Tax and Technological Aspects of the Transition to Sustainable Energy

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Abstract. In today's environment, the international community is facing a number of fundamental long-term problems, the solution of which is relevant for each country within the new paradigm of sustainable development. Key problems include the level of energy security of the national economy, increasing the energy efficiency of the national energy system, and increasing its environmental friendliness. The basis for the transition to sustainable energy is coordinated energy and tax policies. The latter should aim at establishing such rules and conditions for the national energy system that would make it more adaptable to new conditions and adoption of environmentally friendly green technologies.

The article substantiates the need for a systematic approach to reforming the existing taxation in accordance with the principles of sustainable development. We study the basic principles of changing the domestic tax system in the direction of its greening, and, in particular, the use of the environmental tax as a tool for managing the impact on the energy system. We describe new properties of energy systems arising from the introduction of digital technology in the production and consumption of electricity and its impact on the level of adaptability of the energy system. Increasing the environmental friendliness and adaptability of the national energy system will facilitate the transition of the energy sector and economy to the path of sustainable development.

1. Introduction

Today's world is facing the global challenge of transitioning to the new paradigm of sustainable development, based on the need to preserve the level of economic, scientific, and technological development as well as the availability of amenities for an increasing number of people on the planet. For the first time, the key points of the concept of sustainable development were described back in 1987 in the report "Our Common Future" by the World Commission on Environment and Development (WCED). Since then the meaning the term "sustainable development" is loaded with has broadened considerably. The content of the "sustainable development" concept began to include not only the preservation of the status quo, but also restoration of damage caused by the society to the environment. Poor environmental conditions drag down economic growth; so, for example, the global GDP loses annually about 10% to 15% due to environmental pollution (given the harm caused to public health) [1].
One of the key factors in achieving sustainable development is the operation of sustainable energy. Sustainable energy is the energy industry that meets the current energy needs of the society without reducing the ability to meet future energy needs [2,3]. The International Energy Agency defines sustainable energy as that which takes into account the balance between energy security, economic development, and environmental protection [4].

In Russia, in order to follow the global process of transition to sustainable energy, it is necessary not only to develop new technologies, but also to provide economic substantiation of the very plausibility and specific ways of arranging the transformation process. One way to facilitate the transition is to reform the tax system in line with sustainable development principles. A scientifically backed tax reform can make taxes a powerful tool to encourage the adoption of new energy-saving technologies, reduce carbon dioxide (CO₂) emissions, and increase the share of renewable energy in energy consumption. The development and implementation of tax policy in accordance with the principles of sustainable development that contributes to environmental protection and public health is of great social and economic importance for the country.

1.1. Environmental taxes as an energy management tool

The national energy system is a complex dynamic system whose development is determined by both internal processes in the system and external factors. The development of internal trends in the energy system, as governed by the logic behind technical and economic processes, can lead to increased efficiency and environmental friendliness through the introduction of new technologies. Nevertheless, environmentally friendly energy policies that are well-designed and scientifically backed should be implemented to ensure that national energy system emissions are reduced in the long run.

At high level, there are two groups of methods for implementing managed impact on the national energy system: (1) direct impact methods and (2) indirect impact methods. Direct impact methods consist in the adoption of specific economic and organizational measures aimed at eliminating "weak points" in the system by improving the reliability of its individual elements, creating new interconnections, etc. Indirect impact methods consist in creating favorable conditions for the functioning of the national energy system, under which energy companies will not be overburdened with administrative and economic barriers in the development and implementation of green energy technologies.

The effectiveness and acceptability of the methods of direct or indirect impact depend on the current situation and the need for government intervention in the development of the national energy system. Methods of direct impact on energy systems are aimed only at certain structural elements, while methods of indirect impact cover both the energy sector and the country's economy as a whole. Direct impact methods are certainly more costly, as they are related to direct financing of investment projects in the energy industry, provision of soft loans to energy companies, etc., while indirect impact methods mainly incur costs in public administration.

One of the methods of indirect impact on the development of the country's economic system in general and its energy component in particular is taxes. In the process of implementing the regulatory function, taxes may have both stimulating and discouraging effects on the economic system. The incentive effect is implemented through a system of benefits and exemptions.

The purpose of ecological taxation is to reduce the negative impact on the environment by introducing taxes in those areas where the negative impact is most pronounced: energy, transport, and industrial production. Depending on the scope of application, environmental taxes are divided into transport taxes, energy taxes, taxes on waste, earmarked charges, and royalty [5]. On average, energy taxes currently account for more than 70% of all environmental tax revenues in European countries (see Fig.1).

B. Boske [7], V. V. Gromov [8], Yu. B. Ivanov, N. N. Bashkirova, E. A. Ermakova [9], and others, in their analyses of the essence of environmental taxes, identify the following key points: (1) the main
The function of environmental taxes is monetary compensation for damage caused by the taxpayer to an individual or the society as a whole as a result of pollution; (2) the tax base is not the cost, but the physical characteristics of the taxable asset; (3) environmental taxation must comply with the "polluter pays" principle, i.e., the tax must be collected from the source of pollution; (4) if it is impossible to collect the tax from the source of pollution, the taxable asset may also be another asset related to the source of pollution.

From the economic point of view, the introduction of environmental taxes stems from the necessity to express in monetary terms those losses for the society that are created by the taxpayer's activity due to its negative impact on the environment. Depending on the purpose of their introduction, environmental taxes are divided into several groups: (1) compensatory, i.e., those necessary to reimburse state expenditures on environmental protection; (2) fiscal, designed to increase state tax revenues; (3) regulatory, i.e., those necessary to adjust the behavior of taxpayers [9].

At present, environmental taxes are predominantly regulatory. As noted by a number of scholars, in most countries environmental taxes are taxes that have a regulatory impact on taxpayers, but are not Pygopian taxes sensu stricto [10, 11]. In order for the tax to be considered environmental, it should be aimed at protecting the environment, i.e. it should create an incentive for taxpayers to use those taxable assets that have better environmental performance. Environmental taxes, as a tool of indirect impact on the energy system, can facilitate the transition to sustainable energy.

![Figure 1. Total revenue from environmental taxes by type of tax, in EU-28, 2002-2017. Source: [6].](image)

Coordinated energy and fiscal policies aimed at the transition to sustainable energy imply, on the one hand, the establishment of rules and conditions conducive to the development of green energy, and, on the other hand, the formation of a number of elements and interconnections between them that could most efficiently participate in redirecting the flow of energy resources.

1.2. Environmental taxes in Russia

Economic and social development goes hand in hand with a continuous increase in energy consumption and production, which means the need to accelerate the transition to sustainable energy by improving the efficiency of existing energy technologies and introducing new ones, including renewable energy. The current situation in the Russian energy industry generally reflects a continuation of the longstanding trend toward extensive development, is environmentally and economically inefficient, and lacks internal incentives for self-improvement. It seems that the introduction of carbon restrictions and support for the
development of green technologies can stimulate the transformation of energy towards renewable energy sources (RES).

Unlike European countries that seek to diversify their energy sources, Russia does not have an urgent need to increase the share of renewable energy sources in its energy balance. However, between 2013 and 2018, there has been some progress in the development of renewable energy in Russia. The Government of the Russian Federation has enacted a number of Decrees and Orders on the arrangement of work in the area of renewable energy and, in particular, establishing state goals in this area. Unfortunately, the initially established share of RES that amounted to 4.5% of the total electricity production in 2020, was reduced to 2.5%. Nevertheless, it is now realized that development of RES is one of the tools to improve energy security of regions, create jobs, improve energy efficiency of the electric power industry, and reduce its negative impact on the environment (Table). According to experts' estimates, 1 KWh of electricity coming from renewable energy sources replaces from 550 g to 1 kg of CO$_2$ produced by hydrocarbon generation [12].

Table 1. Dynamics of planned capacity additions of power generating RES, MW.

| Power generation | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Total |
|------------------|------|------|------|------|------|------|-------|
| Solar PV         | 500  | 500  | 500  | 500  | 399  |      | 2 899 |
| Wind             | 270  | 270  | -    | -    | -    | -    | 540   |
| Small hydropower | 159  | 159  | -    | -    | -    | -    | 318   |

Source: the Government of the Russian Federation

According to the data of the Analytical Center under the Government of the Russian Federation, in 2018 the installed capacity based on renewable energy sources in Russia amounted to slightly more than 1.0 GW or 0.4% of the total installed capacity in the Unified Energy System. Electric power generation on the basis of RES did not exceed 0.2% of the total volume of its production in the country.

Despite the urgency of the problem of transition to sustainable energy in Russia, there are many barriers on this path. One of the barriers is the absence of the environmental taxes. Despite the fact that, as early as in the 1990s, A.A. Golub [13], I. A. Bashmakov [14], A. A. Makarov [15], and others noted that environmental taxes were the most important tool of the state environmental policy, there are still no environmental taxes in Russia.

At present, Russian legislation only provides for payments related to environmental pollution. These include:

- environmental levy (paid by companies for processing and disposal of goods and packaging);
- payment for negative impact on the environment (paid by companies for emissions of pollutants into the atmosphere from stationary sources, emissions of pollutants into water, and waste disposal).

Environmental levy payments are sent to the constituent entities of the Russian Federation in the form of subsidies for co-financing of state environmental programs. However, the analysis of the dynamics of payments received by the budget system of the Russian Federation [16] attests to low efficiency of their collection, which is partly due to insufficient responsibility for failing to pay them.

To change this situation, the Ministry of Finance of the Russian Federation has proposed to convert environmental payments into taxes, which are known to be based on a different legal framework. According to the proposal, fixed tax rates would apply to emissions of various substances into the air, discharges into water, as well as industrial waste disposal. Tax payers, companies, and individual entrepreneurs will be able to reduce the amount of payments through activities that can actually reduce the negative impact on nature. The Ministry of Finance believes that the adoption of amendments will allow to increase budget revenues without changing the level of tax burden by improving the quality of
administration. The new tax will help to improve the efficiency of collection of pollution charges, and it is important to develop streamlined mechanisms for allocating tax revenues, especially for implementing programs to support green energy.

The introduction of the environmental tax in Russia is a necessary but not sufficient incentive for Russian energy companies to reduce emissions through the development of green technologies. The next step in reforming Russia's taxation towards greening may be to introduce a carbon tax, the ultimate goal of which is to limit climate change resulting from greenhouse gas emissions.

At the beginning of the twenty-first century, greenhouse gas emissions associated with human activities reached a historic high. In 2019, mankind emitted a record 37 billion tons of carbon dioxide into the atmosphere [17]. However, despite the continuing absolute growth of greenhouse gas emissions in the world, over the past 10 years there has been a process of reducing specific CO₂ emissions per TOE consumed by the economy (see Fig.2). The exception is Japan, where in 2011 there was a sharp spike in specific CO₂ emissions, since as a result of the Fukushima Daiichi accident the Japanese government abruptly abandoned nuclear power and increased the share of hydrocarbons in the country's energy balance.

![Figure 2. Specific volume of CO₂ emissions, tons per TOE.](image)

Source: calculated by the authors based on the data by BP [18].

Russia has joined the Paris Climate Agreement and is expected to reduce its hydrocarbon emissions by 25% from 1990 levels by 2030. A study by I. A. Bashmakov and A. D. Myshak [19] showed that this was quite attainable. In practice, however, this goal is hampered by some common misconceptions. For example, the implementation of measures to reduce greenhouse gas emissions is thought to increase the risks undermining economic development in the regions of the country where coal accounts for a significant share of the energy balance, as well as worsen the investment appeal of those regions where energy-intensive production is located. At the same time, environmentalists agree that the problem of reducing hydrocarbon emissions should be seen not as a threat to the Russian economy, but rather as a possibility of structural changes in the energy industry, which requires focusing on the development of energy alternatives that will ensure economic and social development in these regions [20].

Another common misconception is that the introduction of the carbon tax or carbon credit mechanism will lead to higher electricity and heat prices and lower rates of economic development in the country due to the additional financial burden on consumers. To refute the above, I.A. Bashmakov et al. cite the economic situation in the majority of European countries that make use of the carbon tax as an example.
In addition, in the medium term, higher electricity prices for end users, all other things being equal, will stimulate the development and application of energy-saving technologies, which will also contribute to the achievement of sustainable energy development goals.

The small changes in CO₂ emissions observed in Russia over the last 20 years are mainly due to structural changes in the economy and real GDP dynamics (see Fig. 3), rather than step changes in the operation of the national energy system.

![Figure 3. Dynamics of CO₂ emissions and GDP in Russia](image)

Source: calculated by the authors based on the data by BP and Rosstat.

According to the published research [22], in most OECD countries the set of existing environmental taxes (fuel excises, pollution taxes, etc.) is supplemented by the carbon tax for energy producers. In the Scandinavian countries, the carbon tax was introduced in 1990-1991 to supplement existing energy taxes. Originally, its rate was approximately 11-13% of the energy tax amount. The tax rate was reduced by 25% for companies that signed long-term energy-saving agreements with the government. The amount of funds collected as the carbon tax was partly spent on earmarked subsidies for the introduction of environmentally friendly technologies (40%), and partly (60%) returned to the industry for the implementation of measures to improve overall production efficiency. Since the introduction of the carbon tax to date, CO₂ emissions in the energy sector in European countries have dropped by more than a third while the GDP has grown by nearly a half.

Today, the average effective carbon tax rate for all sectors of the economy in 41 countries considered in the OECD study is 14.4 EUR per CO₂ ton, but the current level of tax proceeds still does not correspond to the real costs of eliminating losses that are caused by climate change [23].

Taking into account the experience of other countries, it can be noted that the successful introduction of the carbon tax largely depends on the systematic approach to reforming the existing taxation in accordance with the principles of the concept of sustainable development. According to some experts [16, 24-25], reforming of the Russian taxation should provide for the following:

1. A unified concept of environmental taxation should be developed, including clearly defined goals and objectives, which should be aimed at achieving sustainable economic development based on environmentally friendly and resource-saving technologies.
2. The current energy and natural resource taxes should be converted to the environmental taxes.
3. The introduction of the carbon tax should be carried out in accordance with the principle of fiscal neutrality, i.e. it should be accompanied by a reduction of rates for a number of existing taxes.
4. The carbon tax rate should correspond to the economic damage caused by each additional unit of CO₂ emissions.

5. Mechanisms for monitoring environmental damage need to be improved and a system of environmental tax policy performance indicators needs to be developed, including, for example, indicators for reducing pollution and resource consumption, assessment of the level of environmental tax revenue, the emergence and degree of activity in the use of new energy-saving technologies, etc.

1.3. Development of Digital Technology as a Factor of Increasing the Adaptability of the National Energy System for the Successful Introduction of Environmental Taxes in Russia

As shown above, the transition to sustainable energy requires the introduction of the environmental taxes in Russia. However, the degree of success and effectiveness of the use of the environmental tax as a tool for managing impacts on the energy system depends directly on its level of adaptability. The adaptability of a national energy system is understood as its ability to withstand stress while continuing to operate normally. In the process of adaptation, technical and organizational changes are taking place in the system, through which it can effectively meet the economy's energy needs under new conditions [26]. The low adaptability of the energy system, including its inability to respond adequately to changes and to develop resource-saving technologies, can lead to the introduction of environmental taxes having a negative, destabilizing impact on the energy system. The implementation of public policies aimed at increasing the adaptability of the national energy system will prepare the energy system for the introduction of a new management tool for the system, such as the environmental tax, contribute to a gradual transition to sustainable energy, and ensure the country's long-term energy security.

Realizing that high adaptability of the national energy system cannot be ensured without following current trends in the world economy and energy, in recent years the government has embarked on the modernization of the Russian power sector. In order to set the stage for the introduction of digital technology in the energy sector, within the framework of the national program "Digital Economy of the Russian Federation" approved in 2017, the Ministry of Energy of Russia has formed a departmental project "Digital Energy", aimed at transforming the energy infrastructure through the introduction of digital technology to improve its efficiency and safety.

The development and implementation of digital technology are fundamentally changing the configuration and properties of power supply systems and blur the line between power producers and consumers. The main new features of energy systems are:

1) demand response. It is a mechanism of communication between the consumer and the producer that allows the consumer to change their own power consumption on the basis of information about the parameters and capabilities of the energy system, which helps to reduce peak loads and the need to introduce new capacity [27].

2) distributed generation. The dissemination of digital technology enables consumers to have their own production, as well as to store and sell electricity. This contributes to the reduction of losses in electric power transmission, flexible response to the change in demand, and an increase in reliability of energy supply [28].

3) smart charging. This is a system of communication with the energy system that enables electric vehicles to be connected and disconnected depending on the price and other parameters of the energy system. If two-way battery charging is available, the electric vehicle can act as an energy source, which provides a number of economic, environmental, and operational benefits [29].

The process of energy digitalization, accompanied by the adoption of new technologies, changes in information security standards for energy systems, the emergence of new participants in the electricity markets, and changes in requirements for facilities and infrastructure of electricity markets, has led to the need to improve relevant legislation. For example, in 2018, Federal Law No. 35-FZ "On Electric Power
Industry" of March 26, 2003 had a number of amendments introduced into it with respect to the regulation of relations in the wholesale and retail electricity markets, with unified requirements for intellectual devices and systems for electricity metering introduced as well.

The growing complexity of the system as a result of new elements and interconnections may produce additional risks and have negative consequences. To ensure long-term stability and adaptability of the Russian energy system, it is necessary, to establish, particularly but not exclusively by legislative action, the rules and mechanisms of interaction between energy system elements and electricity market participants. In this connection, a number of state programs of strategic development of Russia, have been amended to improve the reliability of the domestic market's energy needs following the principles of energy conservation and energy efficiency as applied to the different stages of the process of production, transportation, and consumption of energy resources, with directions for further work identified. Among them are the following: improvement of the regulatory framework and reduction of administrative and other barriers for the purpose of attraction of investments in the energy industry; setting of target guidelines for investments in fixed capital in different industries of the energy sector; implementation of a number of measures to ensure sustainable energy supply to consumers in certain areas of the Russian Federation, as well as the development of the main power network; development and implementation of measures to stimulate electricity production based on the use of renewable energy sources.

2. Conclusion

Achieving sustainable development by Russia is impossible without coordinated tax and technology policies. Reforming the tax system through the introduction of environmental tax will make it possible to adjust energy production processes that are undesirable for the society and reduce the use of environmentally harmful technologies in the energy industry. Taking into account the experience of other countries, the conversion of a number of non-tax environmental levies and payments into taxes can only be called the first stage of the environmental reform of Russian taxation aimed at setting the stage for the transition to sustainable development. In order for the introduction of environmental taxes to become effective and have the desired impact on the Russian energy industry towards greater greening and adaptation, a number of theoretical aspects need to be worked out that take into account the current taxation scheme and tax burden compensation mechanisms.

The dissemination of digital technology in energy production (primarily that based on renewable energy sources) and consumption, the emergence of intelligent systems of control and linking of consumers and producers in energy systems fundamentally alter and complicate the organizational and technological structure of the energy industry and require closer attention to the problem of increasing energy adaptability.

It seems that the development and introduction of intelligent energy systems will contribute to the improvement of greening and adaptability of the national energy system and will facilitate the transition of energy and economy to the path of sustainable development.

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