the Energy Strategy of Ukraine for the period until 2035 «Security, energy efficiency, competitiveness» was created, which is the country's course on the way to preserving the environment through balanced use of nature.

Objectives of the article

The main tasks of the article are the analysis of energy efficiency measures, an overview of the energy strategy of Ukraine for the period until 2035, one of the scientific approaches to the formation of an energy efficiency management strategy, innovative energy technologies, an analysis of the concepts of an energy efficiency indicator and a method of targeted energy monitoring, consideration of war as a factor affecting the acceleration the rate of growth of the relevance of combining business and energy efficiency into one balanced system.

The main material of the research

Irrational use of energy resources and a gradual increase in their extraction, as well as generally insignificant energy efficiency and a small share of alternative energy sources negatively affect the state of the environment.

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Sometimes energy efficiency is called the «fifth fuel» («invisible fuel»), implying that one of the most effective ways to solve the climate problem is to use less energy, that is, not to increase the energy supply, but to reduce the demand for it. Researchers claim that developed countries can reduce energy consumption by 25% with virtually no loss to their residents. Therefore, only the abandonment of fossil fuels and the transition to renewable energy will not save the situation. We should fight against our wastefulness and ignorance. Each country, community and individual can determine the limits of their real needs and consume energy to a sufficient extent, but not more [1].

Energy efficiency and the use of alternative energy sources are the two main strategies of many countries to reduce gas emissions into the atmosphere. According to the UN, energy efficiency can affect this process faster and without costs, such as the introduction of «green» technologies, so it plays an important role in correcting the current environmental situation. There is a close relationship between energy efficiency and CO2 reduction. According to representatives of the International Energy Agency (IEA), CO2 emissions can be reduced by 65% over the next 20 years simply through the active use of energy-efficient technologies. Energy efficiency issues in Ukraine are dealt with by the State Agency for Energy Efficiency and Energy Saving [2]. According to international agreements signed by Ukraine, Ukraine is obliged to reduce the energy intensity of its economy and the negative impact on the climate, as well as to stimulate energy consumers, including industrial enterprises, to increase energy efficiency. At the same time, the Association Agreement between Ukraine, on the one hand, and the European Union, the European Atomic Energy Community and their member states, on the other hand (Association Agreement), contains requirements for the introduction at the legislative level of a number of mechanisms to stimulate enterprises to energy efficiency and climate protection.

Today in Ukraine there are about 44,000 industrial enterprises of various forms of ownership, including large – 239 (0.5%), medium – 4,854 (10.8%), small – 39,779 (88.7%) (Fig. 1).

At the same time, the total number of processing industry enterprises is almost 35.2 thousand.

The main consumers of energy resources in Ukraine are industry (30.2% of total energy consumption), household (32.8%) and transport sectors (19.5%) (Fig. 2).

The basic funds and technologies of many enterprises were created back in Soviet times and require significant energy modernization. At the same time, appropriate capital investments increase the competitiveness of products. Energy efficiency has an impact on competitiveness at the level of enterprises and individual sectors of the economy. This, in turn, has a positive effect on the economic situation of the country as a whole.

At the same time, over the past 5 years, the total level of energy intensity of Ukrainian industry has decreased by only 4%, with a decrease in total added value by 37% and a decrease in energy consumption by 39%.

The weak dynamics of the decrease in energy intensity indicates a low level of production modernization as a whole [3].

Uninterrupted supply and efficient use of fuel and energy resources, the possibility of their extraction in the country and accessibility for the population, enterprises and organizations currently determine the speed, pace and sustainability of the development of a particular state [4].

Before the start of the full-scale invasion, Ukraine's energy sector was very dependent on other countries. Even at the end of 2021, half of the nuclear reactors were operating using Russian nuclear fuel. Gas was obtained from Europe, coal was mined and purchased, for example, from South Africa, and oil and diesel were supplied from Russia and Belarus.

Currently, the situation has changed somewhat and the same oil products are obtained from more friendly

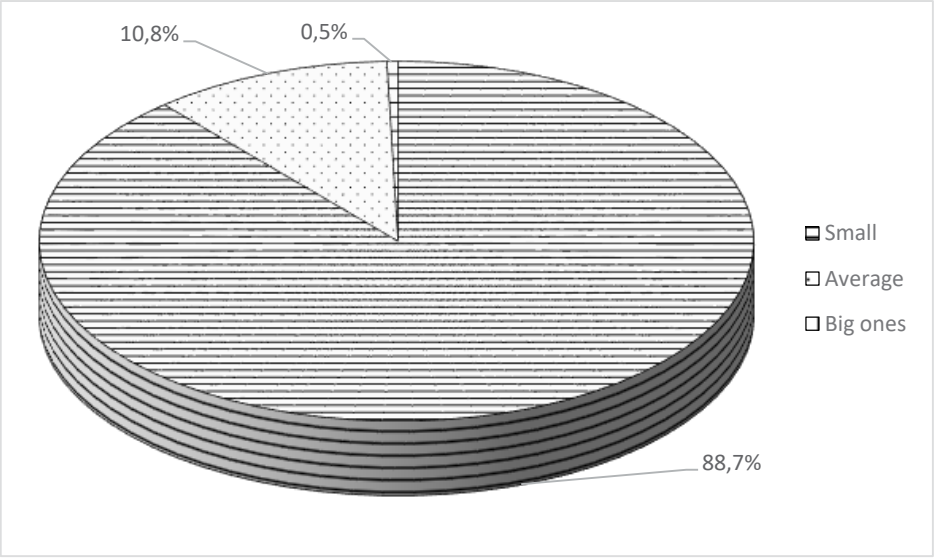

Figure 1 – Industrial enterprises of Ukraine

Source: created by the authors based on [3]

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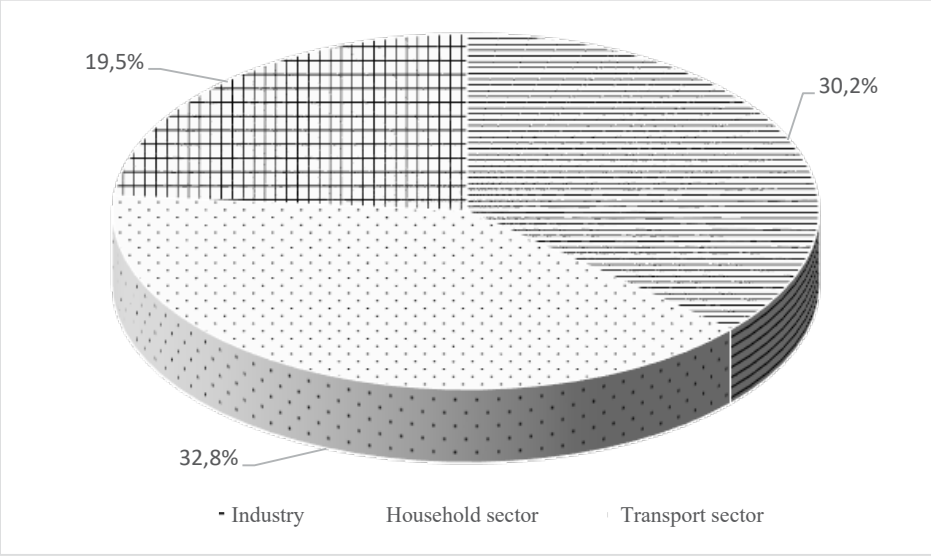

Figure 2 – Main consumers of energy resources in Ukraine

Source: created by the authors based on [3]

countries – Lithuania, Poland. Coal is still mined, some mines operate even in Donetsk region.

Many energy enterprises were not modernized, energy-efficient measures were not implemented to reduce energy consumption, and renewable energy developed very slowly and unsystematically [5].

Therefore, the issues and problems of energy efficiency management of enterprises, organizations, institutions of any form of ownership (state or private) are becoming increasingly urgent and one of the main ones, on the solution of which depends the economic security of our state.

Energy efficiency management can be defined as a component of the general system of enterprise management and energy management, especially that which is aimed at realizing the energy potential of the company for the purpose of significantly improving the energy processes of this company, with the aim of its transition to energy independence, sustainability, energy security and the introduction of innovative approaches, energy-saving technologies, and optimal use of energy resources at its disposal.

According to the Law of Ukraine «On Energy Saving», there should be specialists responsible for energy efficiency at each level of management, from state to local (business object). That is, energy efficiency can be represented in the form of a hierarchical pyramid (Fig. 3) [6].

Energy efficiency management of an industrial enterprise is a separate case of management, which, according to the definition of M. Meskon, involves 4 main management functions: planning, organization, motivation, control, as well as two compatible processes: the communication process and the decision-making process (Fig. 4) [7].

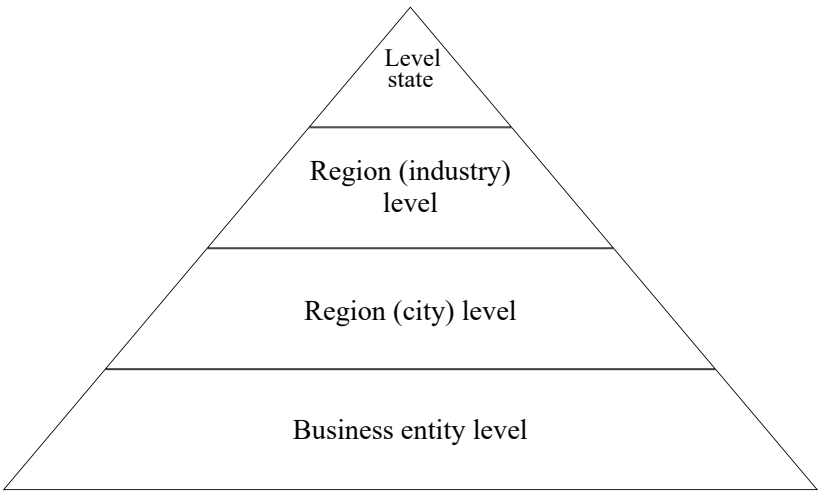

Figure 3 – Hierarchical structure of energy efficiency management

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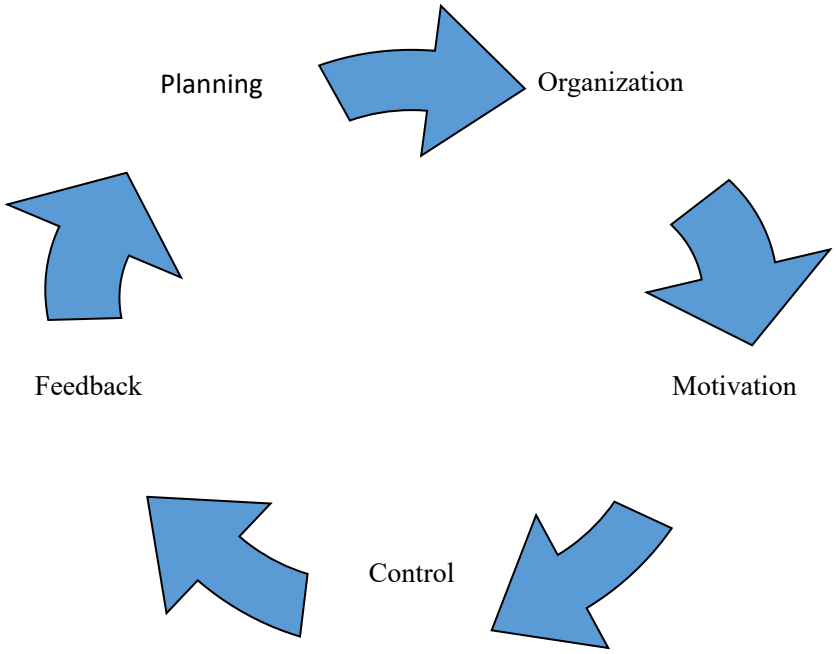

Figure 4 – The main functions of enterprise management

Source: created by the authors based on [7]

To assess energy efficiency: production or technological process, the «energy efficiency indicator» is used, which evaluates the consumption or loss of energy reserves.

Energy performance indicator – a numerical value of the energy performance of a facility, which is used for energy efficiency ranking, energy efficiency requirements and/or for a certificate. Energy efficiency indicators must be updated and constantly compared with the baseline energy consumption. They are determined by the calculation method [8].

The method of target energy monitoring (TEM) can be used as the basis of the energy management system. The method of targeted energy monitoring was developed and is widely used in large industrial enterprises of Western Europe and the USA as one of the parts of the general structure of enterprise management. According to the estimates of the British Agency for Energy Efficiency, the implementation of CEM reduces the current costs of energy resources in monetary terms by 10-20% without additional costs for technology modernization. Most often, the implementation of CEM is recommended as a priority measure in a comprehensive program to improve energy efficiency.

The CEM method requires a clear organizational structure responsible for its functioning. The core of such a structure is the energy management service, and the peripheral links are energy accounting centers [6].

O. Kirylenko considers the energy saving strategy as a process of determining the main direction (perspective) of the business entity's functioning in order to ensure energy-saving effects, taking into account the established new target guidelines, the possibilities of the internal environment, external conditions and establishing a system of energy-saving measures that will make it possible to achieve the formulated forecast parameters [9].

Modern innovative approaches to energy efficiency management are currently characterized by relevant trends in three sectors of energy management: energy distribution, energy optimization and energy storage (energy conservation).

According to Grand View Research, the global market for distributed energy generation will reach $573.7 billion by 2025, exhibiting a CAGR of 15% between 2014 and 2025.

Blockchain has established itself as a potential new technology in the decentralized energy sector, providing increased control over energy sources, transparent trading and secure data for energy regulation. According to Markets and Markets, the global blockchain in energy market is forecast to reach US$7.1 billion by 2023, growing at a CAGR of 78.32% from an estimated US$394.3 million in 2018.

Innovative trends in the energy distribution sector include:

– transition to equal energy trade;
– distributed energy production;
– technologies of remote or island microgrids.

Such technological trends are observed in energy optimization as:

– predictive analytics;
– automated response to the request;
– energy management systems of smart buildings.

Innovative trends in the energy saving sector are characterized by close attention to the creation of energy storage systems and equipment, namely:

– thermal energy accumulators;

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– rechargeable lithium-ion batteries;

– vanadium batteries (v-flow batteries) (serve more than 20 years).

Many world-renowned foreign companies currently have successful experience in implementing such innovative energy technologies, including: Green Mountain Energy (Houston, USA) – provides fully renewable energy services from solar, wind, geothermal, hydro and biomass sources, in accordance with the developed by a company with a portfolio of services in terms of commercial clients and households; supports the policy of carbon compensation, invests in projects to reduce the impact of greenhouse gas emissions, etc.; Cisco (California, USA) is one of the leaders in the energy industry among the suppliers of computer network systems with a wide range of products and services designed for utility needs. Over the past 5 years, Cisco has implemented more than 440 energy efficiency projects and currently provides its activities with the lion's share of renewable energy sources (83%). Schneider Electric (France), WePower (Lithuania), BluWave-ai (Canada), Brenmiller Energy (Israel) are also among the companies actively implementing innovative technologies for energy efficiency and energy efficiency management. Among the domestic energy-efficient companies are startup PassivDom (created a house without connection to power grids and water supply systems, but in it you can enjoy the benefits of developed civilization), Kyiv company SolarGaps (created blinds-generators with solar panels), Lviv company PRANA (created recuperators – mechanical ventilation systems that can return 93% of heat) [4].

18 серпня 2017 Уряд схвалив Енергетичну стратегію України на період до 2035 року «Безпека, енергоефективність, конкурентоспроможність», яка визначає напрям розвитку енергетичної системи та має забезпечити її модернізацію разом з зменшенням залежності від імпорту енергоресурсів.

The key tasks of the strategy in the field of energy efficiency are (Fig. 5):

– reduction of the energy intensity of the Ukrainian economy from the current 0.28 t/ths. dollars USA up to 0.13 (per PCS) by 2035;

– implementation of the energy management system in state and municipal buildings, as well as in enterprises;

– stimulation of energy saving at the level of consumers, formation of energy-efficient consciousness among citizens;

– stimulating the improvement of energy efficiency by implementing the monetization of end-user subsidies, minimizing the amount of subsidies in the future;

– ensuring accounting of generation and use of all forms of energy and energy resources (electricity and thermal energy, natural gas, etc.);

– increasing the energy efficiency of the residential sector by creating instruments of state technical and financial support;

– introduction of mechanisms for stimulating energy efficiency in the housing sector (energy audit, financial instruments, etc.);

– support for initiatives to improve the energy efficiency of buildings; implementation of demonstration and pilot projects [10].

The strategy envisages making investments in infrastructure development mainly at the expense of attracted investments – the share of investments from the state budget should not exceed 5-10%. The key body in the implementation of the strategy should be the Ministry of Energy and Coal, while the Ministry of Regions is primarily responsible for the field of heat energy and improving the energy efficiency of buildings [11].

Returning to the events after the start of the full-scale invasion, it is worth noting that all the statistics presented in the article illustrate the state of energy efficiency management until September 24, 2022. Speaking about today's realities, enterprises demonstrate the ability to adapt to new conditions by maintaining the country's course in the field of balanced environmental management. According to Viktor Bilko, Deputy Head of the State Energy Efficiency Agency, in difficult times of war and energy challenges, energy-efficient projects enable businesses to function stably, reduce energy costs, and remain competitive.

The agricultural enterprise visited by the civil servant, which focuses its activities on growing vegetables

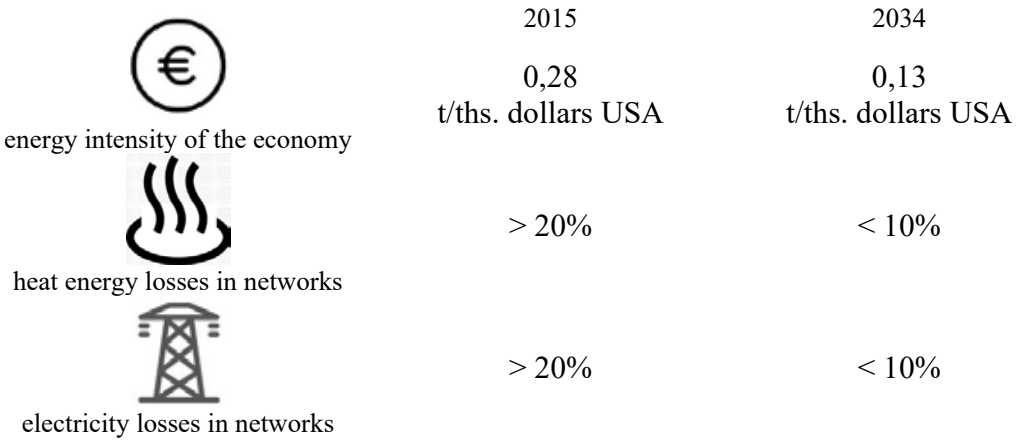

Figure 5 – Key planned indicators of the energy efficiency strategy [11]

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in greenhouses, is one of the examples of those who in the past implemented an energy-efficient energy complex, which is currently saving them in a crisis period for the state. The company implemented the innovative technology of trigeneration, i.e. production of thermal and electrical energy according to the principle of cogeneration and rational use of natural gas combustion by-products for plant nutrition.

Measures that increased the level of economic efficiency:

– generation of electricity for lighting greenhouses, thermal energy for their heating and carbon dioxide for feeding plants using a 6 MW cogeneration plant based on gas piston engines;

– replacement of thermal energy from natural gas thanks to an electrode boiler, a wood chip and straw boiler with automated bale feeding;

– reduction of the company's costs for logistics, using equipment for the production of biomass;

– reduction of the specific consumption of electricity for the cultivation of products and increase of the volume of light by 2 times thanks to LED lighting systems and as a result – a significant increase in productivity.

Companies that believe that such modernization of the production process is expensive should remember that the profitability of each of these measures was from 2 to 5 years, which is a rather small period of time in the scale of the company's existence [12].

Conclusions

Efficient use of energy helps to prevent abuse of resources and protect the environment. Energy efficiency management is impossible without the development of innovative approaches and the introduction of innovative technologies. In order to build an energy-independent and sustainable economy, it is absolutely necessary to develop energy-saving technologies, create and implement in enterprises and organizations systems for the accumulation and further use of energy from alternative sources, form and improve energy management both at the level of business entities and at the level of the state. In order to assess energy efficiency and the degree of achievement of the established goals of the enterprise, it is necessary to determine energy efficiency indicators. The method of targeted energy monitoring (TEM) can be used as the basis of the energy management system, which will help create an individual approach to each enterprise. Ukraine is one of the most energy-intensive economies in the world and has a huge potential for energy saving and energy efficiency. In addition to technology, the country needs an energy efficiency development plan. Such a plan is the Energy Strategy of Ukraine for the period until 2035 "Security, energy efficiency, competitiveness". Turning to current events, we see that business is accepting the challenges of war regardless of economic concerns. This becomes possible thanks to the reduction of energy dependence.

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