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EFFICIENCY OF DEVELOPING RENEWABLE ENERGY MARKET IN RUSSIA [1]

The goal of this study is to systematize and provide a quantitative and qualitative assessment of potential positive economic and non-economic effects of the implementation of a new mechanism for supporting renewable energy in Russia. It should result in achieving the national medium-term objective to increase the share of renewable energy in the wholesale electricity and capacity market to 2.5 % by 2024. The introduction examines the mechanism for supporting the generators of renewable energy by capacity charge in the wholesale electricity and capacity market. It is assumed that the main positive effects from implementing this mechanism will be the replacement of hydrocarbon fuels burned for generating the electricity in traditional coal or gas power plants; improvement in the trade balance; multiplier effects from the development of RES in related industrial sectors, new value added and jobs in the sectors producing the generating and auxiliary equipment for generators; reduction of carbon dioxide emissions; decrease in average prices in the wholesale electricity market; reduction of expenditure on environmental activities and measures to protect the health in the territories with traditional power plants; additional fiscal charges. As a result, the quantification of these effects amounts to 47.77 billion rubles in 2024. The authors rely on the experience of foreign countries, expert estimates, forecasts by the Russian Ministry of Energy and the Ministry of Economic Development, research by the Russian Energy Agency, International Energy Agency, International Renewable Energy Agency, Community for Renewable Energy Policy in the 21st Century (REN21), statistics of Russian Federal State Statistics Service.

Keywords: renewable energy sources, solar energy, wind energy, small hydropower, bioenergy, RES, RES support mechanisms, capacity charge, capacity provision contract, wholesale electricity and capacity market

Introduction

Renewable energy is becoming an integral part of the global energy sector. During the decade from 2004 to 2013, the installed global capacity of solar power plants increased by 53 times. In 2015, 100 % newly commissioned capacity in the European Union came from renewable energy sources (RES) [1]. The current transformation of the global energy sector is caused, in particular, by the fact that the new RES technology (primarily solar and wind energy) reached the level that enables it to compete with traditional energy production based on fossil fuels. The price instability of commodity markets makes a case for looking for alternative energy sources. The dependence on energy exporters prompts the states with no significant natural resources to adopt import substitution policies and try to reduce this dependence. The global warming, which is of anthropogenic nature, requires new approaches to energy supplies that would reduce greenhouse gas emissions. One of the most important features of this process is the change in the structure of energy production and consumption, with a higher share of carbon-free technologies, in particular, those based on renewable energy sources (RES) [2]. RES support policies are implemented in 173 countries, including Russia, where a new support mechanism with capacity charge in the wholesale market was adopted in 2013. Except for large hydro power plants, renewable energy is very poorly represented in the Russian energy system— electricity generated from RES amounts just to 0.5 % of the total volume. Meanwhile, the development of RES in Russia is economically sound, and the objective of this study is to demonstrate it. To this end, we propose a methodical approach to assessing the economic, environmental, and social effects resulting from the implementation of support mechanism in the wholesale electricity and capacity market, which should ensure the commissioning of 5.9 GW of new RES capacity by 2024. The range of considered issues determines the relevance and timeliness of this study.

The mechanism to support the production of electricity based on renewable energy sources (RES) in the wholesale electricity and capacity market was defined by the Decree of the Government of the

[1] Original Russian Text © I. A. Grechukhina, O. V. Kudryavtseva, E. Yu. Yakovleva, published in Ekonomika regiona [Economy of Region]. — 2016. — Vol. 12, Issue 4. — P. 1167–1177.

Russian Federation No. 449 of May 28, 2013[2]. According to this Decree, the support for RES generating facilities is provided through capacity provision contracts (CPC), which establish the right of investors to benefit from regulated prices based on the installed capacity of the relevant power generating facilities.

The projects are selected within the maximum volume of installed capacity defined for each year. This, on the one hand, should ensure the achievement of medium-term strategic target for RES (i. e. 2.5 % of electricity generation and consumption by 2020[3]) and, on the other hand, it should limit total capacity of RES generating facilities and support provided for the projects by the state. In addition, the maximum volume established for commissioning new RES capacity should take into account the potential of localization. The limits of installed capacity for RES generators for 2014–2024 are established in the Directive of the Government of the Russian Federation No. 1472-r of July 28, 2015[4] (Table 1).

Table 1

Targets for annual commissioning of installed capacity for generating facilities based on renewable energy sources in the price zones of wholesale electricity and capacity market in 2014–2024*

Type of generating facility	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Wind power plant	—	51	50	200	400	500	500	500	500	500	399	3,600
Solar power plant	120	140	200	250	270	270	270	—	—	—	—	1,520
Small hydro power plant	18	26	124	124	141	159	159	—	—	—	—	751
Total	138	217	374	574	811	929	929	500	500	500	399	5,871

* Directive of the Government of the Russian Federation No.1472-r of July 28, 2015. Retrieved from: http://government.ru/docs/all/102917/ (date of access: February 04, 2016).

Since 2013, RES projects have been elected, annually and on a competitive basis, for four years ahead. The projects are selected by the criterion of lowest capital costs established by the state in view of international experience and particular characteristics of the cost structure for implementing the projects in the target regions of the Russian Federation[5] (Table 2).

Table 2

The limits on capital and operating costs by technology*

Type of renewable energy generation	Capital costs, 2014–2024, thousand rubles/kW	Unit operating costs, thousand rubles/MW per month
Solar power plant	116.5–103.2	170.0
Wind power plant	116.5–103.1	118.0
Small hydro power plant	146.0	100.0

* Directive of the Government of the Russian Federation No.1472-r of July 28, 2015. Retrieved from: http://government.ru/docs/all/102917/ (date of access: February 04, 2016).

An important condition for ensuring the competition is the requirement for localization of equipment production, which in various years is established in varying degrees for the wind power plants, solar power plants, and small hydro power plants. The government has set the localization targets for each RES type for the period until 2024 (Table 3). A failure to comply with the localization target leads to the application of significant penalty rates to estimated capacity charge—for wind power plants and small hydro power plants such rate is 0.45; for solar power plants it is 0.35.

[2] On the Mechanism to Promote the Use of Renewable Energy Sources in the Wholesale Electricity and Capacity Market. Decree of the Government of the Russian Federation No. 449. Retrieved from: http://government.ru/docs/all/87499/ (date of access: March 27, 2016).

[3] Directive of the Government of the Russian Federation No.1472-r of July 28, 2015. Retrieved from: http://government.ru/docs/all/102917/ (date of access: February 04, 2016).

[4] ibid.

[5] Barkin, O. G. VIE-generatsiya na rynke elektroenergii v Rossii. Normativnaya baza, tekushcheye sostoyanie, problemy i perspektivy razvitiya. Prezentatsiya [RES generation in Russian electricity market. Regulatory Framework, Current State, Problems and Prospects of Development. Presentation]. Razvitie vozobnavlyaemoy energetiki na Dalnem Vostoke Rossii. 3 Mezhdunar. Konf. Yakutsk 25–27.06.2015 g. [Developing Renewable Energy in the Russian Far East. 3d International Conference, Yakutsk. June 25–27, 2015]. Retrieved from: http://www.eastrenewable.ru/upload/iblock/2ea/1.%20%D0%95%D0%BB%D0%B5%D0%BD%D0%B0%20%D0%A4%D0%B5%D0%B4%D0%BE%D1%80%D0%BE%D0%B2%D0%B0.pdf (date of access: October 25, 2016).

Table 3

The localization targets for production of main or auxiliary renewable energy generating equipment within the Russian Federation*

Types of renewable energy generation	Year of commissioning	Localization target, %
Wind power plant	2016	25
	2017	40
	2018	55
	2019–2024	65
Solar power plant	2014–2015	50
	2016–2024	70
Small hydro power plant	2014–2015	20
	2016–2017	45
	2018–2024	65

* On the Mechanism to Promote the Use of Renewable Energy Sources in the Wholesale Electricity and Capacity Market. Decree of the Government of the Russian Federation No. 449. Retrieved from: http://government.ru/docs/all/87499/ (date of access: March 27, 2016).

In the support scheme, the effective use of installed RES capacity is implemented through the introduction of unit capacity factor (UCF) representing the minimum volume of electricity that must be generated by RES unit per year. If RES generator does not produce this minimum volume of electricity, the capacity charge is decreased. Table 4 presents the minimum levels of installed capacity utilization, which should be complied with by RES generating facilities during the year, as well as the factors used in calculating the capacity price.

Table 4

The unit capacity factor for renewable energy technology*

Types of renewable energy generation	UCF, %	Achievement of regulatory UCF, %	Factor for calculating the capacity price
Wind power plant	14	< 50	0
Solar power plant	27	50–75	0.8
Small hydro power plant	38	< 75	1

* On the Mechanism to Promote the Use of Renewable Energy Sources in the Wholesale Electricity and Capacity Market. Decree of the Government of the Russian Federation No. 449. Retrieved from: http://government.ru/docs/all/87499/ (date of access: March 27, 2016).

According to estimates of the International Energy Agency and the International Renewable Energy Agency, the development of renewables industry leads to multiple economic and non-economic effects including, in particular, the following[6]:

— replacement of the hydrocarbon fuels burned for electricity generation in traditional coal or gas power plants;

— improvement in the trade balance;

— multiplier effects from the development of RES in related industrial sectors, new value added;

— reduction of carbon dioxide emissions;

— decrease in average prices in the wholesale market following the replacement of traditional power plants by RES generators;

— reduction of expenditure on environmental activities and measures to protect the health in the territories with traditional power plants;

— new jobs in the sectors producing the generating and auxiliary equipment for RES generators;

— additional fiscal charges;

— lower volumes of fresh water used for cooling the units of thermal plants operating on hydrocarbon fuels [3].

When assessing various positive effects from expanding the RES generation, we rely on projected commissioning of such capacity in the wholesale electricity market set by the Directive of the

[6] Rethinking Energy: Towards a new power system. (2014). IRENA Report, Abu Dhabi. Retrieved from: http://www.irena.org/rethinking/ (date of access: February 05, 2016).

Government of the Russian Federation No. 1472-r of July 28, 2015 (Table 1), which should ensure the achievement of the national medium-term target for RES at 2.5 % by 2024[7].

Substitution of Fossil Fuels Burned for Energy Production in Traditional Power Plants

The current mechanism of marginal pricing on electricity market implies that the price for all bidders is based on the bid submitted by the closing electricity supplier, which is usually a thermal power plant with the highest level of marginal costs that was the last to submit the price bid. In the competitive selection of price bids on the day-ahead market, the value of such price bid submitted by a power plant is equal to the value of its variable costs for fuel. Obviously, if variable costs exceed the price bid, the plant will operate at a loss. In this case, the market value of fuel saved on thermal power plants through substitution by new RES capacity will be equal to the value of RES-generated electricity in the wholesale market or revenue of RES generators.

The estimates of potential fuel savings are based on expected production of RES-generated electricity and existing forecasts of market prices by zones for 2015 and 2024 (Table 5).

Table 5

The forecast of price distribution per kWh for 2024, by Unified Energy System (UES)*

Price zone	UES	2024 price (RUB/kWh)
1	UES Center	2.304
	UES Northwest	1.970
	UES Volga	2.127
	UES South	2.306
	UES Urals	2.289
2	UES Siberia	1.011
	UES East	1.170

* Scenario Forecasts for the Power Industry Development for the Period until 2030, the Ministry of Energy of the Russian Federation, the Agency for Forecasting Power Industry Balances, 2010. Retrieved from: http://www.e-apbe.ru/5years/pb_2011_2030/scenary_2010_2030.pdf (date of access: February 04, 2016).

In this case, for price zone 1 (first five UES), the average price for 2024 will be 2.199 RUB/kWh and, for price zone 2 (UES Siberia and East), 1.090 RUB/kWh.

Therefore, with the expected total comm of RES capacity at 5,871 MW, total generation of 11.586 billion kWh[8], and with the distribution of the total production between price zones 8:1, the RES-based production volume will be 10.3 billion kWh in the price zone 1 and 1.286 billion kWh in the price zone 2. As a result, in 2024, the value of fuel savings will amount to 24.05 billion rubles.

Improvement in the Trade Balance

Solar, wind, geothermal, hydro power and ocean energy are the country's internal resources. Therefore, the development of RES may have a positive impact on the trade balance, if the reduction of energy imports will be greater than the imports of RES technology [4]. For example, it is estimated that, in 2010, the domestic production of RES-generated electricity enabled Spain to reduce its fossil fuel imports by 2.8 billion dollars[9] and in Germany, in 2012, the savings on fuel imports amounted to 13.5 billion dollars[10].

For fuel exporting countries that subsidize their domestic prices, the development of RES can minimize domestic fuel consumption and maximize the export volumes [5]. In the Middle East and North Africa, the solar radiation intensity is so great that, in the midday hours, when power consumption is at its peak, solar power generation can fully cover this peak demand [6]. Currently, the peak electricity

[7] Directive of the Government of the Russian Federation No. 1472-r of July 28, 2015. Retrieved from: http://government.ru/docs/all/102917/ (date of access: February 02, 2016).

[8] Directive of the Government of the Russian Federation No. 861-r of May 28, 2013.

[9] Macroeconomic Impact of Renewable Energies in Spain. (2011). Deloitte and APPA (Spanish Renewable Energy Association). Retrieved from: www.appa.es/descargas/APPA2011web.pdf. (date of access: March 06, 2016).

[10] News release, July 05, 2013, BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) 2013, available in German. Retrieved from: www.bmu.de/bmu/presse-reden/pressemitteilungen/pm/artikel/altmaier-und-roesler-buergerdividende-soll-netzausbau-beschleunigen-undbreitereakzeptanz-fuer-die-energiewende-schaffen/ (date of access: March 27, 2016).

consumption is covered by expensive backup generation based on oil or liquefied natural gas, which makes the solar energy commercially viable without any subsidies[11].

In the Russian context, such substitution of hydrocarbon fuels by expanding RES generation to 11.586 billion kWh by 2024 suggests that it would be possible to withdraw these volumes of fuels from domestic electricity balance and export them. In this case, it would be possible to apply the international prices to the saved volumes of fuels in 2024.

Creation of Value Added

It is known that the development of one sector leads to multiplier effects in related industries and areas. The practice of other countries shows that the development of RES comes in the format of small and medium-sized businesses and affects primarily the power engineering industries (equipment for hydro power plants, wind power plants, biomass and biogas thermal power plants, solar power plants), development of solar panel manufacturing (solar panels, silicon wafers, fasteners, etc.), production of auxiliary power equipment (cables, transformers, switches, etc.) [7, p. 298].

In many countries, including Russia, the development of locally produced RES technology is promoted by including the localization requirements in the scheme of state support policy, that is, in order to get the support, the investors in RES projects should use a specific percentage of domestic technology. Ultimately, this should contribute to the development of domestic production, creation of additional value added and jobs within the country. The developed economies with a strong resource and technology base can achieve a high level of localization within a fairly short period by organizing the domestic production of required equipment and components, importing experience in implementing the projects, developing design and construction, etc. [8]. However, the localization requirement is not always an optimal and acceptable solution for a specific level of economic development. Sometimes, it becomes a serious barrier to investment in RES projects, as it is, for example, in Russia, [9].

The fundamental soundness of the Russian government's policy on localizing the production of equipment for RES as a condition for providing the state support was confirmed in 2013 and 2014 by successful completion of tenders for solar energy projects under the decisions adopted for this industry. The issue of localization was resolved by two winners of tenders for construction of solar power plants (SPP): Hevel, a company controlled by Renova, built a manufacturing plant in Chuvashia for the needs of Avelar Solar Technology, its subsidiary, and Solar Systems, a Chinese company, began the construction of a production facility in Tatarstan [7, p. 43].

Unlike for the solar generation, today, there is virtually no equipment produced in Russian for the needs of wind energy and small hydropower [10]. This situation makes it impossible to achieve the level of localization required under the support scheme, which becomes a significant constraint to the development of the industry and the main cause of weak activity of investors and developers at the tenders held in 2013–2014. Today, Russia produces almost nothing of what may be included in the scope of equipment delivery for wind power plants. Therefore, localization requirements of 35 % in 2014 and 55 % in 2015 were from the very beginning unrealistic as it was impossible, within such a short period, to organize the production facility, certify it with the main supplier of wind power units, ensure the harmonization and standardization in accordance with Russian and international requirements. They were also unrealistic because of the period required to deploy any mass production of industrial equipment. As a result, the competitive selections held in 2014 and 2015 practically failed, which, along with difficult economic conditions, undermined the confidence of investors and equipment suppliers in the development of Russian wind energy market.

Creation of New Jobs

The development of RES can solve some of the problems in the area of employment. RES sector is already the largest employer. In 2014, it accounted for 7.7 million jobs excluding the large hydropower sector[12]. In terms of employment, the leaders in RES sector include China, Brazil, United States, India, Germany, Spain, and Bangladesh. In China, RES sector employs 2.6 million people, including 1.6 million

[11] Sunrise in the Desert Solar becomes commercially viable in MENA. (2012). PWC, Robin Mills and Emirates Solar Industry Association. Retrieved from: www.pwc.com/en_M1/m1/publications/solar-in-the-desert-in-collaboration-with-emirates-solar-industry-association.pdf (date of access: March 08, 2016).

[12] 2015 renewables Global Status Report. (2015). REN21 (Renewable Energy Policy Network for the 21st Century). Retrieved from: http://www.ren21.net/status-of-renewables/global-status-report/ (date of access: March 03, 2016).

employed in the solar energy industry (photovoltaics). The second rank, in terms of job creation, is held by Brazil, largely as a result of liquid biofuel production [11].

The dynamics of employment varies considerably by specific RES technology. Since 2011, the number of jobs in solar energy has tripled and surpassed those in the wind energy. In the bioenergy, the highest number of jobs is in the area of liquid biofuel production, despite the recent strong growth of employment in the area of waste management, especially in large farming and cattle breeding countries, such as Brazil[13].

The data collected on various RES projects show that renewable energy creates more jobs per MW of installed capacity than the traditional power industry. This is true both at the stage of construction and during the operation of generating facilities [12].

Given the estimated RES-based energy production volumes and their correlation with German data on generation growth, the potential increase in the number of permanent jobs in Russia can be estimated at 90–105 thousand jobs[14].

Reduction of Greenhouse Gas Emissions and Sustainable Development

There is a view that the electricity generated by RES is a completely eco-friendly option. This is not quite the case, since these sources of energy have a fundamentally different range of environmental impact compared to the traditional power industry. Moreover, in some cases, the impact of the latter represents even lower hazard [13]. In addition, certain types of environmental impact by RES are essentially unclear and not explored to date. Therefore, all forms of energy supply, including RES, have a negative impact on the environment [14]. However, in aggregate, throughout the life cycle of power generation ranging from production of equipment to its full write-off and disposal, the impact of RES is significantly smaller than the one made by the traditional power industry. In most cases, RES technology does not consume fuels during operation and does not use exhaustible natural resources. RES technology also consumes substantially less water than traditional power generation [8].

The contribution of the power industry to climate change is viewed as its biggest negative impact on the environment. The power industry is responsible for 40 % of CO_2 emissions. We can make a comparative analysis of CO_2 emissions made by various technologies per kWh of produced electricity throughout their life cycle[15]. To determine the total emissions throughout the life of a power plant, we should take into account the emissions at each stage of the life cycle. In cases involving the use of fuels (biofuels, fossil fuels or nuclear fuel), we should consider their supply chain, uncontrolled emissions during extraction and combustion (not only carbon dioxide, but also methane, nitrogen oxide and other greenhouse gases), manufacturing of equipment for exploration, infrastructure and transportation related emissions. We should also take into account emissions related to supplies of electricity and heat to generating facilities, production of cement and metals required for construction of such facilities, etc. [2]

Based on a life cycle approach, it is necessary to consider the carbon footprint of solar panel production, emissions during the transportation of natural gas from the field to power plant, emissions associated with decommissioning of nuclear power plants and disposal of nuclear waste [10]. In the course of its life cycle, a RES facility makes 10–120 times less emissions than a natural gas power plant (the most eco-friendly of traditional technologies) and up to 250 times less than a coal power plant. Therefore, the potential represented by RES technology for reducing GHG emissions means that they must play a key role in combating the climate change and should be an essential part of any scenario for the development of global power industry [6].

Let's try to quantify the reduction of CO_2 emissions in Russia as a result of commissioning 5.9 GW of new RES capacity in 2024.

The increase in the share of low-carbon technology is accompanied by a proportional reduction of total GHG emissions. Given the well-known ratio of 1MWh = 0.456 tons of CO_2, the reduction of emissions in 2024 will be 11.586 billion kWh × 0.456 tons/MWh = 5.283 million tons.

[13] Renewable Energy and Jobs (2013). Annual Review IRENA. Abu Dhabi, 144.

[14] Sunrise in the Desert Solar becomes commercially viable in MENA. (2012). PwC, Robin Mills and Emirates Solar Industry Association, p. 301. Retrieved from: www.pwc.com/en_M1/m1/publications/solar-in-the-desert-in-collaboration-with-emirates-solar-industry-association.pdf (date of access: March 08, 2016).

[15] The life cycle of generating technology refers to the entire period of its existence ranging from the production of construction units and power plant equipment to electricity generation and decommissioning of the power plant.

The valuation of this reduction in CO_2 emissions depends on the cost of a ton of CO_2 emissions in 2024. Given the high variability on emissions trading market, we propose to build the valuation based on the average cost of a ton of CO_2 emissions trading in the European trading market, over the period of its existence (since 2012), in the amount of 5 euro per ton. In this case, under the euro exchange rate of 70 RUB/EUR, the savings in 2024 will reach 1.85 billion rubles.

Reduction of Average Prices in the Wholesale Market Through Higher Share of RES Generators

A phenomenon of declining average prices for electricity in forward markets can be observed in the markets of countries with a significant share of RES. In 2015, the average prices in the day-ahead market in Germany (the largest European electricity market) fell to 31.68 euro (2,533 rubles, 34.62 dollars) per 1 MWh. The lower prices were reported only in 2004 at Epex Spot SE in Paris[16]. The main factor mentioned to explain this reduction was the increased production of energy by wind and solar power plants. In 2016, the experts expect a further decline of market prices. Similar trends are also observed in the long-term segment of the market[17]. The reduction of prices has already been announced on long-term supply contracts for a period until 2019, where the price per 1 kWh of supplies for the period of 2014–2019 appears to be lower than 4 cents, which is its historical minimum [15].

Given that, in the Russian market, the share of renewable energy is insignificant (excluding large hydro power plants), one cannot currently see this effect in Russia.

Additional Fiscal Charges

Export customs duties. If the saved hydrocarbon fuels can be sent for exports, the state will receive additional revenue from export duties. The regulatory regime established for export revenue depends on the type of fuel and can produce various economic results. The highest tax is imposed on oil exports. However, the share of crude oil and fuel oil in the power generation is low. Natural gas makes a significant share in the electricity balance and can be viewed as a rationale for this hypothesis. Based on estimated efficiency of gas units at 45 % and industry-average gas consumption for electricity generation, the production of 11.586 billion kWh of electricity will require the consumption at the level of 11.586 billion kWh × 94.304 m^3/MWh: 0.45 = 2.428 billion m3 of gas in 2024.

The Energy Forecasting Agency (EFA) set the forecast price of gas for 2024 at 369 dollars per 1,000 m^3 [18]. In this case, under the dollar exchange rate of 70 RUB/USD in 2024, the notional value of exported fuels may reach 58.236 billion rubles. (2.428 × 369 × 65). Therefore, in 2024, the value of export duty, under a notionally constant rate of 30 %, will amount to 18.81 billion rubles.[19]

Profit tax. The profit tax on new generating companies can be calculated on the basis of estimated 10 % profitability and current profit tax rate of 24 %. The revenue is calculated based on the distribution of expected RES electricity volumes of 11.586 billion kWh by price zones and tariffs. In this case, the profit tax will be

$$[10.31 \text{ billion kWh} \times 2.199 \text{ rubles/kWh} + 1.28 \text{ billion kWh} \times 1.09 \text{ rubles/kWh}] \times 0.1 \text{ x } 0.24 = \\ = 0.577 \text{ billion rubles.}$$

Land tax or land rent. Land plots used for accommodating RES generating facilities are subject to profit tax or rent. Among various types of RES technology, the largest users of land are wind power plants (on average, 3–4 hectares per 1 MW of installed capacity), solar power plants (2–3 hectares per 1 Mw of installed capacity), biomass and biogas power plants that use the plant mass harvested from specially planted fields. If we assume that, on average, 3 hectares of land are used for every megawatt of

[16] Coal Glut, Renewables Make EU Power Cheapest in Decade. (2016, January 01). Bloomberg News. Retrieved from: http://www.renewableenergyworld.com/articles/2016/01/coal-glut-renewables-make-eu-power-cheapest-in-decade.html (date of access: May 07, 2016).

[17] Bundesministerium fuer Wirtschaft und Energie. Energiedaten: Ausgewaehlte Grafiken. Retrieved from: http://www.bmwi.de/DE/Themen/Energie/energiedaten.html (date of access: May 07, 2016).

[18] Electric power industry development forecast for the period till 2030. (2010). Ministry for Energy of the RF, Agency for balance forecast in the electric power industry. Retrieved from: http://www.e-apbe.ru/5years/pb_2011_2030/scenary_2010_2030.pdf (date of access: February 04, 2016).

[19] On approval of rates of export customs duties for goods exported from the Russian Federation beyond the member states of the Customs Union and on repealing certain acts of the Government of the Russian Federation. Decree of the Government of the Russian Federation No. 756 of July 21, 2012. Retrieved from: http://government.ru/docs/all/83507/ (date of access: February 04, 2016).

installed capacity then, by 2014, the accommodation of capacity projected for these plants will require approximately 17.613 thousand of additional hectares of land (5,871 MW × 3). The rental rates have been recently legislated (2 % of cadastral property value). Therefore, at the minimum cadastral value of 6 thousand rubles per hectare, the total amount in 2024 will be

$$17.613 \text{ hectares} \times 6{,}000 \text{ rubles x } 0.02 = 0.00211 \text{ billion rubles.}$$

Income tax on earnings. If we take the number of really new jobs in RES industry (30 % of the potential 90 thousand jobs), the income tax rates of 13 % and the average annual salary of approximately 700 thousand rubles, the amount of income tax collected in 2024 will be 2.46 billion rubles.

Water rate. The calculation of water fee is based on the average value of this charge for small hydro power plants in the amount of 9 rubles/MWh and projected electricity production on small hydro power plants (1.971 billion kWh in the wholesale market). Therefore, in 2020, the water fee will be

$$1.971 \text{ billion kWh} \times 9 \text{ rubles/MWh} = 17.7 \text{ million rubles.}$$

An important advantage of RES is the fact that there is no need to increase investment in operating costs in related industries, such as extraction and processing, transportation and storage of fossil fuels, disposal and storage of waste resulting from their processing and burning, which in the Russian context represents a significant share of fuel costs for the power plants. In 2024, in the wholesale electricity and capacity market, the total economic effect from developing RES industry will amount to 47.77 billion rubles annually (Table 6).

Table 6

Total economic effect of the development of RES industry in 2024

Type of economic effect of development of RES	Estimate, billion rubles
Substitution of fossil fuels	24.05
Lower green-house gas emissions	1.85
Additional fiscal charges, total, including:	**21.87**
gas export duties	18.81
profit tax	0.58
land tax or land rent	0.002
income tax	2.457
water fee	0.017
Total	**47.77**
Results with no economic estimate	
Lower spending on environmental measures	—

The existence of such results casts doubt on the need for any state support of the development of RES. However, this would be an error. As a matter of fact, the costs of RES development are borne by some economic agents, while its benefits are reaped by the others. Therefore, the role of the state is to ensure an equitable redistribution of this additional product between agents by using its own tools.

Table 7

Gross, technical and economic potential of RES-based electricity production*

RES technology	Technical potential, Billion kWh/year	Economic potential reached in 2005, billion kWh/year	Realizable potential in 2020, billion kWh/year
Small hydro power plants	126 (372)	172.50	387.80
Biomass	140	5.20	155.40
Biogas	151.20	—	27.30
Land-based wind power plants	2,216 (6,517)	0.10	23.50
Sea-based wind power plants	9,676	—	2.10
Total	10093.2 (16856.2)	177.80	419.10

* Source: Compiled by the authors according to [7 p. 40] materials and Review of Opportunities to Introduce Renewable Energy in the Russian Federation. Ecoprotection! Report. Retrieved from: http://ru.boell.org/sites/default/files/ree-report-2013.pdf (date of access: February 04, 2016).

Almost all Russian regions offer opportunities for economically viable use of several types of renewable energy sources [16]. The technical potential of RES resources is five times higher than the annual consumption of primary energy resources in Russia, while their economic potential can provide for one-third of the annual energy needs of the Russian economy. Three leaders in terms of potential electricity production include bioenergy (biofuels and biogas). Its possible output is estimated at 180 billion kWh/year by 2020 (Table 7). However, the domestic market for liquid and gas biofuels has not yet emerged, and the produced solid biofuels (wood pellets) are almost entirely shipped to European and Asian markets.

As shown in Table 8, the development of solar, wind energy and bioenergy has the greatest potential in Russia.

Conclusion

The methodology for assessing macroeconomic effect of implementing the support mechanism presented in this study suggests to consider the savings of hydrocarbon fuels, reduction of greenhouse gas emissions, decrease in average prices in the electricity market, reduction of expenditure on environmental activities and measures to protect the health in the territories with traditional generation facilities, creation of new jobs, additional fiscal charges, multiplier effects from the development of RES in related industrial sectors as separate elements of this effect. According to presented calculations, the total effect from implementing the support policy in Russia will amount to 47.77 billion rubles in 2024. The developed model is methodologically important for further research aimed at studying the regulatory impact of RES support mechanism in order to assess the economic, social and environmental effects of its implementation.

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References

1. Sidorovich, V. A. (2015). *Mirovaya energeticheskaya revolyutsiya [World energy revolution].* Moscow: Alpina Publ., 208.

2. Vaytszekker, E. U., Khargrouz, K., Smit, M. et al. (2013). *Faktor pyat. Formula ustoychivogo rosta: Doklad Rimskomu klubu [Factor five: the formula for sustainable growth, a report to the Club of Rome].* Moscow: AST-Press, 368.

3. Verbruggen, A. & Lauber, V. (2012) Assessing the performance of renewable electricity support instruments. *Energy Policy, 45,* 635–644.

4. Haas, R. R. (2011). Efficiency and effectiveness of promotion systems for electricity generation from renewable energy sources, Lessons from EU countries. *Energy, 36,* 2186–2193.

5. Grechukhina, I. A. (2016). Faktory razvitiya vozobnovlyaemykh istochnikov energii v Rossii i v mire [Factors of development of renewable energy sources in Russia and the world]. *Nauchnyye issledovaniya i razrabotki v epokhu globalizatsii. Sb. statey mezhdunar. nauch.-prakt. konf. (5 fevr. 2016 g.) [Research and development in an era of globalization. Collected works of Scientific and Practical Conference (Feb. 5, 2016))].* Ufa: Nauchno-izdatelskiy tsentr Aeterna Publ., 75–79.

6. Fyuks, R. (2016). *Zelenaya revolyutsiya. Ekonomicheskiy rost bez ushcherba dlya ekologii [Green revolution: economic growth without harming the environment].* Moscow: Alpina non-fikshn Publ., 330.

7. Kopylov, A. E. (2015). *Ekonomika VIE [Economy of renewable energy].* Moscow: Grifon Publ., 365.

8. Porfiryev, B. N. (2013). Alternativnaya energetika kak faktor snizheniya riskov i modernizatsii ekonomiki [Alternative energy as a factor in reducing the risks and modernizing the economy]. *Problemy teorii i praktiki upravleniya [Problems of management theory and practice], 6,* 8–22.

9. Kopylov, A. E. (2013). Aktualnoye razvitie sistemy podderzhki VIE v Rossii. Ekologo-pravovoy monitoring [Current development of res support system in Russia. Environmental and legal monitoring]. *RNEI-Monitoring. Klimaticheskaya politika i prava cheloveka. — Vyp. 2. Vozobnovlyaemye istochniki energii [RNEI-Monitoring. Climate policy and human rights. — Issue 2. Renewable energy resources].* Berlin: Nemetsko-russkiy obmen Publ. 2013.

10. Fortov, V. & Popel, O. (2013). Vozobnovlyaemyye istochniki energii v mire i v Rossii [Renewable energy sources in the world and in Russia]. *Energeticheskiy vestnik [Energy bulletin], 16,* 20–31.

11. Menanteau, P., Finnon, D. & Lamy M.-L. (2003). Prices versus quantities: choosing policies for promoting the development of renewable energy. *Energy Policy, 31,* 799–812.

12. Rutovitz, J. & Harris, S. (2012). *Calculating Global Energy Sector Jobs: Methodology.* Johannesburg: University of Technology, Institute for Sustainable Futures, Sydney, Greenpeace Africa, 52.

13. Porfiryev, B. N. (2011). *Priroda i ekonomika: riski vzaimodeystviya [Nature and economy: risks of interaction].* Moscow: Ankil Publ., 352.

14. Shaytanov, V. Ya. & Zolotov, L. A. *Ekologicheskie aspekty ispolzovaniya vozobnovlyaemykh istochnikov energii [Environmental aspects of using renewable energy sources].* Retrieved from: http://solex-un.ru/energo/review/opyt-ispolzovaniya-vie/obzor-1-napravleniya-vie-ekonomika-effekty-sostoyanie-v-rf-1 (date of access: 27.03.2016).

15. Jasim, S. & Kunz, C. (2013). *Erneuerbare Energien im Strommarkt. Renews Kompakt. Agentur für Erneuerbare Energien.* Retrieved from: http://www.unendlich-viel-energie.de/media/file/276.AEE_RenewsKompakt _Strommarkt_dez13.pdf (date of access: 27.03.2016).

16. Bobylev, S. N., Kudryavtseva, O. V. & Yakovleva. Ye.Yu. (2015). Green economy regional priorities. *Economy of region, 2,* 148–159. doi 10.17059/2015–2-12.

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