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SURVEY OF THE WORLD PRACTICE OF IMPLEMENTING ENERGY-EFFICIENT TECHNOLOGIES IN TERMS OF MINING ENTERPRISES

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ABSTRACT

Purpose is the analysis of world practice of applying the best available techniques to increase energy saving and energy efficiency of mining enterprises being the important factor of the economic development.

Methods. The research methodology is based on the scientific approaches: historical-evolutionary, interdisciplinary, integration, process, and situational. Methods of retrospective, categorical, and system analysis as well as modeling have been applied. The analysis was performed on the basis of both initial information sources (original texts of legislative documents, strategies) and material of the international analytical organizations (International Energy Agency, World Bank) as well as the data of official statistical records.

Findings. For the first time, different variants of the best available techniques in Japan, the USA, and the EU have been analyzed as well as the role of a state in applying institutional measures of energy efficiency support, including mining complex, and prospects of its use in the Russian Federation. It has been determined that energy efficiency is the effective and economically feasible tool in reaching sustainable development of the national economy. It has been demonstrated that energy saving and increased energy efficiency may reduce the needs in investment, raise industrial competitiveness and consumer welfare as well as improve environmental protection owing to the reduced greenhouse gas emissions and decreased air pollution. Energy efficiency growth has direct effect upon the industrial competitiveness; it can be achieved by means of innovations.

Originality. Emphasis has been put on the key scientific and technical aspects and approaches stimulating increased energy efficiency in the developed countries under the effect of strong, coordinated, and consistent national policy in different sectors of economy.

Practical implications. The carried-out analysis is useful in terms of the innovative and technological development of different industries of the Russian Federation in the context of its complicated cooperation with European countries and the USA, dependence on foreign technologies, and limited access to them.

Keywords: *energy efficiency, best available techniques, energy security, strategy, innovations, mining enterprises*

1. INTRODUCTION

Environmental compatibility and energy efficiency define the development of the growing number of economic sectors including mining industries. Increasing energy efficiency provides considerable energy saving in many countries worldwide (Bridge, 2004; Vagonova & Volosheniuk, 2012).

International Energy Agency (IEA), autonomous international body in the frameworks of the Organization for Economic Co-operation and Development (OECD) is in close operation with different international organizations and governments of many countries (Elam, Padró, Sandrock, Lindblad, & Hagen, 2003; International Energy Agency, 2019). In 2010, in the frameworks of cooperation with the big Eight countries, a program was developed covering 25 measures in the sphere of energy supply and increase in energy efficiency parameters as well as strategies and action plans, appropriate regulation, attraction of private investments to increase energy efficiency, monitoring, implementation of the measures, energy efficiency classes for buildings and minimum requirements for them, striving for zero energy consumption in the buildings, energy labeling and certification, stage-by-stage refusal from the inefficient lighting devices and systems, compulsory standards for the motor fuel efficiency, fuel-saving components for cars, increase in fuel efficiency at the expense of eco-driving, energy management in the production, energy-saving services, and other measures; it is of special importance for mining regions (Khod vypolneniya politiki…, 2010).

In 2016, problems concerning energy efficiency and energy saving, were discussed within the frameworks of the G20. It was stated (Kommyunike liderov…, 2016), that those problems are the long-term priority of the organization. Countries-members of G20 agreed on the fact that cooperation in the field of energy efficiency may stimulate economic activity and effectiveness, strengthen energy safety, and improve environmental conditions. Being consumers of more than 80% of the global energy, those countries may play an important part in the improvement of energy efficiency situation.

Earlier in 2014, within the frameworks of that organization, the Energy Efficiency Leading Programme of the G20 (EELP) was adopted to provide the basis for comprehensive, flexible, and voluntary cooperation in the sphere of energy efficiency (Plan deystviy…, 2014). Members of the G20 assumed obligations to improve considerably energy efficiency of the energy utilization by activating cooperation in the sphere of energy efficiency and encouraging the development and implementation of various national programmes, policies, and measures reflecting social and economic diversity of the G20 countries. The EELP plan covers transportation vehicles (especially, heavy-duty trucks), household appliances and equipment, financing, buildings, industrial processes (energy management in the production), and electric power industry. The EELP also includes five new key areas of cooperation: Super-Efficient Equipment and Appliances Deployment initiative (SEAD), best available techniques (BAT), district energy systems (DES), and exchange with information, data, and indices (Ob okhrane okruzhayushchey sredy, 2017).

Currently, the Russian Federation is facing the problem of providing integrated approach to the BAT implementation in different spheres and improvement of the state regulation system in the particular selected sphere. Transition to the principles of the best available techniques has made it possible to reduce the level of anthropogenic effect upon the environment, to improve energy efficiency and resource saving for the production of various industries.

Main objective of the paper is to analyze the best available techniques in the sphere of energy efficiency in terms of the countries, being the international leaders in energy saving, and consider possibilities of applying foreign practices in the RF.

Best Available Technique (BAT) is the technology to manufacture products (goods), to perform operations, to provide services determined on the basis of current achievements of science and technology and the best combination of the criteria of achieving the environmental protection goals in terms of the available technical possibility of its application (O poryadke opredeleniya…, 2014).

According to the Resolution of the Government of the Russian Federation of 23.12.2015 #1458 "On the method to determine a technology as the best available one as well as the development, actualization, publication of engineering information reference books concerning the best available techniques", "while defining technological processes, equipment, technical means, methods as the best available techniques, they should be considered in terms of their meeting the following criteria:

a) the lowest level of negative impact on the environment per unit of time or volume of produced products (goods), completed work, provided services or compliance with other indices of environmental impact envisaged by the international agreement of the Russian Federation;

b) economic efficiency of the implementation and operation;

c) application of resource- and energy-saving methods;

d) period of implementation;

e) industrial implementation of technological processes, equipment, technical means, methods in terms of two or more objects of the Russian Federation having negative environmental impact (O poryadke opredeleniya…, 2014).

Currently, in terms of a complicated interaction of the Russian Federation with foreign countries, dependences on technologies, and possible limited access to the most important foreign technologies, problem of innovative and technological development of different industries is of special importance.

Efficient energy use should combine solutions of different problems such as problems of energy safety, limitation of greenhouse gas emission, and solution of environmental problems (e.g. air pollution).

In support of the aforementioned, Order of the Government of the Russian Federation of 19.03.2014 #398-p has approved the Complex of Measures aimed at refusal from the use of outdated and inefficient technologies, transition to the BAT principles, and implementation of the up-to-date technologies. Russia is only at the beginning of its way of using and implementing the best technologies; that is why, while being at that stage, it is rather important to study the available practices of other countries to select the most efficient and appropriate solutions.

Mining industry is one of the largest energy consumers (Mikaeil, Sohrabian, & Ataei, 2018; Antoljak, Kuhinek, Korman, & Kujundžić, 2018); its share of greenhouse gas emission is rather significant (Kovalenko, 2019). In its turn, processes of concentration at mining enterprises require considerable energy consumption; the energy may be either generated on site or supplied from the power networks (Beshta, 2012; Jain, Cui, & Domen, 2016). Mining enterprises are the largest consumers of fuel for motor vehicles and mechanisms used for ore crushing and concentrate production. Moreover, according to the International Council on Mining and Metals, about 7 – 8% emissions of greenhouse gases are accounted for the mining industry (Bondarenko, Kovalevs'ka, & Ganushevych, 2014; Cherniaiev, 2017; Dryzhenko, Moldabayev, Shustov, Adamchuk, & Sarybayev, 2017; Menshov & Sukhorada, 2017).

Due to that fact, correct statement of scientific-research and experimental-development activities is rather important to develop new and improve the available technologies of low-carbon energetics, which helps achieve the required level of mining production emissions within the required period of time (Kalybekov, Sandibekov, Rysbekov, & Zhakypbek, 2019).

To analyze the application prospects and possibilities of BAT implementation in Russia, we will study the international experience in terms of the best available techniques in the sphere of energy saving and energy efficiency in mining regions.

2. METHODS

Methodology of the research is based on the scientific approaches: historical-evolutionary, inter-disciplinary, integration, process, and situational. Methodologies of retrospective, categorical, system analysis, and modeling have been applied. Analysis was performed on the basis of both primary information sources (original texts of legislation documents and strategies) and the materials of international analytic organizations (the International Energy Agency, the World Bank). The paper involves data of the official statistic accounting, analytic and other information in the sphere of energy saving and improvement of energy efficiency of the Ministry of Energy of the Russian Federation as well as other federal bodies of executive power, bodies of executive power of the Russian Federation subjects, bodies of local government, organizations dealing with the regulating types of activities, and organizations working in the sphere of energy saving and improvement of energy efficiency.

3. BEST AVAILABLE TECHNIQUES OF THE DEVELOPED COUNTRIES

Japan is one of the world leaders in the sphere of innovations development in terms of such factors as scientific-research and experimental-development activities (SREDA), number of the granted patents, and share of high-technology exported products. The country has one of the world highest indices of that share to the GDP of the investment share into high technology and scientific-research activity. In this context, Japan understands innovations as "a wide range of technological, social, and institutional changes which helps organize the country's activity in different spheres in a completely new way" (Bancheva, 2013). Japan pays great attention to innovations in the development and implementation of cutting-edge environmental and energy-saving technologies; that has resulted in the fact that nowadays the country is the "incubator" of the newest developments in the sphere of energy-efficient and low-carbon technologies. In particular, Japan is active in dealing with the modernization of transport sector and transition to new fuel types, such as bioethanol, dimethyl ether, and gas-to-liquid (GTL) (Japan's public broadcaster…, 2017).

Moreover, Japan is developing actively the "new energetics" which includes renewable energy sources (RES), high-efficiency gas- and coal-burning thermal power stations, cogeneration, heat pumps, fuel elements etc. Particularly, more than 10 mln of heat pumps were installed by 2014 all over Japan (Kaneko, Uchida, Shrestha, Ishihara, & Yoshioka, 2018; Shrestha, Uchida, Ishihara, Kaneko, & Kuronuma, 2018; Farabi-Asl, Chapman, Itaoka, & Noorollahi, 2019).

Besides, since recently, problems connected with the development of technologies in the field of rational energy consumption in buildings have being assuming their importance. As for the specific actions in the sphere of BAT, the Top Runner Programme may be emphasized; the Programme has a special place in the Japanese energy-saving policy. The Programme started in 1998. It is aimed at specific categories of products (used in Japan in large quantities and assuming considerable amount of energy) where energy intensity is possible to be reduced.

Essence of the Program is to introduce compulsory target normative indicators (standards) in terms of energy efficiency. The standards are based on the best available techniques in the market, i.e. on the basis of the most energy efficient products available within that very product category. In this context, the initially specified standard may become the minimal target indicator in several years. Thus, within the Top Runner frameworks, level of the required energy efficiency in terms of specific product categories may experience constant increase (Yoshikawa & Watanabe; 2008; New Growth Strategy, 2013; Ranga, Mroczkowski, & Araiso, 2017).

Energy efficiency performance of the product is indicated in the periodically updated catalogues, with the help of labeling on the proper devices etc. Companies producing or importing such products have the average weighted indicator – Runner Standard – for each category of machines and equipment; that indicator should reach the standard value by the target financial year. That average weighted value is calculated according to the following formula: {(number of units shipped inside the country for each product name) × (energy efficiency of consumption per unit)} ÷ total amount of the units shipped inside the country.

Soon after the end of target financial year, manufacturers fill up the questionnaires indicating the data on the number of the shipped units, energy consumption efficiency etc. to prove that they meet the specified standards. The survey is conducted by the Agency for Natural Resources and Energy. If energy efficiency indicators do not have high values, the controllers may consult the manufacturers to provide them with the necessary recommendations (Zindler & Locklin, 2016).

Emphasis should be laid on the distinct difference between Japan and Russia in the policy of BAT support. In terms of Japan, advanced technologies and innovations represent one of the elements in the interrelated, balanced, and long-term action strategy. The situation in Russia is somehow different, if we take, for instance, the practice of adoption of the Law on BAT (FL of 21.07.2014 #219-F3 "On introducing changes into the Federal Law "On environmental protection" and certain legislative acts of the Russian Federation). In fact, (Zindler & Locklin, 2016) Russian legislation set the transition to BAT as a key goal of the national ecological reform, reducing to it the problems of waste standardization and harmful substances disposal. In this context, BAT is considered to be a kind of overall panacea to solve the problems concerning environmental control; moreover, in this term, BAT is believed to start the processes of innovative and modernization development. As a result, we can observe certain imbalance in the goal setting – transition to BAT has become a goal in itself.

On the contrary, Japan can be an example of the approach in terms of which the problems, related to the spheres of energy efficiency or stimulation for the transition to cutting-edge technologies, are not represented separately but considered and solved along with other issues within the frameworks of the concerted strategic policy (Pasculescu, Vlasin, Suvar, & Lupu, 2017). Japan Revitalization Strategy may be the example here; Japanese government announced the development of that strategy in June 2013 (Moran, Lodhia, Kunz, & Huisingh, 2014).

The Strategy concept supposed combination of three fundamental approaches:

– aggressive monetary and credit policy;

– flexible taxation policy;

– growth strategy aimed at stimulation of personal sector investment.

Specific implementation of the Revitalization Strategy should cover three action plans:

– Strategy of Global Public Awareness Activity;

– Plan of Japanese Manufacturing Revival;

– Plan of Strategic Market Development.

One of the points of the Plan of Japanese Manufacturing Revival was to facilitate scientific and technological innovations. In its turn, the Plan of Strategic Market Development had to stimulate new "growth points" in terms of four global segments having considerable growth potential where Japan was admitted to be the one with the competitive advantages in terms of other countries. Development of demand and supply for clean and economically efficient energy was highlighted as one of such strategic segments for future growth.

Owing to the improvement and large-scale implementation of heat pumps (HP) in Australia, attention is being increasingly focused on the use of low-potential solar heat accumulated in rocks and near-surface soil the whole year round. Temperature potential of the soil near the surface is not high being about 10 – 20°C. Energy with such a potential is rational to be used through the heat-transfer loop of a heat-pump plant (HPP) for industrial and communal heat energy supply (Joseph, Airah, & Ashrae, 1985; Goldstein, Hill, Budd, & Malavazos, 2007; Obaid, Cipcigan, Muhssin, & Sami, 2017).

Use of low-potential rock heat in coal mines in heat pump geosystems providing co-generative production of electric, heat, and mechanical energy has resulted in considerable saving of organic fuel and energy as well. In terms of energy-saving technologies, natural geosystem along with HPP and combustible artificial gases of well underground coal gasification (WUCG), basing upon the utilization of heat energy of gasification products (temperature of the well discharge gas is 600 – 800°C) and heat storage tank, are of great interest. That helps use efficiently two energy sources simultaneously to provide an energy consumer with the required heat (Bondarenko, Tabachenko, & Wachowicz, 2010; Lozynskyi et al., 2018; Suyarko, Ishchenko, & Gavrilyuk, 2018; Bomba et al., 2018).

WUCG gas is generated underground by burning (gasification) of coal seams by means of underground gasification. WUCG essence is in the drilling wells from the surface, firing the coal seam, injecting oxidizer (e.g. air) for coal burning, and getting artificial generator gas which is supplied to the surface through wells. Further, the gas is sent to the heat exchanger to utilize the gas heat and get hot water supplied into the heat storage tank. Hot heat carrier is supplied to the communal heat supply system through the heat pump plants (Lozynskyi, Dychkovskyi, Saik, & Falshtynskyi, 2018).

Australia considers application of HPP to be rather prospective while using waste water heat and ventilation emissions of mines. Heat pumps are also possible to be used while heating the air coming into the mines; in winter, one can implement the project on using low-potential heat of the drop inlet intake (i.e. from the artesian well) or while water pumping from the main shaft sump. Thus, application of HPP using low-potential energy of urban waste water for heat supply is the progressive energy-efficient and environmentally safe technology to generate heat at mining enterprises. Implementation of such a technology helps save organic fuel (coal, natural gas, fuel oil) in boiler houses resulting in zero emissions of harmful greenhouse gases into the environment. Consequently, new tendencies in developing technological schemes of complex use of geosystem (Earth's interior) to generate electric energy and heat have made it possible for Australia to increase efficiency of mining enterprises and their economic indicators (Falshtynskyi, Lozynskyi, Saik, Dychkovskyi, & Tabachenko, 2016).

The USA is one of the world leaders in the implementation of measures to improve and finance energy efficiency. According to forecasts, by 2020, the USA will have become one of the most energy-efficient countries-members of the International Energy Agency. Energy efficiency in the USA may be analyzed in terms of two aspects. On the one hand, energy efficiency and use of the best available techniques mean the implementation of the advanced developments in the manufacturing industry making it possible to reduce the production impact upon the environment and use the available resources in a more efficient way. On the other hand, it is joining the interests of electric energy producers and consumers so that the consumers will use the most efficient technologies. In this case, the task is much more complex than in the first case (Smith, Capehart, & Rohrer, 2015; Worley, & Solanki, 2016; Middleton, Gupta, Hyman, & Viswanathan, 2017; Jirušek & Vlček, 2017).

The USA approach to stimulation of BAT implementation into the production is in the changes of requirements for the enterprise activities to be compatible in terms of the application of the technology admitted as the best one or alternative to it. General principle of stimulation of BAT implementation in the USA includes four stages. Stage one is the analysis of the techniques available in the production and their parameters and prospects of implementation. Then the indicators, achieved in terms of the use of optimal technology, become the requirements applied in the context of certain industry enterprises. Third element represents the federal system of licensing the activities of an enterprise controlling the standards compliance. Fourth element is in the possibility for the USA states and territories to develop their own programmes and adopt the licensing authority of the federal center.

The state authorities and local governments adopt Civil Engineering Standards, while fiscal incentives are given at both federal and state levels. Over the last decade, energy efficiency in civil engineering has been improved considerably owing to investment and voluntary building labeling. Industrial sector also applies standards for equipment and tax incentives. In 2012, the Order by the President "On stimulating investment into industrial energy efficiency" highlighted following measures to increase energy efficiency: stimulation of capital investment in production to increase competitiveness of the industrial sector as well as the investment in production of combined heat-power engineering, reducing costs of energy, release of the future capital for its investment into business, reducing air pollution, and job creation.

In terms of chemical and petrochemical sectors, use of cutting-edge technologies (such as modern equipment, best catalyzers, separation) at both current and new plants may result in considerable energy saving. However, construction of new plants is the most efficient way to implement advanced technologies. Within the period of 1994 – 2007, energy intensity of the chemical sector reduced by 39% as a result of implementing advanced technologies. Energy consumption by petroleum processing plants, using up-to-date technologies, is by 20 – 30% less than the average values in terms of the whole field.

Energy efficiency resource standards (EERS) propose the companies under regulation the specific target indicators for reduction of energy consumption per certain period (the indicators increase annually); if the companies do not observe those standards, certain penal sanctions are imposed on them (Brennan & Palmer, 2013).

The most advanced energy-saving technological scheme has been developed in the USA taking into account the possibilities of several alternative environmentally safe energy sources; following sources are the most potentially productive ones: energy of WUCG gas and rock heat in the alternative co-generative geosystem of energy supply being implemented on the basis of a heat pump cycle. To do that, a technology of well underground coal seam gasification and heat pump geosystem of energy supply with well rock heat exchangers located in the underground mine workings has been applied (Nguyen & Pham, 2019).

Alternative co-generative geosystem of energy supply operates as follows. Hot generator gas (600 – 800°C) of underground gasification goes up to the surface through the producing well and is supplied to the WUCG gas heat recovery unit. The heat recovery unit heats the reused flowing water, which is circulating within the heat network loop of the heating system. In terms of the mentioned scheme of the co-generative process, heat is transferred to the used network water providing its pre-heating only. The required parameters within the heat network loop may be achieved in terms of additional use of rock heat. To do that, clusters of wells, operating as heat exchangers, are constructed in the mine workings; the clusters are of honey-comb (diamond) shape. The circulating water of the heating system is supplied from the consumers to the well rock heat exchangers. Then it is heated and sent to the HPP evaporation tank where heat is transferred to the cold water coming from the water distribution system. Water, heated in the heat pump, increases the flowing water temperature within the heating system loop. On average, total heat from the heat recovery unit and heat pump provides heating of the network water of the heat supply system up to 80°C. The latter is supplied to the heating system through the heat pipelines; the heating systems maintain the temperature in premises at the level of not lower than 18°C. Even in cold winter days, temperature of the rock mass in a mine does not go lower than 20 – 40°C providing more efficient operation of the heat pump plant than during the use of low-potential heat of atmospheric air (Wieber, 1980; Tabachenko, 2001; Stephens, Brandenburg, & Burwell, 2017; Haiko, Saik, & Lozynskyi, 2019).

After heat output in the heat recovery unit, WUCG gas is sent in two flows for its further burning. Major share of the gas is transferred to a free-piston gas engine for electric energy generation. The rest of the gas is used to heat water in a boiler unit as well as to generate steam in the heat recovery unit and evaporator. That pair is used to generate electric energy in a turbine generator and following heating of the flowing water in a water condenser (Tabachenko, 2001).

Researchers recommend one more cutting-edge technology in the development of transformation energy which will provide efficient operation of mine boiler-houses. Current mine boiler-houses may be transformed into mini-electric power plants on the basis of construction of co-generative system of electric, thermal, and mechanical power generation (Pivnyak, Razumny, & Zaika, 2009; Pivnyak, Samusia, Oksen, & Radiuk, 2015).

Analyzing the tools of BAT implementation and advancement of the USA energy efficiency in Russia, conclusion can be made on the "imbalance" in the state policy. In Russia, that "imbalance" is observed towards the state regulation. In the USA, similar "imbalance" is seen where certification and tightening of standards are key tools for energy efficiency advancement. However, in the USA there is the social pressure on the companies in favour of the advancement of environmental groups and up-to-date solutions as well as a set of local initiatives, which are supported actively by federal authorities. Those two factors are not available in Russia.

Over the recent years, Canada has reached considerable progress in terms of energy efficiency. That has become possible owing to the numerous federal and regional programmes providing grants, credits, and financing to stimulate the implementation of energy-saving technologies. However, currently, the priority of Canadian government is shifting from direct financing and crediting to the programmes stimulating dissemination of information concerning the data, tools for their analysis, and demand control programmes being financed by power corporations and supported by regional bodies of state authority (Carlson & Pressnail, 2018; Maiorano, 2018; Maiorano, 2019).

Use of biofuel in different industries is growing. In terms of the transportation sphere, one can note the increase in biofuel use owing to federal Renewable Fuels Regulations stipulating following compulsory condition: fuel mixture will include fuel types obtained from the renewable sources (Alsubaie, Fowler, & Elkamel, 2019). On average, manufacturers and importers of oil fuels should provide 5% of the renewable fuel for petrol (comparing to the situation as on 15 December 2010).

To stimulate capital investment in the energy-efficient technologies, tax incentives are applied. That may be the use of accelerated amortization of capital costs (for different permanent installations generating power involving renewable energy sources (e.g. wind, solar power, geothermal energy) or waste heat as well as the equipment making it possible to save energy by using energy resources in a more efficient way).

Department of Mineral Resources of Canada adopts standards reflecting the development of new technologies, e.g. construction and exploitation of net-zero-energy buildings (Tardifing, Pope, & Lubun, 2011; Syed & Hachem-Vermette, 2019).

Nowadays, the world is paying great attention to the co-generative processes, i.e. combined generation of thermal, mechanical, and electric energy while fuel (coal, fuel oil, natural gas etc.) burning. It is proposed to take synthetic generator gas, produced during underground gasification of bituminous and ligneous coal seams, as the fuel. Canada has developed principally new and economically efficient technological schemes of combined gas-steam-turbine system to generate energy resources on a unified energy carriers – gas, which is obtained on the basis of well underground coal gasification (WUCG), free-piston plants, and heat energy storages (Blickstead, 1990; Gnanapragasam, Reddy, & Rosen, 2010; Richardson & Singh, 2012; Olateju & Kumar, 2013).

Co-generative production has three technological cycles of power generation; they complement each other favouring full employment of energy resources. Cycle four, completing the co-generative production, is energy and biological generation operating on the heat of main-process waste water. In terms of the combined energy system, initial energy carrier (WUCG gas) is obtained by a geotechnological method of the coal deposit development with the use of well underground coal seam gasification.

4. DISCUSSION

Following tendencies may be included into the list of world key tendencies in the sphere of innovative and best available techniques of energy saving which Russia should pay attention to and which are proved to be efficient:

– application of the system of "smart" meters and "smart" networks making it possible to provide overall efficiency of the electric energy market; use of "smart" systems of energy management which helps have constant monitoring and define possibilities for energy efficiency increase;

– renewable energy sources. Wind and solar energy account for the largest investment expenditures in that sector; according to the International Energy Agency, each of them will require USD 11 trn within the period of 2017 – 2060. Moreover, the sector includes common use of biomass with coal during electric energy generation;

– implementation of standards of the fuel efficient use and saving. Currently, only four countries (Japan, Australia, the USA, and Canada) use those standards. In terms of energy-consuming industries, progress in the sphere of energy efficiency is stipulated by the investment in new possibilities and, to a lesser degree, modernization of technologies and closure of old objects rather than by the improvement of the current objects capacity.

Practice of the developed countries demonstrates that energy supply systems with HPP have higher coefficient of use of crude soil or rock energy. Due to the development of privatization and use of the production nature, large energy consumers are increasingly refusing to use centralized energy supply systems; thus, that system is becoming less competitive with the decentralized generation of electric and heat power. In such a situation, large industrial energy consumers as well as owners of large buildings (administrative facilities, hotels, sta-diums etc.) have become interested in alternative and cheap lighting and heating technologies. Owing to the continuous nature of co-generative processes for generation of electric, mechanic, and thermal energy, fuel efficiency will be close to maximum (90 – 93%) within a year and day and improve environmental situation. Implementation of such projects makes it possible to exclude emissions of greenhouse carbon dioxide gas (CO_2) and nitrogen oxides (NO_2 and NO_3) generated while natural gas burning, as well as CO_2, sulphur oxides (SO_2 and SO_3), NO_2 and NO_3 formed during the coal burning; that will help reduce environmental pollution. Consequently, use of alternative energy sources and application of the principles of their maximum preservation are of growing interest in terms of the available patterns of energy consumption, which has resulted in the problem being so acute today.

5. CONCLUSION

Energy efficiency in foreign countries increases owing to:

– implementation of new heat pumps capable of withstanding cold climatic conditions and operating more efficiently with the caloric power output being more than 70% at the temperature of –25°C;

– improved thermal insulation and glazing, energy-efficient conditioners, and solar water heaters;

– optimization of the demand for heating and cooling in buildings in terms of the control improvement: smart thermostats, being programmable and connected (i.e. network) devices, controls and regulates heating and cooling loads. The saving may vary from 15 up to 50% depending on the technologies of construction and control;

– smart solutions for lighting systems: implementation of recent developments in that sphere will make it possible to improve lighting in buildings (i.e. changes in colour temperature to replicate natural lighting).

To provide innovative development in the sphere of energy-efficient technologies, it is required to have strong, well-coordinated, and consistent state policy in different sectors of economy which will take into consideration specific objectives of national energy policy and include different areas such as taxation, international cooperation, investment support, development of municipal facilities and others.

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ОГЛЯД СВІТОВОГО ДОСВІДУ ЗАСТОСУВАННЯ ЕНЕРГОЕФЕКТИВНИХ ТЕХНОЛОГІЙ НА ГІРНИЧОДОБУВНИХ ПІДПРИЄМСТВАХ

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Мета. Аналіз світового досвіду використання найкращих доступних технологій для підвищення енергозбереження та енергетичної ефективності гірничодобувних підприємств, які є важливими факторами інноваційного розвитку і економіки.

Методика. В основі методології дослідження застосовані наукові підходи: історико-еволюційний, міждисциплінарний, інтеграційний, процесний і ситуаційний. Використано методики ретроспективного, категоріального, системного аналізу, моделювання. Аналіз виконувався на основі як первинних інформаційних джерел (оригінальні тексти законодавства, стратегій), так і на основі матеріалів міжнародних аналітичних організацій (Міжнародного енергетичного агентства, Світового банку), а також даних офіційного статистичного обліку.

Результати. Вперше проаналізовані різні варіанти найкращих доступних технологій в Японії, США, ЄС, роль держави у застосуванні інституційних заходів підтримки енергоефективності, в тому числі у гірничодобувному комплексі, а також перспективи їх використання у Російській Федерації. Визначено, що енергоефективність є дієвим і рентабельним інструментом досягнення сталого розвитку економіки країни в цілому. Показано, що енергозбереження та підвищення енергоефективності може знижувати потребу в інвестиціях, збільшити конкурентоспроможність промисловості й добробут споживача, а також покращувати охорону навколишнього середовища, завдяки зниженню викидів парникових газів та зменшенню забруднення повітря. Підвищення енергоефективності безпосередньо впливає на конкурентоспроможність промисловості та може бути досягнуто за рахунок інновацій.

Наукова новизна. Виділено ключові науково-технічні асп екти й підходи, що стимулюють підвищення енергоефективності в розвинених зарубіжних країнах під впливом сильної, скоординованої та послідовної політики держави у різних секторах економіки.

Практична значимість. Проведений аналіз корисний у побудові інноваційного та технологічного розвитку різних галузей Російської Федерації в умовах її непростої взаємодії з країнами Європи і США, залежно від зарубіжних технологій та обмеженого доступу до них.

Ключові слова: *енергоефективність, найкращі доступні технології, енергобезпека, стратегія, інновації, гірничодобувні підприємства*

ОБЗОР МИРОВОГО ОПЫТА ИСПОЛЬЗОВАНИЯ ЭНЕРГОЭФФЕКТИВНЫХ ТЕХНОЛОГИЙ НА ГОРНОДОБЫВАЮЩИХ ПРЕДПРИЯТИЯХ

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Цель. Анализ мирового опыта использования наилучших доступных технологий для повышения энергосбережения и повышение энергетической эффективности горнодобывающих предприятий, которые являются важными факторами развития экономики.

Методика. В основе методологии исследования применены научные подходы: историко-эволюционный, междисциплинарный, интеграционный, процессный и ситуационный. Использованы методики ретроспективного, категориального, системного анализа, моделирования. Анализ выполнялся на основе как первичных информационных источников (оригинальные тексты законодательства, стратегий), так и на основе материалов международных аналитических организаций (Международного энергетического агентства, Всемирного банка), а также данных официального статистического учета.

Результаты. Впервые проанализированы различные варианты наилучших доступных технологий в Японии, США, ЕС, а также роль государства в применении институциональных мер поддержки энергоэффективности, в том числе в горнодобывающем комплексе, перспективы его использования в Российской Федерации. Определено, что энергоэффективность является действенным и рентабельным инструментом достижения устойчивого развития экономики страны в целом. Показано, что энергосбережение и повышение энергоэффективности может снижать потребность в инвестициях, увеличить конкурентоспособность промышленности и благосостояние потребителя, а также улучшать охрану окружающей среды, благодаря снижению выбросов парниковых газов и уменьшению загрязнения воздуха. Повышение энергоэффективности напрямую влияет на конкурентоспособность промышленности и может быть достигнуто за счет инноваций.

Научная новизна. Выделены ключевые научно-технические аспекты и подходы, стимулирующие повышение энергоэффективности в развитых зарубежных странах под влиянием сильной, скоординированной и последовательной политики государства в различных секторах экономики.

Практическая значимость. Проведенный анализ полезен в построении инновационного и технологического развития различных отраслей Российской Федерации в условиях ее непростого взаимодействия со странами Европы и США, зависимости от зарубежных технологий и ограниченного доступа к ним.

Ключевые слова: *энергоэффективность, наилучшие доступные технологии, энергобезопасность, стратегия, инновации, горнодобывающие предприятия*

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