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**ANALYSIS OF THE EXPERIENCE OF FINANCIAL INSTRUMENTS USE FOR
MODERNIZATION OF THE POWER-ELECTRICITY SECTOR OF THE ISLAND
COUNTRIES OF THE CARIBBEAN BASIN**

Abstract. The results of the author's systematization of the experience of the Caribbean countries regarding the introduction and use of financial instruments for stimulating the modernization of the electricity generation sector are presented within the article. The assumption about the presence of additional factors of stimulating activity of the state is formulated, which stipulates the lack of identity of the effective transformations of the energy matrix, even with the introduction of a similar number of financial instruments. It is proposed to include the objective realities of economic reality and the internal intrinsic differences between the instruments themselves to the mentioned factors.

Keywords: renewable generation technologies, power engineering, modernization, governmental policy, financial instruments.

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**АНАЛІЗ ДОСВІДУ ВИКОРИСТАННЯ ФІНАНСОВИХ ІНСТРУМЕНТІВ
ДЛЯ МОДЕРНІЗАЦІЇ ЕЛЕКТРОЕНЕРГЕТИЧНОГО СЕКТОРУ ОСТРІВНИХ КРАЇН
КАРИБЬСЬКОГО БАСЕЙНУ**

Анотація. У статті викладені результати авторської систематизації досвіду країн Карибського регіону щодо запровадження та використання фінансових інструментів стимулювання модернізації сектору виробництва електричної енергії. Сформульовано припущення про наявність додаткових факторів стимулювальної активності держави, що обумовлюють неідентичність результативних трансформацій енергетичної матриці навіть за умов запровадження аналогічної кількості фінансових інструментів. До згаданих факторів пропонуємо віднести об'єктивні реалії економічної дійсності та внутрішні сутнісні відмінності між самими інструментами.

Ключові слова: відновлювані технології генерації, електроенергетика, модернізація, урядова політика, фінансові інструменти.

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**АНАЛИЗ ОПЫТА ИСПОЛЬЗОВАНИЯ ФИНАНСОВЫХ ИНСТРУМЕНТОВ
ДЛЯ МОДЕРНИЗАЦИИ ЭЛЕКТРОЭНЕРГЕТИЧЕСКОГО СЕКТОРА ОСТРОВНЫХ
СТРАН КАРИБСКОГО БАСЕЙНА**

Аннотация. В статье изложены результаты авторской систематизации опыта стран

Карибского региона в отношении внедрения и использования финансовых инструментов стимулирования модернизации сектора производства электрической энергии. Сформулировано предположение о наличии дополнительных факторов стимулирующей активности государства, которые обуславливают неидентичность результативных трансформаций энергетической матрицы даже в условиях внедрения аналогичного количества финансовых инструментов. К числу упомянутых факторов предлагается относить объективные реалии экономической действительности и внутренние сущностные отличия самих инструментов.

Ключевые слова: возобновляемые технологии генерации, модернизация, правительственная политика, финансовые инструменты, электроэнергетика.

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Introduction. The electricity generation sector is an important component of the economy of each country – the volumes and stability of electricity generation, as a universal energy resource, largely determine the production potential of other industries and public welfare. Scientific and technological progress occasionally causes the re-equipment of production and the transition to the use of new technologies. It is now in the world that there is a technological re-equipment of the electric power industry, the general reference point of which is the transition to more environmentally sustainable technologies based on the use of renewable energy sources. It so happened that for Ukraine, this stage of development of the world's electric power industry coincided in time with the exhaustion of the production resource of the bulk of generating capacity, as evidenced by the financial statements of generating companies [1]. That is, in domestic conditions, an extremely topical issue is not only technological but, at least, technical rearmament of the industry. However, the modernization of the power industry on the necessary scale is connected with the need to attract enormous amounts of financial resources, which is complicated by the existing economic and political situation. Therefore, it is extremely valuable and relevant to consider the study of foreign experience of using financial instruments to stimulate sector modernization.

Actual scientific research and issues analysis. The instruments for stimulating the modernization of electric power industry are the subject of a wide range of research of the scientific community of the world and Ukraine. Scientific publications of recent years are devoted both to covering some aspects of the use of sector modernization tools [2; 3], and complex estimation of their variability [4; 5]. Relevant topics aroused the interest of scientists in the post-Soviet space [6–8]. However, with all the attention given to the scientific community regarding the use of financial instruments for the modernization of electricity, a systematic study of this problem has not yet been carried out. Assessing the experience of the island Caribbean countries in this area and formulating a conclusion on the effectiveness of individual instruments, as well as the factors that determine it, are in fact the goal of the presented study. The basis for achieving this goal is to assess the effectiveness of the use of financial instruments for the modernization of electricity, which is proposed to be determined by the technological structure of production.

Results of the research. In the Caribbean, there are 13 independent island states. Most of them are characterized by a number of features that impose a significant imprint on the development of electricity. First, the countries are located on the islands, which complicates the transport and supply of both primary energy sources and inter-island transmission of electricity. Most of the island countries of the Caribbean region have a rather small area (the area of seven out of thirteen countries does not reach thousands of square kilometers), most of them are often without significant reserves of fossil resources, including fuel. An important threat to human life and economic activity is weather conditions. Hurricanes that cause significant damage and destruction are quite frequent in the region. On the other hand, placement in relative proximity to the equator and the volcanic nature of many islands leads to the rich potential of renewable energy sources. The Earth's surface in this zone receives a significant amount of solar energy, constant trade winds make promising wind power, and volcanoes allow the use of geothermal potential. However, governments in the countries have radical differences in their actions in relation to electricity. If in some countries its problems and development are dealt with quite seriously, then in others it is left to false, regardless of its importance to the economy. The difference in ratio is followed even in the plane of statistics. If in Dominica, Cuba and in the Dominican Republic information provision of state regulation is formed consistently and thoroughly, then the Bahamian government has no relevant data and, even by the

development of its energy policy in 2012-2013, was forced to restrict itself to the 2009 data on a part (85% of generation) of the electricity sector [9]. The described situation with the Bahamas is not an isolated case; the same can be observed in Antigua and Barbuda, Saint Lucia, Haiti, Saint Kitts and Nevis, Trinidad and Tobago.

The statistics show a very heterogeneous development of electricity in the region. The electricity production per capita rate per country varies from 5900 to 68 kWh per year.

Cuba has the largest generation volumes in the region (20,288 GWh in 2015), but this country also has the largest area and population, which pushes it to the seventh place in terms of electricity generation per person (1770 kWh). The core of Cuban electricity is thermal technology. The share of power plants operating on combustible raw materials, in the total volume of generation – almost 100%. However, the transformation of the energy matrix that has been observed over the past 15 years has led to a tangible revision of the raw material base [10; 11]. More than twenty percent, of the reduction of the share of fossil fuels in the structure of Cuba's generation was offset by a similar increase in the share of other producers, the basis of which evidently forms the generation of sugar cane processing waste [11, p. 7]. The production of electricity from biomass is considered to be more environmentally sustainable than burning fossil fuels. Without going into the detailed consideration of this issue, it is worth emphasizing, however, that biomass as a primary energy carrier also has significant disadvantages (the release of carbon monoxide into the atmosphere and the depletion of soils). The development of technologies that would involve the use of other renewable sources in Cuba is not observed. There is also no deliberate state policy on electricity modernization. The transition to biomass was apparently due to the reduction and increase in the cost of supplies of fossil fuels and their products. At the same time, the conversion of TPPs energy blocks onto new raw materials was not associated with significant capital requirements.

Electricity sector of Trinidad and Tobago (5,306 kWh in 2014) is the most powerful among the countries represented by the per capita production index. [10; 12]. In this country, significant volumes of natural gas are produced, and the government subsidizes its consumption. It is therefore quite natural that gas became the basis of the island's electricity industry. In the direction of modernization of the electric power industry, there are no government initiatives, although there are indications of instruments (tax, customs incentives and accelerated depreciation) that were used earlier [13].

The next country in terms of per capita production is the Bahamas (5050 kWh in 2014). [10; 12], they were mentioned above. The basis of electric power industry in its territory is the generation using natural gas, diesel and heavy petroleum products [13]. The tools used to stimulate the development of electricity are weakly effective, apparently because of the inconvenience for the monopoly network operator Bahamas Electricity Corporation. The power of the Bahamas, like many other countries, in terms of energy imports and high electricity prices, can be explained by the possibility of transferring the corresponding costs to tourists.

Barbados is the third country in terms of per capita electricity generation (2529 kWh in 2014.) [10; 12]. The volumes of the restored generation of Barbados are increasing, but are still insignificant. The island provides for a number of financial instruments for the modernization of the sector, but it is still based on TPPs with predominant use of natural gas and diesel. [14].

St. Kitts and Nevis are gradually developing solar radiation, although the basis of generating capacities is diesel generators. Production per capita in 2014 was 2607 kWh [10; 12]. So far, the most important tool for modernizing the country's power industry was the resources of international financial institutions, although the country also provides a "net" bill and taxes on fuel consumption [15, p. 11]. The efficiency of the electricity modernization policy of St. Kitts and Nevis can be considered relatively high.

Electricity production per capita in St. Lucia in 2014 was 2041 kWh [10; 12]. Almost 100% of electricity is produced by diesel generators, and there are no special tools to stimulate sector modernization. Saint Lucia is one of the countries that has not specified the tools of modernization of the electric power industry.

The electricity sector in Grenada in 2016 provided 2036 kWh per person [10; 16]. The mentioned volume of generation is not enough for the development of an important industrial complex on the island, but the life and the service sector are provided at an acceptable level. The basis of the Grenada Generation Complex (99% of production) are diesel generators, the share of renewable sources remains small,

although the pace of solar energy growth is high [16]. The position of the government of this country in relation to the modernization of the electric power industry is more active than in Cuba and Saint Lucia. In its framework, in addition to the traditional attraction of resources of international financial organizations [17, p. 7]. Special financial instruments are also used to stimulate investors: grants, concessions, VAT privileges, royalties from hydrocarbon sales [18, p. 17; 19, p. 4]. However, Grenada's policy on electricity modernization is essentially at an early stage and it is too early to assess the effectiveness of the use of the selected instruments.

In Dominica, electricity production per capita in 2016 amounted to 1522 kWh [10; 20]. The country has a powerful enough for its territory and population generating complex, the basis of which are diesel generators. The share of diesel generators in the structure of the installed capacity of the island increases, while the power of hydropower has declined not only in terms of value in the system, but also in absolute measure [20]. Therefore, there is a rather rapid development of the power industry in Dominica (the capacity of diesel generators has increased by a factor of 1.5), but there is no technological upgrade and revision of the energy matrix towards renewable technologies. The government has not introduced special tools geared towards technological modernization. Of the financial instruments used for the development of energy, it is possible to specify only loans from international financial institutions and budget resources [21; 22].

Jamaica is one of the largest island countries in the region, both in terms of area and population. The volume of electricity generation per person in 2016 amounted to 1512 kWh [10; 23]. A significant part of the electricity generation and the whole network on the island is controlled by the Jamaica Public Service Company (JPSC). According to statistical data [23] and JPSC statements [24], we can state the process of slow transformation of the technological structure of electricity production. For 2012-2016, there was a reduction in the absolute volume and share of generation from more environmentally sustainable sources – the share of hydro generation, gas turbines and other renewable and relatively stable sources decreased. Instead, the share of steam and diesel generators increased to 38.4%. The Jamaican government's policy on transforming the energy matrix and the development of the electricity industry is quite aggressive, along with the support of the global renewable energy stimulus trend, which introduced such instruments as: green tariff, system subsidy fund, tax incentives for imports of renewable generation equipment, "net" account, - also involves diversification of production through the use of natural gas and coal [13; 23; 25, p. 18, 26].

In the Dominican Republic in 2016, 1490kW of electricity per person was produced [10; 27]. The country's power and electricity sector is characterized by significant shifts both in terms of generation in general and in technological structure. From 2001 to 2016, installed power generation power increased by 30%, and its production – by 68%. At the same time, the country develops hydropower, solar and wind technologies – in 2016, the share of each in the structure of installed capacity was 16.6%, 0.5% and 2.9% respectively, although in 2001 the share of hydro generating capacity was 13, 0%, the development of wind energy started only in 2012, and the solar – in 2016. The share of steam and gas turbines for the same period decreased from 55% to 27.8% of the total installed capacity. There was also an increase in the share of diesel capacity from 23.6% to 31.2% and combined cycle capacity from 7.0% to 21.5%. In the actual production volumes, the largest weight was in 2001 (38.5%) and continued to hold diesel generators in 2016 (43.1%). Renewable technologies in 2016 already took over 11.6% of the total generation. Moreover, for all technologies during the years 2001–2016, significant fluctuations in the share of production are characteristic, which is obviously due to the market conditions for energy carriers. The wide technological spectrum of the available generating capacities in the Dominican Republic allowed maintaining a relatively stable total production. The wide technological spectrum of the available generating capacities in the Dominican Republic allowed maintaining a relatively stable total production [27].

The list of financial instruments of the state policy of modernizing the power industry of the Dominican Republic is presented in the Law No. 57-07 "On the Promotion of the Development of Renewable Energy Sources and Their Special Regimes" [28]. The law provides for such instruments: tax and customs privileges (Articles 9-12); loans from the renewable energy development and energy efficiency fund, which is formed by the tax on fossil fuels (Article 13); carbon certificates for emission reductions in the atmosphere (Article 14); special mode for renewable sources, which determine the rules

for connecting the generator to the network and settle with it (Articles 17-20); the share of renewable sources in the structure of purchasing electricity by distributors (Article 21); sanctions for violation of the law (Articles 30-31).

The transformation of the generating capacity and electricity generation sector discussed above suggests that the power industry modernization tools in the Dominican Republic are considered to be the most effective among all Caribbean island countries.

The basis of the energy sector of Antigua and Barbuda is thermal power plants. The government of this country in general plays a passive role in the development of electricity. The renewable energy of the islands is only emerging.

The electricity generation per capita in 2014 was 1213 kWh [10; 29]. Saint Vincent and the Grenadines in 2014 produced 1189 kWh per inhabitant [10; 12]. The policy of stimulating the modernization of electric power industry is rather weak as it involves only two instruments: the “green” tariff and the “net” account [13]. The weakness of the mentioned initiatives of the government quite logically provokes an increase in the share of traditional sources (diesel generators) in the structure of electricity generation by islands [30].

Against the background of the above countries, Haiti is allocated. The power and electricity sector in this country meets the energy needs at the minimum level (in 2014, only 69 kWh per person) [10; 12]. About 70% of the population has no access to electricity in general. The basis (71%) of the Haiti energy sector's supply of primary energy resources is firewood [31]. The Haitian power and electricity sector is opaque, initiatives to develop and implement financial instruments for sector modernization are weak, and their further fate is unknown.

We've got an opportunity to compare data on the financial instruments of the modernization of the electricity sector of each island state of the Caribbean region and the dynamics of the technological structure of electricity production (see Table 1).

Conclusions. The survey and systematization of the experience of the Caribbean island countries, the comparison of the governments' activities to stimulate the modernization of the power industry with the dynamics of the technological structure of generation, indicate the ambiguity of the results of the introduction of financial instruments for the development of modern technologies in the sector. On the one hand, the example of the Dominican Republic, which employs as many as six instruments, proves their expediency. Logically, the results of Saint Lucia, Dominica, and Jamaica are the same as in the mentioned above countries, there are at times fewer financial instruments for the modernization of the power and electricity sector. On the other hand, the number of financial instruments introduced in Antigua and Barbuda is similar, and the result is not observed. At the same time, there are no mention of special financial instruments for Cuba, and a significant technological transformation of the sector took place. Therefore, the introduction of financial instruments for the modernization of the electric power industry is not a guarantee of future transformations. Similarly, government activity in stimulating the modernization of electricity is not a prerequisite for the actual transformation of the energy matrix, as shown by the experience of Cuba. It is worth to suggest that in relation to the formation and transformation of the technological structure of the electric power industry, there are additionally some objective factors of economic reality. Such factors include the possibility of transferring the high level of expenses for electric energy to tourists, eliminating the interest in the development of modern renewable technologies; unfavorable foreign economic and political situation (political tension between Cuba and capitalist states in the conditions of loss of support of the USSR) caused a forced reorientation to new energy sources. The above assumptions need to be verified in subsequent studies, gradually expanding the list and considering more economically powerful continental countries.

It is also necessary to pay attention to the nature of the introduced financial instruments. In comparison with the Dominican Republic and Antigua and Barbuda, which was made above, the more active role of the state in the transformation of the Dominican power sector should be taken into account.

If the instruments of Antigua and Barbuda are of mostly passive characters – creation of a favorable institutional environment for potential investors (green tariff, energy wheel, net account, attraction of resources of international financial institutions); then the Dominican financial instruments foresee coercive elements (electricity procurement structure) and redistribution (taxation of fuel and benefits to renewable technologies, emissions trading, targeted financing from the Development Fund).

Table 1.

Financial instruments and assessment of the technological modernization of the electricity industry of the Caribbean island countries															Sources				
No	Country	Characteristics of shifts in the technological structure of power industry													Sources				
		budget investments	definition of the structure on electricity purchase	donor investments	“green” tariff	tax collection/fuel tax	“power” wheel	concessions	tax privileges	costs transfer on to the network operator	resources of international financial institutions	subsidies for fuel	trade by emissions on CO ₂	development fund		“net” account	Renewable Energy Rider		
1	Antigua and Barbuda	+	-	-	+	-	+	-	-	+	-	-	-	-	-	-	+	Significant transformations are not observed	[29, c. 15, 17-19]
2	The Bahamas	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	Significant transformations are not observed	[9; 13; 32; 33]
3	Barbados	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	Significant transformations are not observed	[14; 34-37]
4	Haiti	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	The industry does not develop at all	[31]
5	Grenada	-	-	+	-	+	-	-	-	+	-	-	-	-	-	-	-	Weak revitalization of renewable energy	[16; 17, c.7; 18, c. 17; 19, c. 4]
6	Dominica	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A significant shift towards unsustainable technologies	[20-22]
7	The Dominican Republic	-	+	-	-	+	-	-	-	-	-	+	-	-	-	-	+	A significant shift towards sustainable technologies, government actions are most effective in a group of countries	[27; 28]
8	Cuba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A forced transition to biofuels	[11, c. 23-24]
9	St. Vincent and the Grenadines	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	A gradual shift towards unsustainable technologies	[13; 30]
10	St. Kitts and Nevis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Weak revitalization of renewable energy	[12; 15; 38]
11	St. Lucia	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	Significant transformations are not observed	[12; 39; 40]
12	Trinidad and Tobago	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	Gas reserves deactivate the task	[12; 13]
13	Jamaica	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	A gradual shift towards unsustainable technologies	[23-26]

(Sources: [12-40]).

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