Социально-экологические проблемы устойчивого развития

Social and environmental problems of sustainable development

УДК 620.9

ВЛИЯНИЕ ЭКОНОМИЧЕСКИХ, ТЕХНОЛОГИЧЕСКИХ, СОЦИАЛЬНЫХ И ЭКОЛОГИЧЕСКИХ ФАКТОРОВ НА РАЗВИТИЕ ЭНЕРГЕТИКИ В РЕСПУБЛИКЕ БЕЛАРУСЬ

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Изучается влияние экономических, технологических, экологических и социальных факторов на развитие энергетического сектора путем совершенствования методологии устойчивого энергетического развития. Под устойчивым энергетическим развитием автор понимает улучшение саморегулирующейся системы энергоснабжения и энергопотребления, обеспечивающей энергетическую безопасность, одинаково доступное удовлетворение энергетических потребностей и стремлений всех слоев общества к сохранению окружающей среды. Факторы устойчивого энергетического развития разделены по следующим критериям: по направлению воздействия (внешние и внутренние); по сфере, к которой они относятся (экономические, технологические, социальные и экологические); по принципам оценки устойчивого энергетического развития (доступность ресурсов, направления социально-экономического развития, спрос на энергоресурсы, энергетическая безопасность). При предлагаемом автором методе расчета интегрального показателя, характеризующего устойчивое энергетического развитие, каждому из факторов (экономические, технологические, социальные и экологические) присваивается одинаковый вес. Проведен динамический анализ устойчивого эренгетичисего развития Республики Беларусь в 2010–2019 гг., который в 2019 г. вырос на 4 % по сравнению с 2010 г. В разрезе отдельных факторов наблюдается следующая динамика:

1) экономические факторы: наибольшее значение было достигнуто в 2011–2012 гг. (0,432), наименьшее наблюдалось в 2013 г. (0,385);

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2) технологические факторы характеризуются значительной степенью неравномерности: самое высокое значение было достигнуто в 2019 г. (0,418), наименьшее наблюдалось в 2014 г. (0,336);

3) уровень социальных факторов существенно не изменился: самое высокое значения в 2014 г. (0,949), самое низкое значение наблюдалось в 2010 и 2019 гг. (0,923);

4) экологические факторы устойчивого энергетического развития имели положительную динамику: их уровень увеличился в 2019 г. по сравнению с 2010 г. на 4,37 % с 0,559 до 0,585.

По результатам анализа сформулированы меры, направленные на устойчивое энергетическое развитие Республики Беларусь:

1) развитие электротранспорта. На сегодняшний день в стране эксплуатируется около 3100 транспортных средств с электрическим приводом;

2) использование электроэнергии в жилищном строительстве для отопления и горячего водоснабжения;

3) полная электрификация железнодорожного транспорта. В настоящее время этот показатель составляет около 25 %;

4) создание и развитие энергоемких отраслей промышленности (водородная энергетика, цементная промышленность, цветная металлургия, химическая промышленность и т. д.).

Ключевые слова: устойчивое энергетическое развитие; факторы; интегральный показатель; динамический анализ; меры.

THE IMPACT OF ECONOMIC, TECHNOLOGICAL, SOCIAL AND ENVIRONMENTAL FACTORS ON THE DEVELOPMENT OF THE ENERGY SECTOR IN THE REPUBLIC OF BELARUS

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The article is devoted to the study of the influence of economic, technological, social and environmental factors on the development of the energy sector by improving the methodology of sustainable energy development. By sustainable energy development, the author understands the development of a self-regulating system of energy supply and energy consumption, ensuring energy security, equally affordable satisfaction of energy needs and aspirations of all segments of society to preserve the environment. The factors of sustainable energy development are divided according to the following criteria: by the direction of impact (external and internal); by the sphere to which they relate (economic, technological, social and environmental); by the principles of assessing sustainable energy development (availability of resources, directions of socio-economic development, demand for energy resources, energy security). With the method proposed by the author for calculating the integral indicator characterizing sustainable energy development, each of the factors (economic, technological, social and environmental) is assigned the same weight.

A dynamic analysis of the sustainable economic development of the Republic of Belarus in 2010–2019 was carried out, which, in general, in 2019 increased by 4 % compared to 2010. In the context of individual factors , the following dynamics is observed.

1. Economic factors: the highest value was achieved in 2011–2012 (0.432), the lowest was observed in 2013 (0.385).

2. Technological factors are characterized by a significant degree of unevenness: the highest value was achieved in 2019 (0.418), the lowest was observed in 2014 (0.336).

3. The level of social factors has not changed significantly: the highest values in 2014 (0.949), the lowest value was observed in 2010 and 2019 (0.9234)

4. Environmental factors of sustainable energy development had positive dynamics: their level increased in 2019 compared to 2010 by 4.37 % from 0.559 to 0.585.

Based on the results of the analysis, measures aimed at sustainable energy development of the Republic of Belarus are formulated.

1. Development of electric transport. Currently, about 3,100 electric-powered vehicles are in operation in the republic.

2. The use of electricity in residential construction for heating and hot water supply.

3. Complete electrification of railway transport. Currently, this figure is about 25 %.

4. Creation and development of energy-intensive industries (hydrogen energy, cement industry, non-ferrous metallurgy, chemical industry, etc.).

Keywords: sustainable energy development; factors; integral indicator; dynamic analysis; measures.

Introduction

Energy consumption is a prerequisite for the existence of humanity. The energy available for consumption has always been necessary to meet human needs, increase the duration and improve the conditions of human life.

The main ways of energy impact on the environment are as follows.

1. The main volume of energy is still received by mankind using of non-renewable resources.
2. Pollution of the atmosphere: thermal effect, emission of gases and dust into the atmosphere.
3. Pollution of the hydrosphere: thermal pollution of water bodies, emissions of pollutants.
4. Pollution of the lithosphere during the transportation of energy carriers and the disposal of waste, during the production of energy.
5. Contamination by radioactive and toxic waste to environment.
6. Changes in the hydrological regime of rivers by hydroelectric power plants and, as a consequence, pollution on the territory of the watercourse [1].
7. Creation of electromagnetic fields around power lines.

In modern society, work to determine and implement a given quality of life is carried out through the introduction of standards (indices). Quality of life standards are a quantitative expression of qualitative categories.

The basic components of the quality of life include the following: income level of the population; development level of the consumer market; provision of housing to the population and the quality of housing condition; the state of the natural environment; provision of basic material benefits to the population; development level of health care and education; the state of the labor market and migration attractiveness.

Currently, there are many methods for assessing the population quality of life, their key difference in the composition of factors that determine the quality of life, and used to calculate the indicators. These methods have their advantages and disadvantages, but none of them is considered generally acceptable which indicates the need for further search and development of methods for assessing the quality of life.

Despite the lack of a single unified approach, it can be noted that almost all approaches partially take into account the environmental and energy components.

In the modern world, the number of countries striving for environmentally sustainable economic development is increasing. Therefore, considering of the impact of energy and the environmental factors, the use of indicators showing a complete and accurate reflection of the living quality of the population becomes relevant. In this regard, in our opinion, when assessing the quality of life, it is important to take into account the level of energy saving and the environmental and climatic components derived from it.

Ensuring socio-economic development, which can be assessed using such an indicator as the quality of life, should be based on reducing the level of resource consumption and, as a result, reducing the anthropogenic load on the natural environment [2].

The task of human development is to provide everyone with equal opportunities to realize their potential, to ensure access to a variety of resources for current generation development: information, natural, social and etc. As for the concept of human development, a person is considered both as an aim and as a means. This development, which puts a person at the center, requires for him and from him equally opportunities and responsibility.

Mankind everywhere looks for ways of profitable investment of funds (labor and investment) for profit and raising the quality of life of an individual or nation.

Research in the United States has shown that the impact of investments in infrastructure (energy, communications, utilities, transportation) on economic development manifests itself in unusually high (up to 60 %) rates of return [3].

Apparently for this reason, over the past 15 years in the world, the consumption of electricity and the number of telephone lines per capita in the household sector has doubled, and the access to the water supply network has increased by half. This progress contributes significantly to increased productivity and improved living standards.

The energy sector has potential opportunities to exert a strong and positive influence on the trajectory of overcoming the crisis and the further development of the country's economy, especially under favorable external condition. The rapid economic growth of the Third World countries observed in recent years will inevitably be accompanied by high demand for energy, in particular for oil and gas.

The standard of life of the country's population is most clearly reflected in the volume and the structure of consumption expenditures. After the recovery of the expenditure structure, which had degraded during the years of the crisis, its further change will take place in accordance with global trends towards a decrease in the share of food and an increase in the share of spending on housing and services.

In September 2015, the UN members adopted the 2030 Agenda for Sustainable Development [4]. It contains a number of goals to eradicate poverty, preserve the resources of the planet and ensure prosperity for everybody. One of the goals is to provide general access to affordable, reliable, sustainable and modern energy sources for all. Each of the 17 goals contains a number of indicators to be reached within 15 years.

In the context of energy development until 2030, in particular, this entails:

– ensuring universal access to affordable, reliable and modern energy services;
– substantially increasing the share of renewable energy in the global energy mix;
– doubling the global rate of improvement in energy efficiency;
– enhancing international cooperation to facilitate the access to clean energy research and technology including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and to promote investment in energy infrastructure and clean energy technology;

– expanding infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries.

The notion and the methodology to assess the sustainable energy development

There are a number of interpretations of this notion. We believe that the simplest and most accurate is the following: the sustainable energy development is the development of a self-regulating system of energy supply and energy consumption providing energy security, equally accessible satisfaction of energy needs and aspirations of all social strata about conservation of the environment.

This definition shows that sustainable energy development is a wider concept than energy security, for the reason that in addition to economic, technological and political factors it also includes ecological and social ones. Besides, energy supply and energy consumption are considered as interdependent parts of one system capable of self- regulation.

Moreover, sustainable development is subject to significant influence of a number of global energy risks, including:

– expansion of the energy system scale;

– threat of an imbalance between energy demand and supply, especially in terms of oil fuel;

– high level and instability of the world oil prices, the end of the cheap oil and gas era;

– disproportions in the world energy infrastructure because of hydrocarbon resources – concentration in the areas remote from the main centers of consumption;

– 90 % of the world GDP is produced in the countries importing energy resources;

– risks of natural and technogenic catastrophes and system accidents, in part because of – terrorist and subversive actions;

– negative environmental impact of energy;

– wide scale of energy poverty which means 2 billion people lacking the opportunity to use energy services in acceptable commercial and technological conditions [5].

The theory and practice of applying the concept of sustainable development in energy have variousapproaches to understand and methods to assess the condition of the given sector from the point of view of sustainable development. The issues of sustainable energydevelopment were considered in the studies conducted by such experts as D. L. Green [6], I. Dincer [7], S. Connors [8], M. V. Myasnikovich [9], K. Prandecki [10], H. Rogall [11], G. W. Frey [12], etc. The methodologies for assessmentof sustainable energy development were worked out by the World Energy Council [13], Georgia Institute of Technology, USA [14] etc.

At the same time, the existing approaches are focused on the determination of separate elements and factors characterizing sustainable energy development rather than on comprehensive consideration of this phenomenon.

Based on an analysis of the studies carried out by national and foreign scientists, we have identified the indicators of sustainable energy development.

All these factors can be divided into the following categories:

1) by the direction of influence – into external and internal ones;

2) by the sphere they relate to – into economic, technological, social, and ecological ones;

3) by the assessment principles of the sustainable energy development – into availability of resources, the directions of social and economic development, demand for energy resources, energy security.

A method to calculate the indicators of sustainable energy development is presented in table 1.

Table 1

Classification and the method to calculate the indicators characterizing sustainable energy development

Factor	Indicator	Explanations concerning calculation
Economic	Availability of credit resources	Difference of 1 and the average interest rate for the credits and deposits of banks in national currency
	Share of energy in GDP	Ratio of the sum of the energy industries output to the total output
	Return on energy sales	Ratio of the sum of the energy industries gross profit to the total energy industries gross revenue
	Share of non- dominant energy resources in the total energy resources import	Difference of 1 and the share of the dominant energy resource in the total energy resources import
Technological	Share of own energy resources in the total energy consumption	Difference of 1 and the share of the imported energy resources in the total energy consumption
	Share of investment in energy	Ratio of investment into the energy industries to the total investment
	Energy-GDP ratio	Difference of 1 the ratio of energy consumption in national currency to GDP
	Share of capacities not involved in the energy industry	Difference of 1 and the ratio of the sum of primary oil refining volume, electricity production, gas through gas pipelines transportation volume and oil through oil pipelines transportation volume converted to uniform measurement units, to the total capacities for primary oil refining, electricity generating capacities, gas pipelines capacity and oil pipelines capacity converted to uniform measurement units

Ending table 1

Factor	Indicator	Explanations concerning calculation
Social	Employment rate	Difference of 1 and the share of the unemployed in the total labor force
	Education	Difference of 1 and the share of the uneducated in the total labor force
	Availability of fuel and energy for population	Difference of 1 and the relation of fuel and energy expenses to the total expenses of households
	Population electrification rate	Share of the population having access to electricity
Ecological	Forest area level	Share of the forest area in the total land area of the country
	Life expectancy	Share of the population seeking medical care
	Coefficient of reducing energy resources consumption	Difference of 1 and the ratio of energy resources consumption for the reporting period to that in the previous year
	CO_2 emissions caused by energy consumption per capita	Difference of 1 and volume of CO2 emissions from energy consumption divided by the population number

The weight of the indicators is determined by the method of group expert assessment at direct estimation. At the same time, each expert establishes preferences of indicators when comparing all possible pairs, i.e. considering all possible pairs of indicators the expert establishes in each of them the reason, which, according to their opinion, exerts a greater influence on the result [12].

According to the concept of sustainable development [4] and taking into account the specific features of energy distinguishing it from other industries (involvement in provision of the national security, mandatory generating capacity reserve, etc.), the economic, technological, social and ecological aspects are equivalent. In this regard, the identical weight equal to 0.25 is assigned to each of the factors.

In this stage, the index is calculated according to the following formula 1:

$$I = \sum_{j=1}^{k} z_j \sum_{i=1}^{m} x_{ij} f_{ij}, \quad (1)$$

where I – index of sustainable energy development;

z_j – weight of j factor;

x_{ij} – weight of i indicator for j factor;

f_{ij} – value of i indicator for j factor;

k – number of factors; m–number of indicators.

The following formula is carried out to reduce values of each indicator to a uniform range normalization of basic data:

$$x_{i,0-1} = \frac{x_i - x_{min}}{x_{max} - x_{min}}, \quad (2)$$

where $x_{i,0-1}$ –normalized value of x_i indicator;

x_i – reference value of an indicator;

x_{min} – the minimum value of an indicator among basic data;

x_{max} – the maximum value of an indicator among basic data.

The analysis of the level of sustainable energy development of the Republic of Belarus

On the basis of the given methodology, the index of sustainable energy development for the Republic of Belarus in 2010–2019 was calculated (table2). Sources of information for calculating the index were the data of the National Statistical Committee of the Republic of Belarus, the Ministry of Energy of the Republic of Belarus, as well as information from open sources.

Table 2

Initial data and calculation results of the index of sustainable energy development for the Republic of Belarus in 2010–2019

Indicator	Weight	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Group indicators characterizing economic factors	0.250	0.421	0.432	0.432	0.385	0.411	0.397	0.394	0.421	0.421	0.423
Availability of credit resources	0.285	0.908	0.864	0.805	0.809	0.785	0.737	0.771	0.877	0.894	0.895
Share of energy in GDP	0.194	0.177	0.220	0.221	0.157	0.108	0.116	0.110	0.105	0.111	0.100
Return on energy sales	0.306	0.075	0.106	0.151	0.085	0.124	0.100	0.092	0.087	0.082	0.098
Share of non- dominant energy resources in the total energy resources import	0.215	0.488	0.514	0.529	0.459	0.595	0.623	0.580	0.577	0.558	0.553

Ending table 2

Indicator	Weight	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Group indicators characterizing technological factors	0.250	0.356	0.366	0.353	0.369	0.336	0.346	0.379	0.389	0.374	0.418
Share of own energy resources in the total energy consumption	0.267	0.150	0.150	0.130	0.145	0.150	0.142	0.147	0.154	0.155	0.165
Share of investment in energy	0.276	0.114	0.155	0.122	0.124	0.134	0.163	0.213	0.243	0.204	0.200
Energy-GDP ratio	0.285	0.790	0.790	0.790	0.806	0.808	0.817	0.814	0.814	0.811	0.830
Share of capacities not involved in the energy industry	0.172	0.343	0.335	0.348	0.383	0.168	0.176	0.286	0.282	0.263	0.480
Group indicators characterizing social factors	0.250	0.923	0.929	0.934	0.941	0.949	0.946	0.945	0.943	0.943	0.923
Employment rate	0.210	0.993	0.994	0.995	0.995	0.995	0.990	0.992	0.995	0.995	0.980
Education	0.198	0.812	0.817	0.820	0.820	0.837	0.837	0.841	0.841	0.838	0.860
Availability of fuel and energy for population	0.372	0.896	0.910	0.922	0.941	0.951	0.947	0.942	0.934	0.936	0.880
Population electrification rate	0.220	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Group indicators characterizing ecological factors	0.250	0.559	0.561	0.561	0.564	0.577	0.579	0.570	0.569	0.569	0.585
Forest area level	0.404	0.425	0.427	0.429	0.431	0.416	0.417	0.421	0.422	0.423	0.463
Life expectancy	0.138	0.763	0.765	0.767	0.768	0.818	0.829	0.832	0.837	0.838	0.838
Coefficient of reducing energy resources consumption	0.156	0.000	0.000	0.000	0.011	0.083	0.082	0.013	0.000	0.000	0.000
CO_2 emissions caused by energy consumption per capita	0.302	0.934	0.935	0.934	0.934	0.935	0.936	0.935	0.936	0.935	0.935
Index of sustainable energy development		0.565	0.572	0.570	0.565	0.568	0.567	0.572	0.580	0.577	0.588

As shown in fig. 1, the level of sustainable energy development of the Republic of Belarus during the study period tended to grow and reached its highest value in 2019 (0.588). Insignificant declines in the level of sustainable energy development during the period under study were observed in 2013 (0.565), 2016 (0.572) and 2018 (0.577). In general, in 2019 the level of sustainable energy development of the country increased by 4 % compared to 2010.

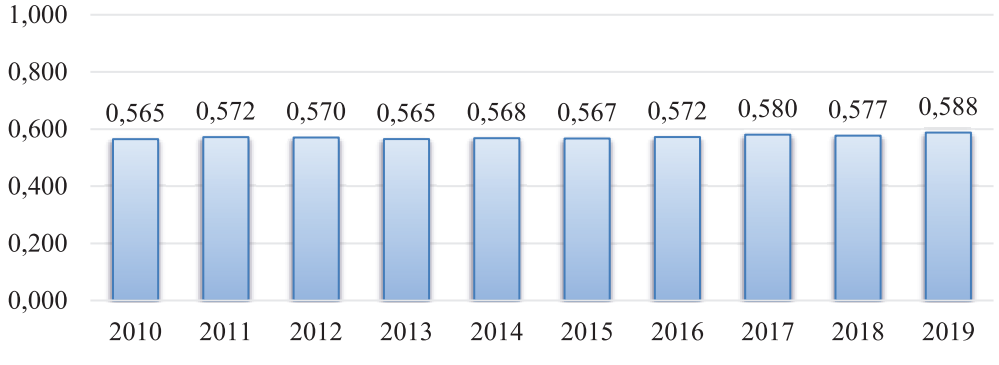

Fig. 1. Index of sustainable energy development for the Republic of Belarus in 2010–2019

For a more detailed analysis, let us consider the dynamics of group indicators for various factors characterizing the sustainable energy development of the Republic of Belarus.

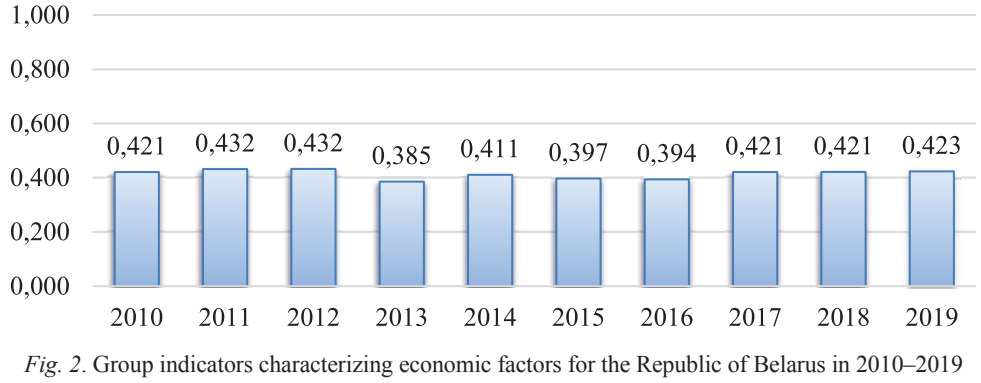

Fig. 2. Group indicators characterizing economic factors for the Republic of Belarus in 2010–2019

Analyzing the economic factors of sustainable energy development of the Republic of Belarus for 2010–2019 (fig. 2), we can conclude that they are characterized by a significant degree of unevenness. Its highest value was achieved in 2011–2012 (0.432), the smallest was observed in 2013 (0.385). In general, in 2019 the group indicator increased slightly by 0.5 % compared to 2010.

With regard to technological factors (fig. 3), the Republic of Belarus in 2010–2019 they are also characterized by a significant degree of unevenness. Its highest value was achieved in 2019 (0.418), the smallest was observed in 2014 (0.336). In general, in 2019 the group indicator increased slightly by 24.4 % compared to 2010.

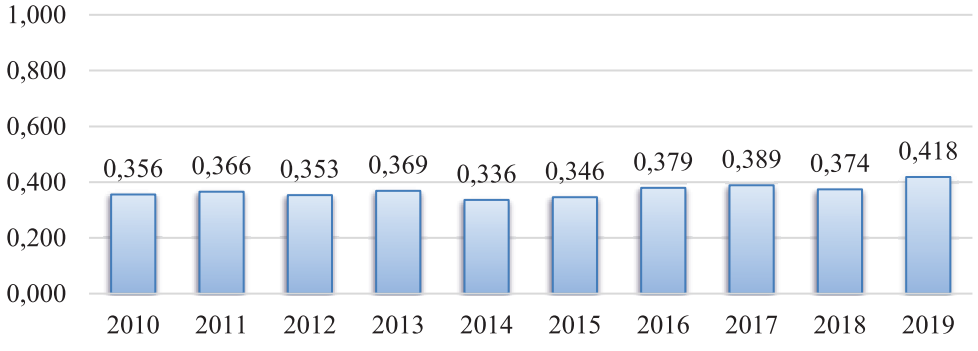

Fig. 3. Group indicators characterizing technological factors for the Republic of Belarus in 2010–2019

The level of social factors of sustainable energy development of the Republic of Belarus in 2010–2019 (fig. 4) did not change significantly. This indicator reached the highest value in 2014 (0.949), the lowest value was observed in 2010 and 2019 (0.923). It should be noted that this indicator decreased in 2019 by 2.1 % against the level of 2018. Among social indicators, in 2019 compared to the base period, the employment rate decreased by 1.3 %. The level of education increased by 5.9 %. The population electrification rate has the highest possible value over the study period. The availability of fuel and energy for population decreased by 1.8 %.

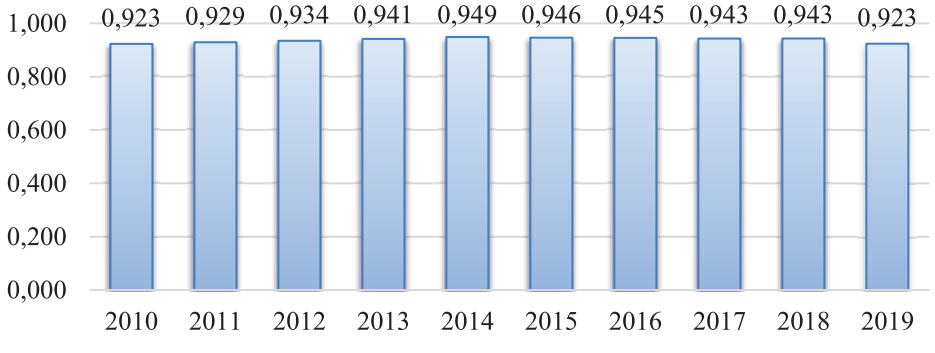

Fig. 4. Group indicators characterizing social factors for the Republic of Belarus in 2010–2019

Regarding environmental factors of sustainable energy development in 2010–2019 (fig. 5), they had a positive trend. Their level increased in 2019 compared to 2010 by 4.37 % from 0.559 to 0.585. Among ecological indicators, in 2019 compared to the base period, the forest area level increased by 8.9 %. The life expectancy increased by 9.8 %. The coefficient of reducing energy resources consumption has the lowest possible value over the study period. The level of CO_2 emissions caused by energy consumption per capita did not fluctuate significantly.

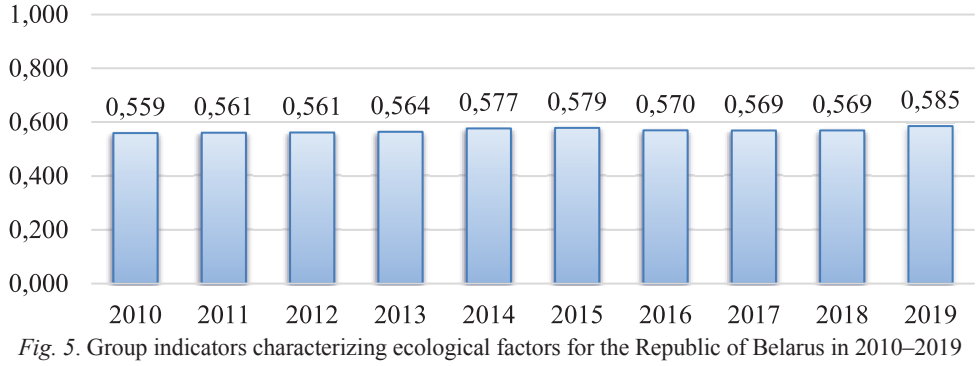

Fig. 5. Group indicators characterizing ecological factors for the Republic of Belarus in 2010–2019

The promising directions of sustainable energy development of the Republic of Belarus

The results of the study showed that economic, technological, social and environmental parameters are the basis for sustainable energy development in the Republic of Belarus. In this regard, the entry into commercial operation of the Belarusian NPP will contribute to the improvement of a number of indicators: «share of non-dominant energy resources in the total energy resources import», «share of own energy resources in the total energy consumption», «share of investment in energy», «share of capacities not involved in the energy industry», «ыemployment rate», «education» and «availability of fuel and energy for population».

At the same time, the entry into commercial operation of the Belarusian NPP is complicated by a number of external factors:

1. At present, it is impossible to export electricity from the Republic of Belarus to the countries of the European Union.

2. Rather low level of electricity consumption in the country in recent years (37 billion kWh with the installed capacity of the Belarusian energy system after beginning of NPP commercial operation – 12,413.99 MW).

Thus, in order to stimulate energy consumption to ensure efficient operation of energy generating capacities in the Republic of Belarus, it is necessary to implement a number of measures.

1. Development of electric transport. At present there are about 3,100 electrically-powered vehicles operating in the Republic.

2. Use of electricity in residential construction for heating and hot water supply. The construction of residential buildings with the use of electricity for these needs is planned at the level of 1.5 million square meters.

3. Full electrification of railway transport. Currently, this indicator is about 25 %.

4. Creation and development of electricity intensive industries (hydrogen energy, cement industry, non-ferrous metallurgy, chemical industry, etc.).

Conclusion

The proposed index allows one to assess the current level of sustainable energy development and study its dynamics over the years, as well as compare the position of the country with other countries. The integral index, which characterizes the level of sustainable energy development, includes not only economic, social and environmental groups of indicators which are traditional for sustainable development, but also technological ones separated into a separate group. The index balances indicators for external and internal factors. The sustainable energy development of the country can be assessed both as a whole and by individual factors and subsystems of indicators. One of the stages of the methodology is the standardization of indicators, which allows them to be brought to a single range. The use of this index is advisable when developing a policy for sustainable energy development.

As shown by the study, the level of sustainable energy development of the Republic of Belarus in the period 2010–2019 had a fairly stable upward trend and in 2019 it reached a value of 0.588, which indicates the average level of sustainable energy development of the Republic of Belarus. For further sustainable energy development of the Republic of Belarus, it is advisable to diversify energy resources, increase the share of electricity in the structure of final energy consumption, increase investments in the energy sector and reduce energy prices for consumers.

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