International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(6), 451-459.

Development of Modern Standards for Energy Efficiency of Industrial Enterprises within the European Union Policy

Chen Pei Zhao[1]*, Gurgen Gukasyan[2], Valery Bezpalov[3], Valeriy Prasolov[4]

[1]Limkokwing University, Malaysia, [2]Peoples' Friendship University of Russia (RUDN University), Institute of Oriental Studies of the Russian Academy of Sciences, Russia, [3]Plekhanov Russian University of Economics, Russia, [4]Financial University under the Government of the Russian Federation, Russia. *Email: zhao.chenpei@outlook.com

Received: 24 June 2020 **Accepted:** 15 September 2020 **DOI:** https://doi.org/10.32479/ijeep.10160

ABSTRACT

This study is aimed at identifying the weaknesses and strengths of the mechanism for managing industrial energy efficiency (EE) under the EU policy. It is of interest not only for countries consuming energy raw materials but also for its suppliers, since they are to predict the situation on the markets and follow global trends in energy saving and environmental protection. Within the framework of the research, the methods of analogies and comparisons are used to determine the costs of switching industrial enterprises to the EE principles. The modeling method is applied to five companies in the EU, the USA, Russia, and China. By comparing the existing mechanism for EE regulating, excellent results for the EU industrial companies can be observed. They are characterized by the achievement of a high level of energy saving (10-12%) at low costs. For most US companies, an adequate level of potential energy conservation can be noticed. Russian industrial enterprises are characterized by low energy saving at a huge investment cost. For companies in China, favorable conditions are created to achieve efficient energy conservation, however, the cost for EE remains high.

Keywords: Costs, Energy Consumption, Energy Efficiency, Energy Management, Energy Saving
JEL Classifications: O1, Q4

1. INTRODUCTION

An energy-efficient economy remains a basis for ensuring continuous economic development and realization of interests for any country. It is confirmed by the economic development of the industrialized countries. The common and essential for all nations is the identification of energy conservation as one of the foundations for energy policy implementation and the creation of effective mechanisms for energy management. The legal framework and a system of standards are crucial instruments for performing energy saving policies and improving energy efficiency (EE) in developed countries.

The conceptual apparatus of EE is enshrined in international legal norms and standards. For example, the international standard for energy management systems ISO 50001 provides a correlation between the services, goods or energy, and the initial level of energy consumption (Yuriev and Boiral, 2018; da Silva Gonçalves and dos Santos, 2019).

The British standard BS EN 16001:2009 "*Energy management systems Requirements for use"* applies the concept of EE, which refers to a reduction in the energy used for a given service or level of activity (Vesma, 2017). The International Energy Agency (IEA) outlines the difference between the terms "energy conservation" and "energy efficiency". According to IEA, energy efficiency is the decrease in the consumption of fuel and energy resources by using more efficient devices, improving the level of management, and introducing the latest technologies. In other words, doing the same with less. Energy conservation concerns limiting or reducing the consumption of fuel and energy resources due to changes in lifestyle or behavior (Armendariz-Lopez et al., 2018; Leaver, 2019). The concept of EE is more common and generally accepted in world practice (Lenz et al., 2018).

Today, the EU policy on EE provides for a common political and regulatory framework laid by the updated EU Energy Efficiency Directive (2012/27/EU) and 2030 climate and energy policy framework. According to this framework, the EU plans to reduce greenhouse gas emissions by 40% in 2030, increase the use of renewable energy by 27%, and EE by 27% (European Commission, 2020).

Recently, the number of studies on the social impacts of EE has been increased (Schleich, 2019). The methodological approaches to assessing EE should be simple to apply and, if possible, based on data that is easy to obtain, to build a comprehensive toolbox (Reuter et al., 2019). Several methods have been proposed for the quantification of multiple benefits or "multiple impacts" of EE in a green economy context. Some of these methods incorporate more qualitative indicators, which can be more prone to subjective views than quantitative indicators (Cainelli et al., 2020).

Researchers also use a methodological approach to assessing EE based on total energy savings (either top-down or bottom-up). These energy savings are calculated for all final demand sectors (households, industry, services, and transport) (Filippidou et al., 2019).

The fossil fuel saving indicator measures the impact of final energy savings on the reduction of its consumption. For each sector, the total final savings are allocated to the various types of fuel (oil, coal, and gas) according to the breakdown of fuel consumption in each sector. It is calculated according to the following formula (1):

$$ES_{fossil,j} = \sum_{i} ES_{fossil,i} \times \frac{FES_{ij}}{FEC} \quad (1)$$

where *ES* represents energy savings from fossil energy carrier *j* and *FECij/FEC* is the final energy consumption share of energy carrier *j* in sector *i* (households, industry, services, transport) relative to total final energy consumption *FEC* (Martins et al., 2019).

The prevention of emissions from energy conservation involves measures of the impact of energy savings on the reduction of CO2 emissions (Canh et al., 2019). CO2 savings are calculated by multiplying the total energy savings by sector by the average CO2 emission of the sector calculated by dividing the total carbon dioxide emissions of the sector (including the indirect CO2 emissions from the power sector and heat production) by its final energy consumption (Łukasik et al., 2019; Salazar-Núñez et al., 2020).

In order to prevent local emissions due to energy savings, an indicator of local air pollution is determined. Based on a typical break-down of energy savings by energy source, local pollutants, which come mostly from local sources, such as transport or industry, using end-use and fuel specific emission factors are avoided (Su et al., 2019). Avoided emissions of air pollutants are calculated by multiplying energy savings expressed in primary terms by the average emission factor of the country, for each type of pollutant, per unit of final energy consumed (Sun et al., 2019).

Impact of EE on achieving the targets of renewable energy sources (RES) is based on the fact that energy savings allow reaching RES targets more easily, i.e. the share of RES in (gross) final energy consumption, as set in Directive 2009/28 for 2020. The RES share is calculated as the ratio between final RES consumption and total gross final energy consumption (Neofytou et al., 2019).

Similarly, an indicator of reducing energy poverty is being determined. Tackling energy poverty is explicitly stated as a policy objective in the European Commission's Communication on the Energy Union Package (Villalobos Barría et al., 2019). This benefit can be represented with an indicator measuring the impact of energy savings on the share of energy costs in disposable household income, as this is a commonly used definition.

EE in buildings has an impact on the evaluated market values. According to a study published by the US Department of Energy (DOE), commercial buildings waste 30% of the energy paid for on average (Campbell, 2019). This wasted energy is estimated at around 61 billion dollars for 2007. Based on a capitalization rate of 8%, a typical value used for building values, the lost asset value amounts to approximately $750 billion. Buildings with a certification of high EE generate a rent which is about 7% higher than otherwise identical buildings and their selling prices are 16% higher (Troup et al., 2019).

Many EU countries highly depend on a few suppliers of fossil fuels, making them vulnerable to supply disruptions, whether caused by political or commercial disputes, or infrastructure failure. To address this issue, the European Commission released its Energy Security Strategy in 2014, putting forward the 2030 energy and climate goals (in particular EE) as long-term measures to mitigate the energy import dependency of the EU. This indicator shows the contribution of energy savings to the reduction of energy import dependency. Dependency is measured through the energy dependency rate (ratio of primary consumption minus primary production over primary consumption). This ratio is first calculated with the observed primary energy production and consumption ("actual dependency rate") and secondly in a fictive situation without energy savings ("dependency rate without savings"). This second ratio is calculated by removing final energy savings in primary terms from the primary energy consumption (Gasser, 2020; Reuter et al., 2020).

While the studies referred to have generated conceptually valid approaches, the availability of data strongly determines their applicability and hence their usefulness for practical use. This calls for broadly accepted definitions for concrete quantitative indicators, allowing to assess the total (co-)benefits and their components, to monitor trends over time as well as to make comparisons across countries or regions, with the ultimate objective of contributing to the design of future effective energy policies.

Among all the methodological approaches to measure EE, the following three main categories can be formed:

Economic impacts comprise EE impacts on economic growth, employment, competitiveness and energy security.

Social impacts are defined as direct effects of EE on energy poverty alleviation, health and well-being (including improved living comfort) and disposable household income.

Environmental impacts include the direct effects of EE on primary/final energy consumption, the mitigation of greenhouse gases (GHG) and other (local) emissions. Primary energy consumption and the related emissions are also directly related to the penetration of electricity and heat generation from renewable energy sources.

The implementation of national standards in the field of EE has become a priority for many countries. It is confirmed by the active worldwide work of national standards organizations, as well as the development and implementation of new EE standards. International cooperation to achieve EE is broadly promoted. Methods for monitoring, determining, and supporting energy saving are involved when developing technical EE standards, energy management processes, systems for certification, testing, and labeling of EE. Against this background, the current paper is aimed at outlining the weaknesses and strengths of the mechanism for managing industrial EE in the EU.

2. MATERIALS AND METHODS

The study uses the methods of analogies and comparisons to determine the peculiarities of modern EE standards and regulate the EE of industrial enterprises. Besides, a modeling method is applied to define the costs of adopting EE principles by companies. For five industrial enterprises of the EU (Torlopp Industrie-und Messtechnik, Salsas Prima, Misko Draugas, Morpheas, Energy s.r.l.), Russia (Kamaflex, Intensive Technologies, Texpro, Rubex Group, Electrodes Production Plant), USA (Kellogg's, Invista, Alcoa, Loram, Cargill) and China (Baolikang Biologicalfeed, Xiamen Gaodike Electronics Industry, Huade, Haojian Tools, Anhui Anze Electric) an assessment of a possible improvement of energy conservation and an average cost of 1% of EE is carried out. The selection of these companies is based on an expanded industry research direction. Thus, among the enterprises, there are representatives of various industries (food, light, chemical, engineering) and organizational-legal forms, with the number of employees more than 200 people. This allows conducting a comprehensive study and making reasonable recommendations.

The analysis of the model is based on the fact that for each level of energy saving, a profitable investment amount exists. An econometric analysis of the results suggests that there is the following dependence of the production volume and EE for a particular level of investments (2):

$$\varphi_\tau(\Delta B)=b_{0\tau}+b_{1\tau}\Delta B \quad (2)$$

where ΔB represents the energy saving level (%);

τ is amount of investment, $\tau=\overline{1,5}$;
$\varphi_\tau(\Delta B)$ is production output at the amount of investment τ;
$b_{0\tau}$, $b_{1\tau}$ is econometric model parameters at the amount of investment τ.

According to the proposed methodology, the mathematical expectation of the production volume $\varphi_\tau(\Delta B)$ of a random value ΔB with a distribution density $f(\Delta B)$ for a normal distribution is as follows (3):

$$f\left(\text{”} B\right)=\frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{(\Delta B-a)^2}{2\sigma^2}} \quad (3)$$

where a represents mathematical expectation of the EE with an average deviation σ.

The formula for the mathematical expectation of the production output is as follows (4):

$$M\left[\varphi_\tau\left(\text{”} B\right)\right]=\int_{-\infty}^{+\infty}\varphi_\tau\left(\text{”} B\right)f\left(\text{”} B\right)d\text{”} B \quad (4)$$

Inserting it into the real limits of integration and replacing mathematical models, it can be obtained:

$$M\left[\varphi_\tau\left(\text{Ä}B\right)\right]=\int_0^{20}\left(b_{0\tau}+b_{1\tau}\text{Ä}B\right)\cdot\frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{(\text{Ä}B-a)^2}{2\sigma^2}}$$
$$d\text{Ä}B==\frac{b_{0\tau}}{\sigma\sqrt{2\pi}}\int_0^{20}e^{-\frac{(\text{Ä}B-a)^2}{2\sigma^2}}d\text{Ä}B+$$
$$\frac{b_{1\tau}}{\sigma\sqrt{2\pi}}\int_0^{20}\text{Ä}Be^{-\frac{(\text{Ä}B-a)^2}{2\sigma^2}}d\text{Ä}B==b_{0\tau}\left[\varphi\left(\frac{20-a}{\sigma}\right)+\varphi\left(\frac{a}{\sigma}\right)\right]$$
$$+\frac{b_{1\tau}}{\sigma\sqrt{2\pi}}\int_0^{20}\text{Ä}Be^{-\frac{(\text{Ä}B-a)^2}{2\sigma^2}}d\text{Ä}B \quad (5)$$

where $\varphi(y)$ represents Laplace transform of y.

To find the integral $\frac{1}{\sigma\sqrt{2\pi}}\int_0^{20}\Delta Be^{-\frac{(\text{”} B-a)^2}{2\sigma^2}}d\Delta B$ set $x=\frac{\Delta B-a}{\sigma}$, x is taken as the new variable. Hence $\Delta B=x\sigma+a$, while $d\Delta B=\sigma dx$. After the change of variables, the formula is as follows:

$$\frac{1}{\sigma\sqrt{2\pi}}\int_0^{20}\text{Ä}Be^{-\frac{(\Delta B-a)^2}{2\sigma^2}}d\text{Ä}B=\frac{\sigma}{\sigma\sqrt{2\pi}}\int_{-a/\sigma}^{(20-a)/\sigma}(\text{xó}+\text{á})e^{\frac{x^2}{2}}dx$$
$$=\frac{\sigma}{\sqrt{2\pi}}\int_{-a/\sigma}^{(20-a)/\sigma}x\sigma e^{\frac{x^2}{2}}dx+\frac{\alpha}{\sqrt{2\pi}}\int_{-a/\sigma}^{(20-a)/\sigma}e^{\frac{x^2}{2}}dx$$
$$=-\frac{\sigma}{\sqrt{2\pi}}\int_{-a/\sigma}^{(20-a)/\sigma}e^{\frac{x^2}{2}}d\left(-\frac{x^2}{2}\right)+\alpha\left[\varphi\left(\frac{20-a}{\sigma}\right)+\varphi\left(\frac{a}{\sigma}\right)\right]$$
$$=\frac{\sigma}{\sqrt{2\pi}}\left[e^{-\frac{a^2}{2\sigma^2}}-e^{-\frac{(20-a)^2}{2\sigma^2}}\right]+a\left[\varphi\left(\frac{20-a}{\sigma}\right)+\varphi\left(\frac{a}{\sigma}\right)\right] \quad (6)$$

Accordingly, the final formula for finding the desired mathematical expectation of output is as follows:

$$M_\tau = M\left[\varphi\left(" B\right)\right] = b_{0\tau}\left[\varphi\left(\frac{20-a}{\sigma}\right)+\varphi\left(\frac{a}{\sigma}\right)\right]+$$
$$+b_{1\tau}\left\{a\left[\varphi\left(\frac{20-a}{\sigma}\right)+\varphi\left(\frac{a}{\sigma}\right)\right]+\frac{\sigma}{\sqrt{2\pi}}\left(e^{-\frac{a^2}{2\sigma^2}}-e^{-\frac{(20-a)^2}{2\sigma^2}}\right)\right\} \quad (7)$$

The proposed approach to identifying and planning the consequences of the development of industrial enterprises allows taking into account the energy saving factor, as well as improving EE and creating a favorable investment climate for business.

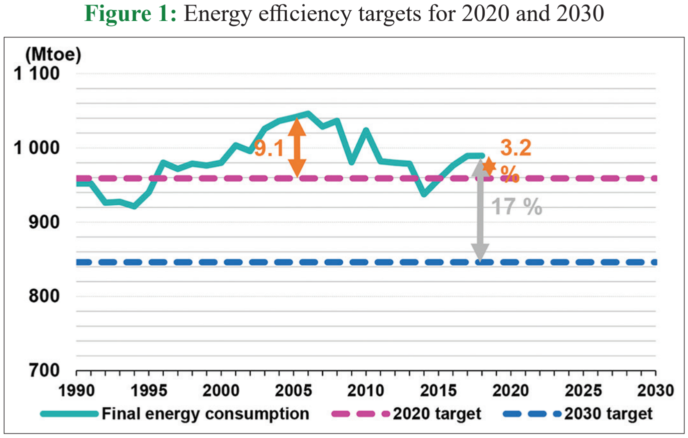
3. RESULTS

The EU has committed itself to a have a primary energy consumption of no more than 1483 Mtoe and a final energy consumption of no more than 1086 Mtoe in 2020 (Figure 1). For 2030 the binding target is at least 32.5% reduction. This translates into a primary energy consumption of no more than 1273 Mtoe and a final energy consumption of no more than 956 Mtoe in 2030 (Eurostat, 2019).

Final energy consumption in the EU is 3 % above the 2020 final energy consumption target. At the same time, the 2030 target is supposed to exceed 17% (Eurostat, 2019). Along with this, a direction is chosen to increase the level of EE and management through the implementation of new developments of national energy standards. The EN 16001 standard is a result of the synthesis of national standards of the EU countries (for example, Sweden (SS 627750:2003), Spain (UNE 2163012007), Denmark (DS 2403:2001) and Ireland (IS393:2005)). Standards for energy management and energy savings in individual countries are shown in Figure 2.

A global standard of ISO 50001 is formed on the basis of the ISO methodology, national energy management standards, and PDCA cycle. According to ISO 14001, the company's energy policy is easily integrated with environmental policy. This standard combines technical and managerial elements, which greatly facilitate the companies to implement an energy management system under ISO 50001.

Figure 1: Energy efficiency targets for 2020 and 2030



Source: Developed by the authors on the Eurostat database

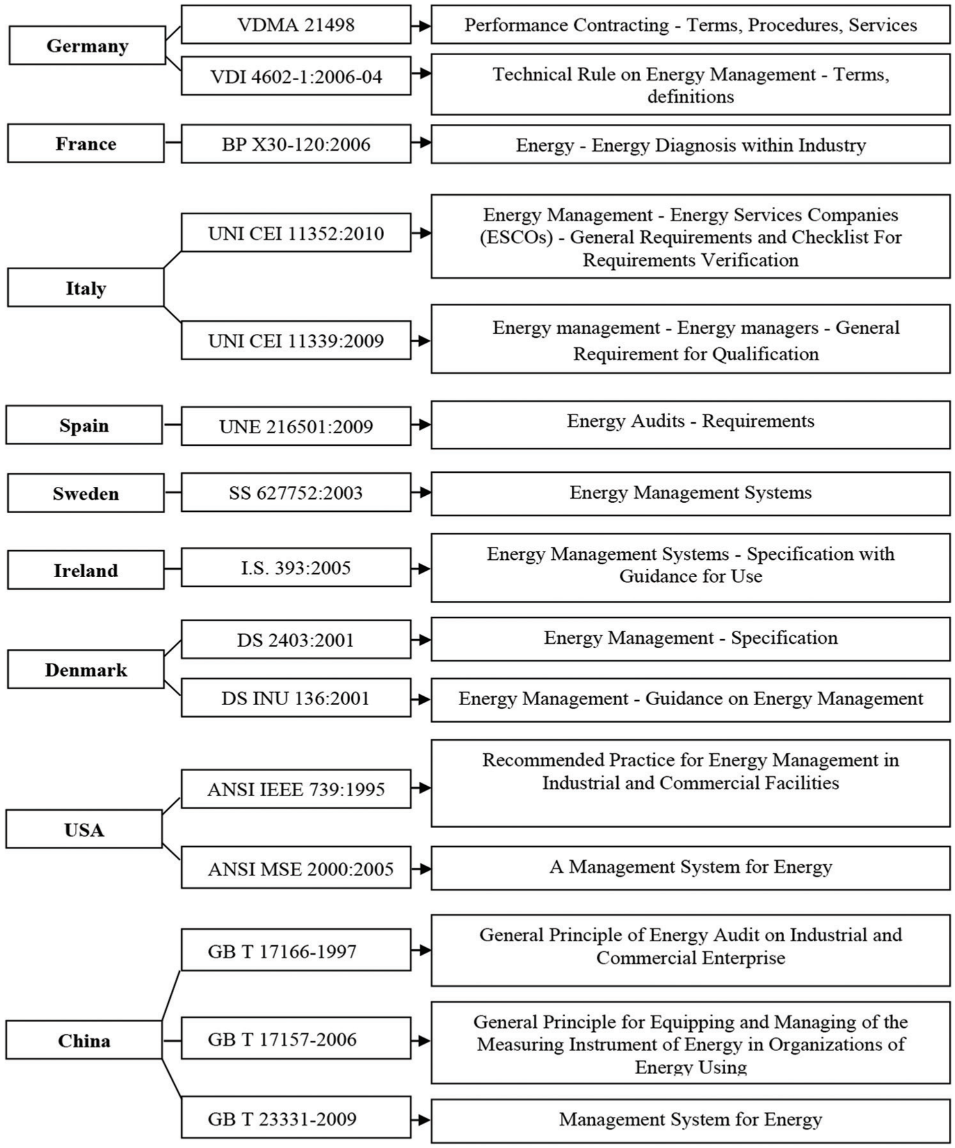
Comparing the ISO 50001 and EN 16001 standards, it should be noted that ISO 50001 is compatible with the EN16001. However, ISO 50001 includes additional concepts and requirements, making it more effective. For example, when appointing an energy management representative, the control over the functioning and implementation of the energy management system is increased. Moreover, ISO 50001 standard includes a description of the energy parameters of the organization; a scheme of activities in the field of procurement of fuel, energy equipment, and management; the degree of environmental impact; and proper emergency response. Therefore, it can be assumed that ISO 50001 will completely replace ANSI MSE 2000:2008 and EN 16001. Within the European standard EN 16001 and the international standard for Energy Management Systems ISO 50001:2011, the use of a benchmarking practice by a company is optional. Though benchmarking is considered essential to support and improve EE activities. Taking into account that the ISO 50002:2014 standard is based on EN 1647-1, it is recommended for companies, that are subject to privatization, to carry out an energy audit under any of the above standards (preferably ISO 50002). These days, EU countries are developing programs encouraging businesses to conduct mandatory and regular energy audits.

In the United States, energy efficiency management is based on the provisions of ISO 50001:2011 and is implemented as a complex administrative system controlled through certification mechanisms and independent audits. The Energy Performance of Buildings Directive 2010/31/EU (EPBD) is the main legislative instrument at EU level to achieve energy performance in buildings. The Directive is based on CEN standards and requires member states to apply energy performance certificates (EPCs) to buildings. Therefore, it enhances the role of European standards in the legal area of all the EU members. According to the Energy Performance of Buildings Directive, since 2021, all new buildings should be nearly zero-energy. At the same time, the definition of the term "zero" energy consumption is formed individually by each EU member state. Methods for regulating the EE of buildings differ from country to country, since they are determined by the climatic, economic, and cultural features.

Energy labeling directive (ELD) 2010/30/EU establishes a framework for the Commission to develop regulations for the labeling of energy-related products. The EU has adopted a plan to join the US Energy Star program for the voluntary labeling of energy-consuming equipment. Besides, in several countries, the government supports the acquisition of energy-efficient equipment through direct subsidies (Netherlands, Germany, Spain) or tax payments (UK, Italy).

The United States has a system of direct control over compliance with the mandatory minimum energy performance standards (MEPS). A 30% tax relief is applied to equipment manufacturers using cutting-edge technologies for renewable energy (Energy Star, 2019). Moreover, since 2009, 34 new or updated standards for more than 40 electrical appliances are introduced in the United States. The introduction of new efficiency standards, including for commercial refrigeration equipment, electric motors, and

Figure 2: National standards for energy efficiency and energy management



Source: Developed by the authors

fluorescent lamps, will reduce energy costs by almost $ 535 billion by 2030 (Standards, 2019). The current law of the US requires any US state to adopt regional guidelines for reducing energy consumption. Thus, relevant regulatory agencies that regulate energy conservation standards are created.

The active energy conservation and EE policy in Russia is caused by the high level of energy intensity of the country's GDP. Even though the energy intensity of GDP has decreased over the period 2000-2018, today its level is 2.4 times higher than the world average and 3.2 times higher than the EU level. Figure 3 depicts comparative indicators of the energy intensity of GDP, considering the purchasing power parity.

A distinctive feature of China's pricing reform is that energy prices for large industrial consumers (ferrous and non-ferrous metal and cement enterprises) depend on the efficiency of energy consumption by the enterprises. Thus, the most efficient consumers pay a standard price for energy carriers and those who have not achieved a particular EE level pay the price, which rises according to the established penalties. Thus, over the past 30 years in China, a weakening of the connection between GDP growth and energy intensity, as well as the reduction in energy intensity of more than 4 times, is seen.

In Russia, the cost of fuel and energy vary from 10 to 40% of the cost of production. Industrial enterprises consume more than a third of primary fuel and energy resources (FER) and more than 50% of electricity. About 15% of worn-out fixed assets are used in the metallurgy and chemical industries. Furthermore, outdated and inefficient energy technologies are applied in the production of building materials. Therefore, about 80% of cement is produced using the more efficient wet process.

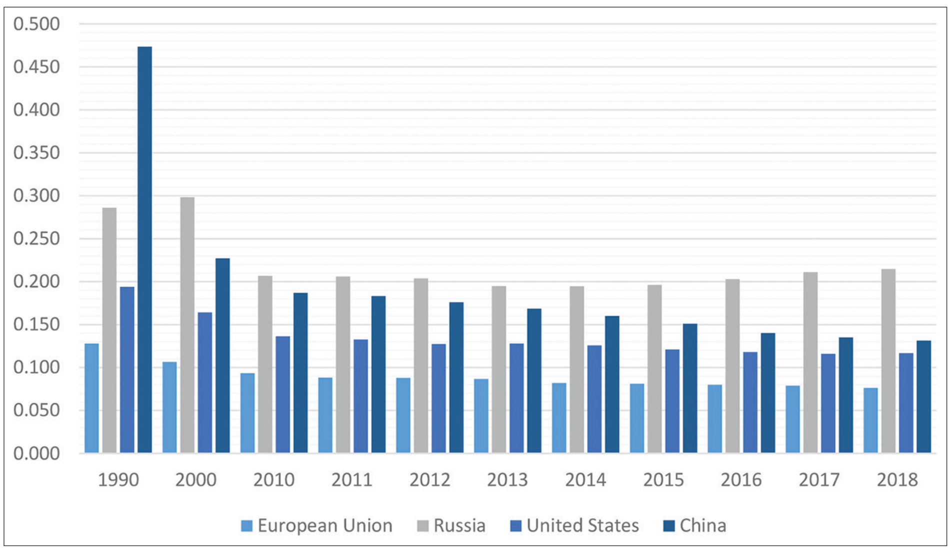
Federal Law of the Russian Federation No. 261-FZ *On energy saving and improvement of energy efficiency* provides for the promotion of EE technologies. According to this law, new enterprises with a high level of EE can set an increased depreciation rate. Moreover, the procedure and conditions for the provision of investment tax credits are established, in particular for organizations that invest in the production of electric and thermal power. The law also provides for administrative responsibility for failure to comply with legislative requirements in the field of improving EE and energy conservation. In particular, the release or sale of goods without information regarding their EE class, design, construction, reconstruction, and overhaul requirements of buildings and structures, as well as equipment accounting.

In the State Report on Energy Saving and Improving the Level of Energy Efficiency in Russia prepared by the Ministry of Energy of the Russian Federation, key guidelines for provisions and projects, programs for the effective implementation of an energy management system based on the requirements of ISO 50001 are set. Today, many fuel and energy companies in Russia, as well as industrial ones, are implementing energy management projects in accordance with ISO 50001:2011.

Alternative investment projects for the companies of the EU, Russia, the USA, and China are modeled, taking into account a possible increase in energy saving to determine the cost of the transition of industrial enterprises to the EE principles (Figure 4).

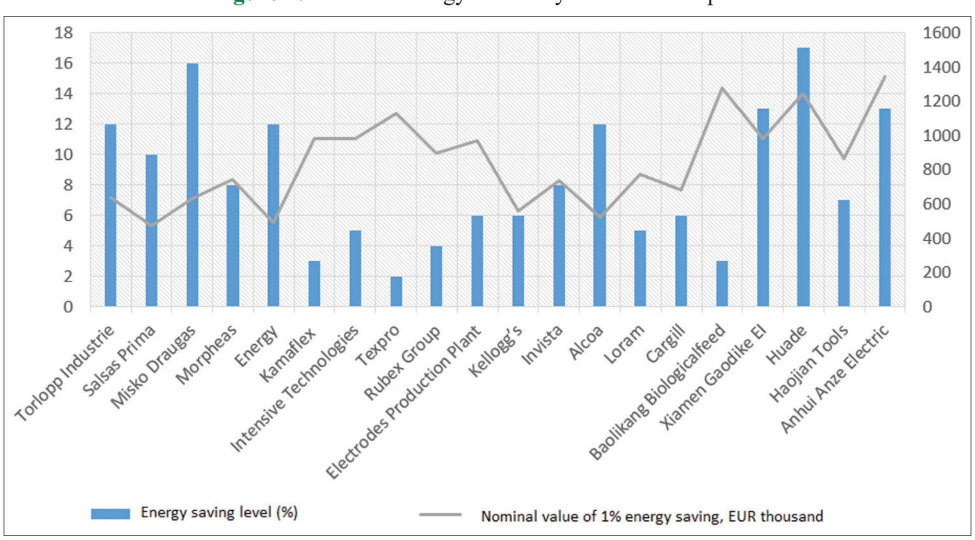
If to compare the existing mechanism for EE regulating in the EU with other countries under consideration, a high level of results for European industrial companies can be noticed. The EU companies achieve excellent energy saving (10-12%) at low costs (an average of 597 thousand euros for 1% energy saving) of its implementation compared to Russia, the USA, and China. For most US companies, a sufficient level of possible energy conservation can also be noted (an average of 7% of the total investment volume). In turn, China creates better conditions for enterprises to achieve a high level of energy saving than the US (an average of 12%). However, at

Figure 3: Energy intensity of GDP at constant purchasing power parities (koe/$2015p)



Resource: Developed by the authors based on Enerdata, 2019

Figure 4: Modeled energy efficiency level for enterprises



Source: Developed by the authors on company materials the same time, the cost of 1% of energy conservation for China remains high (an average of €1106 thousand). Russian industrial enterprises are characterized by a low level of energy conservation (4%) with sufficiently high costs (an average of €995 thousand).

Considering the data above, China is supposed to have more strategic energy saving policy since the country is mainly focused on the prospective development of renewable energy and less on developing the production of new equipment, saving existing fuel and energy resources. In this way, China is hoping to deal with its over-dependence on fossil fuels partly by rebalancing the economy away from energy-intensive industries. For this reason, the Chinese government implements technologies, innovations, and electricity market reform to break the power grid monopoly.

4. DISCUSSION

In economics, the combined effect of standardization based on ISO, IEC, and European standards is more than 1% of GDP. The experience of European companies shows that investment of 1 euro brings up to 20 euros. In particular, for Germany, the annual profit from standardization equals about 18 billion euros. Given the rise of prices, the implementation of energy management to reduce the energy intensity of products and GDP is among the most promising opportunities to improve EE (Foreman, 2018; Kintonova et al., 2019).

The transition to a low-carbon society would boost Europe's economy thanks to increased innovation and investment in clean technologies and low- or zero-carbon energy. Thus, taking into account the EU plan to reduce the harmful effects on the atmosphere, the impact and importance of alternative energy will increase every year. A low-carbon economy would have a much greater need for renewable sources of energy, energy efficient building materials, hybrid and electric cars, "smart grid" equipment, low-carbon power generation and carbon capture and storage technologies (Keho, 2017). Thus, the EE will be a key driver of the transition. By moving to a low-carbon society, the EU could be using around 30% less energy in 2050 than in 2005 (Eikeland and Skjærseth, 2020). As a result, the dependence of the EU on expensive imports of oil and gas, as well as vulnerability to the energy crisis, will reduce. Thus, the EU companies that introduced energy management systems achieved an annual reduction in energy intensity of 2-3% (Choi et al., 2017).

In the US, incentive measures to improve EE are widely used, especially in the manufacturing sector. In particular, the US Congress passed the American Recovery and Reinvestment Act to increase the economic activity of the country. It regulates a number of preferential mechanisms and economic incentives for energy conservation totaling $787 billion. As a result, the average cost of energy consumption per product unit is 18% (in Russia, for example, this value reaches 40%) (Lim and Bowen, 2018; Afanasiev and Shash, 2019; Semin et al., 2019). By 2025-2030, the United States plans to improve EE, develop renewable energy sources, and reduce greenhouse gas emissions. According to the regulation on the amount of energy savings achieved by energy companies, enterprises can raise 30% of energy savings in profit. Under these conditions, investing in energy conservation is 3 times more profitable for the energy supplier than the construction of new energy capacities. About one third of energy resources are consumed by the US industries. At the same time, out of 200 thousand industrial enterprises, about 4 thousand companies use more than 58% of total energy resources, most of which are oil products and natural gas. The government is financing an expedited EE audit of large industrial enterprises, provides recommendations and relevant energy conservation measures (Wang et al., 2016; Stokes and Breetz, 2018).

In China, the companies' products are regularly checked for compliance with energy conservation standards. The country has a voluntary product labeling program focused on manufacturers. Besides, in the conditions of fierce competition, Chinese companies are extremely interested in distinguishing their products from similar ones (Wen and Lee, 2020).

In the EU, one of the most common measures to stimulate EE is an exemption from customs duties on imports of energy saving equipment. If national developments of energy efficient equipment exist, benefits are established for corporate income tax and VAT to reduce the cost of equipment used for energy production. The application of a lower VAT rate for energy-saving devices encourages consumers to choose the most economical option for energy supply. For example, in the Czech Republic, there are lower VAT rates (5% instead of the higher 22% rate) for environmentally sound products and goods related to energy savings, such as thermostatic controls, meters for measuring the amount of heat consumption, thermal insulation measures and energy saving light bulbs (Buettner and Madzharova, 2019). Thus, the VAT exemption is used to invest in energy efficiency.

5. CONCLUSIONS

The EN 16001 standard is the result of the synthesis of national standards of the EU countries. It is combined with other ISO management standards. The ISO 50001 standard is compatible with the EN16001 standard but contains additional concepts and requirements, which make it more effective. In the European standard EN 16001 and the international standard ISO 50001:2011 for energy management systems, the use of a benchmarking practice is optional. However, benchmarking is considered essential to support and improve EE activities. The EU countries are developing programs to encourage businesses to conduct energy audits. At large enterprises, energy audits should be mandatory, regular, and carried out under the relevant European and international standards.

In the United States, energy efficiency management is based on ISO 50001:2011 and is implemented as a complex administrative system controlled through certification mechanisms and independent audits. Furthermore, the US has a system of direct control over compliance with the mandatory minimum energy performance standards (MEPS).

In the EU countries, all new buildings should be nearly zero-energy since 2021. In turn, the definition of "zero" energy consumption is formed individually by each EU member state, as well as methods for regulating the EE of buildings differ from country to country, since they are determined by unique climatic, economic, and cultural features. At the same time, the EU has joined the US Energy Star program for the voluntary labeling of energy-consuming equipment. Thus, in several countries, the government supports the acquisition of energy efficient equipment through direct subsidies or tax payments.

In Russia, the promotion of EE technologies can also be noticed. In particular, it is established that if the budgetary organizations are implementing a program to increase EE, then the savings from the projects aimed at reducing energy consumption will be used for the organization's needs. Newly created enterprises with a high level of EE are given the right to establish an increased depreciation rate. Furthermore, Russia has set the procedure and conditions for the provision of investment tax loans.

In China, energy prices for large industrial consumers depend on the efficiency of their consumption by the enterprises. The most efficient consumers pay a fixed price for energy carriers, while the price for the ones, which have not achieved a particular EE level, rises due to established penalties. Over the last 30 years, a reduction in energy intensity of more than 4 times, and a weakening of the relationship between GDP growth and energy intensity is also noted.

Based on the modeling of alternative investment projects for the examined companies in the EU, Russia, the USA, and China, the costs of switching industrial enterprises to EE principles can be determined. By comparing the existing mechanism for regulating EE, a high level of results for the EU industrial companies can be marked. Thus, the companies are characterized by the possibility of achieving an excellent energy saving (10-12%) at low costs of its implementation compared to Russia, the USA, and China. Russian industrial enterprises are characterized by a low level of energy conservation (4%) at high costs of energy saving. For most US companies, a sufficient level of possible energy saving (an average of 7% of the volume of investments) can be seen. In China, favorable conditions are created for enterprises to achieve a high level of energy conservation, however, the cost of 1% energy efficiency remains high (an average of €1106 thousand). Chinese energy saving policy reveals better results since the matter of saving existing fuel, energy resources, and developing the production of new energy-saving equipment is paid less attention than the prospective development of renewable energy.

REFERENCES

Afanasiev, M.P., Shash, N.N. (2019), Russian federation cross-border investments and bank expansion in Russia. Public Administration Issue, 6, 105-120.

Armendariz-Lopez, J.F., Arena-Granados, A.P., Gonzalez-Trevizo, M.E., Luna-Leon, A., Bojorquez-Morales, G. (2018), Energy payback time and Greenhouse gas emissions: Studying the international energy agency guidelines architecture. Journal of Cleaner Production, 196, 1566-1575.

Buettner, T., Madzharova, B. (2019), Sales and Price Effects of Pre-announced Consumption Tax reforms: Micro-level Evidence from Europoean VAT. Oxford: Oxford University Centre for Business Taxation.

Cainelli, G., D'Amato, A., Mazzanti, M. (2020), Resource efficient eco-innovations for a circular economy: Evidence from EU firms. Research Policy, 49(1), 103827.

Campbell, Q. (2019), Building Performance and Energy Star Ratings in Commercial Office Space. Skidmore College: Economics Student Theses and Capstone Projects.

Canh, N.P., Thanh, S.D., Schinckus, C., Bensemann, J., Thanh, L.T. (2019), Global emissions: A new contribution from the shadow economy. International Journal of Energy Economics and Policy, 9, 320-337.

Choi, B., Park, W., Yu, B.K. (2017), Energy intensity and firm growth. Energy Economics, 65, 399-410.

da Silva Gonçalves, V.A., dos Santos, F.J.M. (2019), Energy management system ISO 50001: 2011 and energy management for sustainable development. Energy Policy, 133, 110868.

Eikeland, P.O., Skjærseth, J.B. (2020), The Politics of Low-carbon Innovation. Germany: Springer International Publishing.

Energy Star. (2019), Available from: https://www.energystar.gov/about/federal_tax_credits.

European Commission. (2020), 2030 Climate and Energy Framework. Available from: https://www.ec.europa.eu/clima/policies/strategies/2030_en. [Last accessed on 2020 May 20].

Eurostat. (2019), Available from: https://www.ec.europa.eu/eurostat/statistics-explained/index.php/Energy_saving_statistics#Final_energy_consumption_and_distance_to_2020_and_2030_targets. [Last accessed on 2020 May 20].

Filippidou, F., Nieboer, N., Visscher, H. (2019), Effectiveness of energy renovations: A reassessment based on actual consumption savings. Energy Efficiency, 12(1), 19-35.

Foreman, R.D. (2018), Criticality of GDP measurement in energy modelling. In: Evolving Energy Realities: Adapting to What's Next, 36th USAEE/IAEE North American Conference, Sept 23-26, 2018. United States: International Association for Energy Economics.

Gasser, P. (2020), A review on energy security indices to compare country performances. Energy Policy, 139, 111339.

Keho, Y. (2017), Revisiting the income, energy consumption and carbon emissions nexus: New evidence from quantile regression for different country groups. International Journal of Energy Economics and Policy, 7(3), 356-363.

Kintonova, A.Z., Yermaganbetova, M.A., Abildinovaa, G.M., Ospanova, N.N., Abdugulova, Z.K., Glazyrina, N.S. (2019), Optimization of business processes based on the supply chain management in an accounting department. International Journal of Value Chain Management, 8, 369-379.

Leaver, J. (2019), International Energy Agency (IEA) Strategic Initiatives and Activities for Hydrogen. Wellington: NZ Hydrogen Association Workshop.

Lenz, N.V., Šegota, A., Maradin, D. (2018), Total-factor energy efficiency in EU: Do environmental impacts matter? International Journal of Energy Economics and Policy, 8(3), 92-96.

Lim, T., Bowen, W.M. (2018), Determinants and evaluation of local energy-efficiency initiatives from the American recovery and reinvestment act. Review of Policy Research, 35(2), 238-257.

Łukasik, Z., Kozyra, J., Kuśmińska-Fijałkowska, A. (2019), A method of calculating CO_2 savings obtained by external lighting of vehicles that use electroluminescent diodes. In IOP Conference Series: Earth and Environmental Science, 214(1), 012104.

Martins, F., Felgueiras, C., Smitkova, M., Caetano, N. (2019), Analysis of fossil fuel energy consumption and environmental impacts in European countries. Energies, 12(6), 964.

Neofytou, H., Karakosta, C., Gómez, N.C. (2019), Impact assessment of climate and energy policy scenarios: A multi-criteria approach. In: Understanding Risks and Uncertainties in Energy and Climate Policy. Cham: Springer. p123-142.

Reuter, M., Patel, M.K., Eichhammer, W. (2019), Applying ex post index decomposition analysis to final energy consumption for evaluating European energy efficiency policies and targets. Energy Efficiency, 12(5), 1329-1357.

Reuter, M., Patel, M.K., Eichhammer, W., Lapillonne, B., Pollier, K. (2020), A comprehensive indicator set for measuring multiple benefits of energy efficiency. Energy Policy, 139, 111284.

Salazar-Núñez, H.F., Venegas-Martínez, F., Tinoco-Zermeño, M.Á. (2020), Impact of energy consumption and carbon dioxide emissions on economic growth: Cointegrated panel data in 79 countries grouped by income level. International Journal of Energy Economics and Policy, 10(2), 218-226.

Schleich, J. (2019), Energy efficient technology adoption in low-income households in the European Union-what is the evidence? Energy Policy, 125, 196-206.

Semin, A.N., Ponkratov, V.V., Levchenko, K.G., Pozdnyaev, A.S., Kuznetsov, N.V., Lenkova, O.V. (2019), Optimization model for the Russian electric power generation structure to reduce energy intensity of the economy. International Journal of Energy Economics and Policy, 9(3), 379-387.

Simionescu, M., Bilan, Y., Krajňáková, E., Streimikiene, D., Gędek, S. (2019), Renewable energy in the electricity sector and GDP per capita in the European Union. Energies, 12(13), 2520.

Standards. (2019), Available from: https://www.standardscatalog.ul.com/standards/en/standard_60335-2-40. [Last accessed on 2020 May 20].

Stokes, L.C., Breetz, H.L. (2018), Politics in the US energy transition: Case studies of solar, wind, biofuels and electric vehicles policy. Energy Policy, 113, 76-86.

Su, Y., Sha, Y., Zhai, G., Zong, S., Jia, J. (2019), Comparison of air pollution in Shanghai and Lanzhou based on wavelet transform. Environmental Science and Pollution Research, 26(17), 16825-16834.

Sun, W., Zhou, Y., Lv, J., Wu, J. (2019), Assessment of multi-air emissions: Case of particulate matter (dust), SO_2, NOx and CO_2 from iron and steel industry of China. Journal of Cleaner Production, 232, 350-358.

Troup, L., Phillips, R., Eckelman, M.J., Fannon, D. (2019), Effect of window-to-wall ratio on measured energy consumption in US office buildings. Energy and Buildings, 203, 109434.

Vesma, V. (2017), Energy Management: Principles and Practice. United Kingdom: Hive House Publishing.

Villalobos Barría, C., Chávez Rebolledo, C., Uribe, A. (2019), Energy Poverty Measures and the Identification of the Energy Poor: A Comparison Between the Utilitarian and Multidimensional Approaches in Chile (No. 243), IAI Discussion Papers. Maharashtra: Ibero-America Institute for Economic Research.

Wang, H., Yang, Y., Keller, A.A., Li, X., Feng, S., Dong, Y.N., Li, F. (2016), Comparative analysis of energy intensity and carbon emissions in wastewater treatment in USA, Germany, China and South Africa. Applied Energy, 184, 873-881.

Wen, H., Lee, C.C. (2020), Impact of environmental labeling certification on firm performance: Empirical evidence from China. Journal of Cleaner Production, 255, 120201.

Yuriev, A., Boiral, O. (2018), Implementing the ISO 50001 system: A critical review. In: ISO 9001, ISO 14001, and New Management Standards. Cham: Springer. p145-175.