Chapter 5
Modern Approaches to Energy Efficiency Management

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5.1 Introduction

Considering the insufficient pace of modernization of the energy infrastructure of metallurgical enterprises and the acute shortage of their own investment funds, the search for sources of financing for projects outside the organization becomes an urgent issue (Kafka et al., 2022; Martínez et al., 2022; Mukhtarov et al., 2022; Sun et al., 2022). The procedure for such relations between an investor and an enterprise is regulated by the Federal Law on Energy Saving since its entry into force in 2009. Considering the existing demand for borrowed capital for the modernization of the energy sector, a large number of energy service companies, as well as energy management companies, have appeared in the markets of developed and developing countries. The role of these companies is not limited only to investing in energy efficiency projects, but also includes a comprehensive approach to their implementation—from preparing a justification for the need for improvements to implementing the measures and solutions themselves (Dinçer, Aksoy, et al., 2022; Dinçer, Yüksel, & Martínez, 2022; Dinçer, Yüksel, Mikhaylov, Barykin, et al., 2022; Dinçer, Yüksel, Mikhaylov, Pinter, et al., 2022; Dong et al., 2022).

As a result, enterprises can use their own capital in the areas of core production development, development of new products and development of new markets. In

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this regard, both enterprises and investors seek to reduce the amount of funds required for their implementation when developing projects (Carayannis et al., 2022; Li, Yüksel and Dinçer, 2022; Yüksel & Dinçer, 2022; Zhang et al., 2022).

Our macroeconomic analysis emphasized the relevance of the research topic, showing that energy resources are of strategic importance not only at the level of national economies, but also in the management system of an industrial enterprise. The total energy saving potential that can be achieved in the next few years in the world is approaching 40 %. Significant progress can be achieved by attracting private investment, and the State only needs to provide appropriate organizational support and infrastructure construction.

5.2 Literature Review

The development of technologies for the use of alternative energy sources is now becoming one of the most studied topics in the economy of energy consumption due to the aggravation of global environmental problems. Studies show that alternative energy should become an important object of macroeconomic regulation (Eti et al., 2023; Li, Yüksel and Dinçer, 2022; Mikhaylov, Bhatti, et al., 2022; Yüksel et al., 2022): a one-percent increase in consumption of alternative energy sources leads to an overall GDP growth of 0.105 %, and GDP per capita by 0.1% (Alwaelya et al., 2021; An & Mikhaylov, 2020, 2021; Mikhaylov, 2021a; Mikhaylov et al., 2023; Mutalimov et al., 2021; Nie et al., 2020; Varyash et al., 2020; Yumashev et al., 2020; Yumashev & Mikhaylov, 2020; Zhao et al., 2021).

Developing countries that are dominated by industrialization processes are adapting their legislation to introduce alternative sources of energy into the production and infrastructure of urbanized areas. Even in countries that cultivate energy-intensive industrial technologies of a medium level of development, such as metallurgy and the production of petroleum products, solar, wind, water and biomass energy occupy a prominent place in the overall structure of consumption (Badr et al., 2022; Barykin, Kapustina, et al., 2022; Dinçer, Aksoy, et al., 2022; Dinçer, Yüksel, & Martínez, 2022; Dinçer, Yüksel, Mikhaylov, Barykin, et al., 2022; Dinçer, Yüksel, Mikhaylov, Pinter, et al., 2022; Kalinina et al., 2022; Khan et al., 2022; Mehta et al., 2022; Mikhaylov, Bhatti, et al., 2022; Mikhaylov, Yumashev, et al., 2022; Nyangarika et al., 2022; Shaikh et al., 2022).

A necessary step in implementing alternative sources is to adapt technologies to local conditions, as well as train and motivate employees at enterprises that are the main consumers of energy resources. A number of projects in developing countries are sometimes carried out in the form of pilot production, which aims to demonstrate the advantages and disadvantages of alternative sources. The main goal of developing such projects is to achieve supply sustainability and commercial efficiency, along with increasing the specific productivity of each new unit of production capacity introduced. Cooperation and organization of technological transfers between developed and developing countries is a promising direction in the use of

alternative resources (Barykin, Mikheev, et al., 2022; Bhuiyan et al., 2021; Bhuiyan, Zhang, et al., 2022; Candila et al., 2021; Danish et al., 2022a, 2022b; Dong et al., 2021; Li, Yüksel and Dinçer, 2022; Liu et al., 2022a, 2022b; Mikhaylov, 2021b; Mikhaylov & Grilli, 2022; Mukhametov et al., 2021; Saqib et al., 2021).

The next area of research is the interdisciplinary nature of energy saving projects and the continuous improvement of technologies. Modern energy saving projects are always interdisciplinary in nature, that is, they consider technological, environmental, social and financial aspects (Fang et al., 2021; Haiyun et al., 2021; Kayacık et al., 2022; Yuan et al., 2021). A significant part of the innovative solutions implemented in industry around the world involve optimizing energy costs (Bhuiyan, Dinçer, et al., 2022; Conteh et al., 2021; Daniali et al., 2021; Denisova et al., 2019; Huang, Masrur, et al., 2021; Huang, Yona, et al., 2021; Khan et al., 2021; Liu, Kato, Mandal, Mikhaylov, Hemeida, & Senjyu, 2021; Liu, Kato, Mandal, Mikhaylov, Hemeida, Takahashi, et al., 2021; Mikhaylov, 2018, 2022; Mikhaylov et al., 2019; Moiseev et al., 2023; Nyangarika et al., 2019a, 2019b; Sediqi et al., 2022).

The technological component, as a rule, provides a reduction in energy consumption by reducing the irretrievable loss of resources or a fundamentally different solution to any production task. For example, low-carbon production technologies are widely promoted and adapted in industry in developing countries (An et al., 2022; An, Mikhaylov, & Jung, 2020; An, Mikhaylov, & Kim, 2020; An, Mikhaylov, & Moiseev, 2019; An, Mikhaylov, & Richter, 2020; An, Mikhaylov, & Sokolinskaya, 2019; Dooyum et al., 2020; Gura et al., 2022; Mikhaylov, 2020a, 2020b, 2020c; Mikhaylov et al., 2020; Mikhaylov & Tarakanov, 2020; Moiseev et al., 2020, 2021).

Of course, these technologies are linked to the environmental indicators of industrial modernization projects and the level of social responsibility of enterprises, and they also focus on innovative financing methods. Some works on management are related to the parallel study of organizational aspects and the principal structure of the main technological solutions that have a great prospect of implementation. Thus, a modern manager should also have the basics of engineering education to understand the principles of energy-saving technologies (An et al., 2021; Danish et al., 2020, 2021; Dayong et al., 2020; Mikhaylov et al., 2018; Nyangarika et al., 2018; Shaikh et al., 2021; Tamashiro et al., 2021, 2023; Uyeh et al., 2021).

5.3 Results

The interdisciplinary nature of projects gives technological solutions a qualitatively new level of economic efficiency, allowing us to consider the long-term impact of technologies on sustainable development and the dynamics of implementing internal improvements. The principle of continuous improvement (continuous improvement) is laid down in the international management standard, it is aimed at adjusting the energy policy of enterprises after analyzing the internal and external environment of energy consumption and checking the results of energy saving programs (Bhuiyan,

Dinçer et al.. 2022; Dinçer et al., 2023; Eti et al., 2022; Kou et al., 2022; Xu et al., 2022). A change in the price of one ton of carbon dioxide emissions (for example, an increase in the emission tax), along with the expected increase in energy prices, has a significant impact on the diffusion of energy-efficient low-carbon technologies in industrial enterprises.

Another direction is the development of financial instruments. Globally, there is a tendency to increase the efficiency of investments in energy conservation in industry, which is also due to the aggravation of environmental problems and the increased dependence of industry on fossil fuels. In the last decade, new instruments for financing energy efficiency projects have been developed. Of particular interest is the experience of large developing countries that are significant players in the markets, such as India and China, since the internal environment is characterized by complex institutional conditions, lack of methodological tools and imperfect infrastructure. It shows that stakeholders providing funding need to use a number of tools. First, these are tools for collecting information about the current level of energy efficiency, the specifics of the functioning of energy markets, institutions for the development of energy technologies, and key development barriers. Transaction costs for finding information about sources of funding and organizing projects remain a serious limiting factor. Many banks, for example, overestimate the amount of risks due to ignorance of the specifics of energy saving projects. In this regard, the government organizes targeted bank financing for energy efficiency projects, in which a number of specialized banks participate, including providing consulting services. Secondly, these are methods for assessing the compliance of the investment climate with the nature and objectives of the project, the impact of socio-economic and political factors on the investment attractiveness of energy-saving technologies. Third, these are practical approaches to clearly defining responsibility centers that would monitor and adjust each stage of the investment project implementation.

Over the past 20 years, the practice of concluding energy efficiency contracts, which is a mechanism for distributing responsibility for energy conservation between an enterprise and an investor, has become widely used. Due to the implementation of such a financing scheme, the enterprise receives from the company not only a ready-made project aimed at improving energy efficiency, but also personnel training services. At the same time, the responsibility of the enterprise will be to pay the difference between the initial costs of providing energy resources and the costs of operating energy-efficient equipment at the expense of the capital costs of the service company. The company's responsibilities include installation and adjustment of energy-efficient equipment, monitoring resource consumption and calculating savings. The spread of such mechanisms is noted in European countries,

In the United States and developed Asian countries, and this is largely due to support at the level of government organizations. The concept of a contract is also reflected in Russian legislation within the framework of the federal law on Energy Saving. However, due to the fact that the company is obliged to ensure the operation of power equipment throughout the entire term of the contract, there is a risk of non-return of investment funds.

And the last direction of improving energy efficiency in the studies considered is the updating of intellectual resources. The need to improve the competitiveness of energy systems encourages companies to use the full range of resources available to them, the key among which is the intellectual potential of personnel. A number of innovative solutions in the intellectualization of technical systems are proposed by domestic authors. Modern approaches to energy resource management are also widely covered by the authors, including through planning methods using digital tools, investment project portfolio management methods, and the formation of information systems for analyzing energy systems at the regional and federal levels.

The most important source of knowledge and experience needed to implement energy saving programs at all levels of government is higher education institutions, which are the mainstay of engineering and research competencies. This is due to the fact that in developed countries, when developing training programs for engineering specialties, the principles of energy efficiency management are included in the scope of training. Russia is also updating its internal educational technologies for developing competencies in the field of energy conservation. The main direction of improving approaches to the educational process is considered to be the implementation of the principle of lifelong learning, which involves the involvement of employees of enterprises in the learning process in parallel with the work process. Also, the participation of higher education institutions in the ongoing programs on energy efficiency research has a huge impact on the formation of advanced competence bases based on theoretical research and industrial experience. Russian universities, along with international ones, are the drivers of promoting innovative developments related to energy saving technologies in the real industrial sector and the ordinary life of mankind. In the future research, we will focus in more detail on the problems of managing intellectual resources in energy management, trace their role at each stage of planning, organizing and controlling energy saving projects at industrial enterprises.

In comparison with external educational institutions, the participation of internal managers in this process is also important in terms of activating creative potential. Moreover, a well-chosen and formulated long-term strategy for staff training and incentives for energy conservation is the key to successful implementation of energy efficiency management approaches. The manager should be involved in the process of creating an energy-efficient production, starting from the development of policies and ending with the implementation of energy-saving measures in the structural division of the enterprise. The list of competencies of managers implementing strategic energy efficiency management should primarily include the ability to carry out long-term planning in the field of energy consumption, knowledge in the field of personnel management and a high level of technical training necessary for the development of technical measures.

Considering the specifics, functional features and high energy intensity of metallurgical production processes, the impact of energy efficiency indicators on the competitiveness of the enterprise as a whole is significantly noticeable. That is why there is a huge potential for improving the efficiency of energy farms in all areas of

the enterprise's activity, without exception, and its successful implementation depends on a clearly formulated management strategy.

According to Russian studies, the promotion of the management strategy is limited by the presence of unfavorable environmental factors, which in turn are caused by problems in the national energy sector. The list of main shortcomings in the operation of power systems includes a low degree of information support, morally and physically outdated technical means, inefficient methods, lack of the necessary level of professional training of personnel, etc. Due to the lag in the efficiency of the existing infrastructure from current trends, there is a slowdown in the implementation of monitoring systems and digitalization of energy processes.

Nevertheless, despite the presence of negative factors, we can note positive trends in improving energy efficiency, namely: increasing requirements for the reliability of energy systems, developing healthy competition in energy markets and dialogue between energy producers, which ultimately leads to the formation of information flows. There is also a trend towards universal integration of international standards into existing management systems at enterprises. Based on the available data and the desire of business owners to improve the efficiency of production processes, it can be assumed that in the long term, a clear trend will be established aimed at developing energy efficiency management mechanisms.

Based on the results of the study of foreign and domestic literature, we were able to focus on the main directions of development of the energy saving sector, so that in subsequent chapters it will be possible to identify promising areas for improving organizational and technical mechanisms for managing energy efficiency. The key drivers of the development of management systems at the present time include the need for continuous improvement of the result, which is caused by the desire of enterprise owners to satisfy their own interests and not lose out in the face of tougher competition. In addition, significant potential lies in improving the efficiency of using human resources and directing the intellectual capabilities of personnel to solve energy saving problems.

Summing up the theoretical research, it is possible to identify the following recommendations for improving management at a metallurgical enterprise:

When developing the energy policy of a metallurgical enterprise, it should be formed as a balanced strategy based on technocratic, innovative and systematic approaches. Determining the share values of a particular approach depends on the current financial performance of the company and the business processes that require attracting investment, whether it is technical solutions or investments in employee development. The list of priority goals of the management policy may include reducing the absolute values of fuel and energy consumption or achieving energy efficiency indicators.

5.4 Conclusion

The key to successful implementation of the energy efficiency management mechanism is primarily the quality of managers' work. That is why one of the factors of management efficiency is considered to be the presence of fundamental knowledge of technological and organizational and economic features of the energy saving process among managers. Managers should also have the ability to create teams that can effectively implement policy principles.

The key direction in forming an energy saving strategy at a metallurgical enterprise is to work with personnel, as it allows increasing the loyalty of employees at all levels to energy policy and maximally involving their innovative potential in solving energy saving problems. The main tasks of managers in realizing the potential of employees include increasing knowledge in the field of energy efficiency, informing about the commitment of management to the principles of economy and improving the energy consumption culture.

The formation and implementation of an energy efficiency management strategy is one of the most important factors for improving the competitiveness of a metallurgical enterprise, ensuring savings in fuel and energy resources, improving environmental performance of production, systematic planning of the enterprise's production systems, and creating a positive image of the company as a leader in energy conservation.

A large potential for energy saving at a metallurgical enterprise lies in the field of personnel management: the effectiveness of its disclosure directly depends on the quality of the techniques and practices used to train and motivate personnel using industry benchmarking. Therefore, along with attracting investments for the modernization of fixed assets, it is worth paying attention to financing personnel development issues.

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