Renewable Energy Sources in Energy Abundant Economy: Russia is in the Focus

1. Energy sector of Russia: high output and inefficient use

Although Russia's fuel and energy industrial complex[i] (FEIC) is a substantial legacy of its national patrimony, with more than 40 thousand operating enterprises, it actually represents a rather small share of all the production units involved in the country's economy, accounting for only 0.8% of the whole. Nevertheless, the share of the energy complex in the total output amounts to almost 20%, whereas in industrial production — about 45% in basic prices, i.e. exclusive of rental elements — the FEIC provides no less than 43% of all budget revenues, and about 70% of the total currency earnings from foreign trade.

Despite the relatively small number of FEIC enterprises, they accumulate about a quarter of the country's fixed assets, and, with reference to industrial production, nearly 2/3, though, as a matter of fact, the official sources of statistical data provided by Rosstat RF[ii] do not include information on the volumes of fixed assets in different spheres of the economy as measured in constant prices, which are exactly the investments in the form of fixed assets directed to the power and energy sector annually. This information provides evidence relevant to the estimates mentioned above, which, in addition to other lacunae, leave out of account the capital concentrated in pipeline systems. As for the latter, the abovementioned estimates of both investments and FEC assets need to be increased. According to the forecast prepared by the Ministry for Economic Development for the socio-economic development of the Russian Federation for the period up to 2030, the share of FEIC investments in 2011 was 32 %. Perhaps, the difference between this figure and our estimates based on Rosstat data – 24.9% (Russian Statistical Yearbook, 2012, p.642-643.) – can be explained by taking into account investments in pipeline transportation.

What is the volume of FEC fixed capital in absolute terms? According to our estimates based on the analysis of economic growth model built on cross-country data for 2010, the ratio of fixed assets as measured in constant prices to the country's GDP was about 5.5:1. Thus, with the GDP amounting to RUB 45.2 billion, Russia's fixed assets in 2010, including the cost of household property assessed at current prices, accounted for about RUB 300 billion; a quarter of this related to the FEC sector was RUB 75 billion, which is notably greater than the annual GDP.

Russia’s FEIC is known to be one of the largest in the world, and produces 1/5 of the world’s total natural gas reserves, 13% of its oil, more than 6% of its hydropower and oil products, and 5% of the total electric and nuclear energy. At the same time, 46% of the total output is exported (Table 1). Although Russia’s GDP amounts to only 3.0% of the world economy, its total FEC output accounts for 10% of the world energy production, while consumption is 5.6%. Russia can therefore be considered one of the world’s greatest energy powers.

Table 1. Russian Energy Sector in the World Economy in 2011

	Volume	World position	Share in the World	Net exports
Oil, mill. t	517	2	12.9	246
Gas, bill. cubic m	677	1	20	196
Coal, mill. t	334	6	4.3	99
Energy from HPS, bill. kW-h	170	4	6.2	
Energy from NPS, bill. kW-h	168	5	4.8	
Petroleum products, mill. t	240	3	6.3	111
Electric Energy, bill. kW-h	1036	4	4.8	17
Energy production, mill. oil. equ.	1315	3	10.0	592
Energy consumption, mill. oil. equ.	731	3	5.6	
Renewables (RE), mill. oil equ.	17.7		1.34	
RE without HPS, mill. oil. equ.	3.5		0.25	
GDP, $ bill. PPP	2363	6	3.0	
Population, mill.	142.9	9	2.06	

Sources: FSSS RF: http://www.gks.ru; IEA, Statistics http://wds.iea.org/wds/ReportFolders/ReportFolders.aspx?CS_referer=&CS_ChosenLang=en; and IMF, World Economic Outlook Database, April 2014: http://www.imf.org/external/pubs/ft/weo/2014/01/weodata

Among the many useful services that the energy sector renders to both the economy and society, such as the provision of comfortable living conditions for the population, power supplies for industrial production, support of the country’s scientific and technical progress, satisfying the demand for services to assist other branches of the economy, etc., there is one service that we especially wish to single out – rent creation. Rent from the oil and gas industry was the basis for the existence of the Soviet Union, whose disintegration followed a two-fold drop in oil prices in 1985, rather than in 1980. In many respects, rental income explains the rapid growth of the Russian economy during the first 8 years of the 21st century, and rent is certain to remain an important element for the country’s economy over the long-term period. Calculated on the basis of production accounting of such resources in world prices for 2010, the volume of the rent created by hydrocarbon production was USD 400 billion (Ickes & Gaddy., 2011), which at the current exchange rate was equal to more than a quarter of the GDP. Unfortunately, a considerable part of this sum was not spent effectively: only about USD 120 billion passed through the budgetary sphere, and the bulk either went into indirect (hidden) subsidies for the inefficient economic sector or was taken "into shadow" (Suslov, 2012). Thus, the major task today is to increase rental incomes that can become a source for investments. Such a task is associated with significant growth in the relative prices of oil, gas, and consequently, other utilities, which cannot be "planned" in the short term. In this regard, the government should make attempts, at least, to minimize offshore trading schemes.

Table 2. Energy Consumption in Russia and Other World Economies in 2010, USA=100%

	Per capita			Per GDP	
	GDP PPP	Energy use	Electricity use	Energy use	Electricity use
Canada	83	103	125	124	125
Czech Republic	54	59	58	109	58
Finland	72	95	107	133	107
Germany	76	57	55	75	55
Greece	52	35	37	67	37
Israel	64	42	54	66	54
Japan	69	55	62	79	62
Netherlands	83	70	50	84	50
Russia	33	69	51	208	51
Sweden	80	76	112	96	112

Sources: Calculated from WB data: & IEA data; IEA, Statistics: http://wds.iea.org/wds/ReportFolders/ReportFolders.aspx?CS_referer=&CS_ChosenLang=en and WB data, WB Data: http://data.worldbank.org/indicator/SP.POP.TOTL

Before we discuss Russia's utilization of renewable resources, let us turn our thoughts to another related problem: the energy efficiency of the Russian economy. As a whole, Russia does not lag behind the developed countries in per capita consumption of energy, consuming about 70% of the US energy rate (see Table 2). Frankly speaking, when we consider that Russia's climate is more severe than that of most other countries, her energy consumption is likely to increase in the future and reach the levels associated with Canada and Finland. In particular, this will relate to the separate types of energy resource that provide technological progress – electric power, motor fuel and what are known as 'renewables' (RES). However, the lag here is not as significant since it falls within the efficiency of energy consumption. Russia's energy consumption per GDP PPP unit is twice as high as that of the USA, one and a half times higher than that of such northern countries as Canada and Finland and three times higher than that of the developed European countries and Japan. The research conducted by Bashmakov and Suslov (Bashmakov et. al. 2008; Suslov, 2005; Suslov, 2007) show that severe climatic conditions only partly contribute to such a big difference in GDP energy consumption. The obsolete technological structure of the Russian economy, the energy losses caused by the depreciation of production facilities and failures in organizational management, as well as a lack of incentives to investment and energy saving, greatly contribute to this problem. Such a high rate of energy intensity calls into question Russia's economic development not only in terms of achieving sustainable growth but also the possibility of economic growth *per se*.

2. Renewable energy: though desirable but for now is disappointing

Looked at from this perspective, it seems clear that the development of alternative energy sources can become a very noticeable factor in reducing the energy cost per unit of output, given the present low level of energy consumption. Russia, with a population amounting to 2% of the world's people, produces and consumes only about 1.3% of global renewable energy production. If we set aside large-scale hydropower, the traditional source of our country's electricity generation and one that is especially widespread in Siberia and in the Far East, Russia's share in both the production and consumption of renewable energy (without the hydroelectric power plants) falls to an insignificant value – one quarter percent.

Besides such a poor performance, other figures testify to the fact that these days the role of renewable energy in Russia is quite insignificant. Even if we take into account large-scale hydropower, the production of energy resources from renewable sources of energy is twice as low as the world average, and in comparison with OECD this figure is three times lower. At the same time, Russia's production of alternative energy appears to be many times less than that of such countries as Finland, Norway, Denmark, Canada and the United States, not to mention Iceland, which consumes its own energy mostly produced from renewable sources (Table 3). At first sight, Russia's use of renewable sources corresponds approximately to the level of the United Kingdom and Japan – 0.12 t.o.e. per capita against 0.1 and 0.15, respectively. However, it is necessary to point out that in Russia the unit use of all energy resources is significantly higher than it is in the rest of the world. As a result, of Japan's total energy use, for example, the share of renewable energy consumption is twice as high as in Russia, and in energy its total production reaches 37.8%, as against 1.3% in our country (Table 3).

Table 3. Renewable energy (RE) in the world and selected world economies, tone of oil e., 2011

	Per capita energy output	Per capita energy use	Per capita RE output	RE share in energy output, %	RE output to energy use ratio, %
Australia	13.63	5.65	0.29	2.10	5.06
Canada	12.02	7.40	1.33	11.04	17.93
Denmark	3.80	3.25	0.55	14.43	16.84
Finland	3.25	6.61	1.73	53.14	26.13
Germany	1.52	3.83	0.38	25.19	10.04
Iceland	15.45	18.42	15.45	100.00	83.83
Ireland	0.38	2.83	0.16	40.82	5.52
Japan	0.41	3.65	0.15	37.80	4.23
Netherlands	3.82	4.60	0.19	4.88	4.06
Norway	41.64	6.00	2.55	6.12	42.50
Spain	0.68	2.69	0.29	43.31	10.96
United Kingdom	2.07	3.00	0.10	4.85	3.34
United States	5.70	7.00	0.43	7.61	6.20
World	1.91	1.89	0.25	12.89	12.98
OECD Total	3.13	4.31	0.35	11.09	8.05
Russia	9.20	5.12	0.12	1.35	2.43

Source: Calculated from IEA data: IEA, Statistics: http://wds.iea.org/wds/ReportFolders/ReportFolders.aspx?CS_referer=&CS_ChosenLang=en and WB data, WB, Data: http://data.worldbank.org/indicator/SP.POP.TOTL

In contrast to Japan and other world economies, all Russia's sources in the overall structure of renewable energy resources, apart from hydro, geothermal and solid biomass, are rather insignificant. Table 4 shows that Japan takes the leading position in the use of geothermal and solar energy; it also uses such sources as wind power and municipal waste. Wind power is more widespread in OECD countries, especially in Europe. Amongst OECD members, the production of biological motor fuel is rather well developed, while Europe specializes in the production of biofuel, and the American continent uses ethanol. And whereas many countries throughout world have started to recycle municipal waste, Russia has only to a very limited extent taken up this practice.

The only achievement of our country today is its leading position in the world's production of pellets (more than 2 million tons a year). Unfortunately, the pellets are mainly exported to European countries; their effective use in Russia is restrained by administrative and economic barriers. It seems relevant to add that nowadays Russia is successfully developing tidal power plants on the basis of original domestic technologies. A number of Russian companies have been paying much attention to the development of large-scale production technologies of photoelectric converters, a business that is again also mainly export-oriented.

Russia’s almost dead-end situation with regard to the production and use of green energy is a cause for especial concern given the breakthrough involved in green energy’s balances abroad. By the end of 2008, the capacity of electric power generating plants using nontraditional RES (without large hydroelectric power stations) reached 280 GW, and in 2010 it exceeded the capacity of all nuclear power plants by 340 GW. By the end of 2009, the total capacity of 150 thousand wind power plants reached the level of about 159 GW. In 2009, when wind power plants with a total capacity of 39 GW came into operation, their capacity as compared to that at the end of 2008 (120 GW) grew by 32%. In 2009, WPPs generated 324 TW-h of electric energy and by 2011 this had grown to 416.8 TW-h.

By the end of 2009, the world’s total capacity of photoelectric converters had reached 21.3 GW, and over the year 2009 it increased by 7 GW, with the growth of sales in the world market being more than 50%. In 2009, the total annual output was 23.9 TW-h, and in 2011 it reached 58.7 TW-h. The total capacity of biomass power plants in 2009 was 60 GW, and the annual electric power output exceeded 300 TW-h. The total capacity of geothermal power plants exceeded 10.7 GW, with the output of electric power amounting to 62 TW-h annually. The total thermal capacity of solar heating systems in 2008 reached 145 GW (i.e. more than 180 mln. m^2 of solar collectors); more than 60 million houses in the world now use a solar hot water supply, with annual growth rates being more than 15%.

The production output of biofuels (ethanol and biodiesel) in 2008 exceeded 79 billion liters per year (about 5% of the world’s annual consumption of gasoline, bioethanol - 67, biodiesel – was 12 billion liters a year, which, when compared with 2004, marked a six fold increase in the production of biodiesel, while the production of bioethanol doubled). In 2011, the world production and consumption of biofuel exceeded 50 billion liters, which is more than one percent of the world market of liquid fuels.

At present, 30 countries operate more than 2 million thermal pumps with a total thermal energy output of more than 30 GW, utilizing natural and waste heat and providing warm and cold supplies for buildings. Yet in Russia today the number of installed heating pumps does not exceed several hundred units.

Table 4. Structure of renewable energy produced by sources (%) in 2011

	Russia	Japan	OECD Europe	OECD Total	World
Hydro	80.42	36.63	23.41	27.94	17.64
Geothermal	2.53	12.70	6.58	7.64	3.87
Solar Photovoltaics	0.00	2.27	2.09	1.16	0.31
Solar Thermal	0.00	2.10	1.51	1.49	1.08
Tide, Wave and Ocean	0.00	0.00	0.02	0.01	0.00
Wind	0.00	2.01	8.47	6.61	2.19
Renewable Municipal Waste	0.00	3.19	4.95	3.24	0.87
Solid Biomass	17.05	40.54	41.29	38.27	68.91
Landfill Gas	0.00	0.00	1.57	2.08	0.53
Sludge Gas	0.00	0.00	0.69	0.34	0.09
Other Biogases	0.00	0.56	3.34	1.53	0.90
Biogasoline	0.00	0.00	0.92	6.63	2.06
Biodiesel	0.00	0.00	4.29	2.61	1.02
Other Liquid Biofuels	0.00	0.00	0.86	0.42	0.50
Total of Renewable Energy	**100.00**	**100.00**	**100.00**	**100.00**	**99.96**

Source: Calculated from IEA data: IEA, Statistics:
http://wds.iea.org/wds/ReportFolders/ReportFolders.aspx?CS_referer=&CS_ChosenLang=en

At the same time, further development of alternative energy generation in Russia would be desirable because it would not only allow us to reduce the energy intensity of production but would also, as a result, release the resources for increasing economic growth. The fact is that 2/3 of the Russian territories, with a population of about 20 million people, are not covered by the networks of centralized power supply. As a rule, these are the regions with the highest prices and tariffs for fuel and energy (10-20 rubles per kW and more). The greater part of Russia's regions are known to be energy deficient and in need of both fuel and energy delivery. For them, as well as for energy importing countries, regional energy security is still a very urgent problem; and while it is one of the world's largest gas producers, Russia has gasified only about 50% of its urban and about 35% of its rural settlements. Otherwise, the Russian regions mainly consume coal and oil products, which are the main sources of local environmental pollution.

The continuous growth of tariffs, energy and fuel prices and the growing costs of a centralized power supply have accelerated the development of autonomous power engineering in the country: over the last 10 years, diesel and petrol generators with unit capacity of 100 kW have exceeded the total output of large power plants. Consumers of energy seek to provide themselves with their own sources of electric power and heat, which, as a rule, results in a reduction in the efficiency of fuel consumption as compared to the combined electricity and heat generation at heat and power plants, as well as a reduction in the efficiency of the country's energy as a whole.

Here, the sources of renewable energy can really compete with the plants that use fossil fuel. An off-grid energy supply based on RES has proved its economic efficiency in many countries, since it allows the economies to avoid the high expenses associated with the laying of power lines. In Russia, it would be effective to use hybrid wind-diesel systems, biomass boilers, and small hydroelectric power stations that have the capacity to compete with traditional fossil fuel technologies.

3. Potential of RES utilization exists but is still not used

Besides these resources, Russia is also endowed with considerable potential for the economic application of renewable energy. Practically all regions of the country possess at least one or another source of renewable energy, and the majority of these resources constitute several types of RES, such as small rivers, the waste of agricultural and timber industry complexes, peat stocks, considerable wind and solar sources, low-potential heat of the earth, etc. In some cases their operation seems to be more commercially attractive when compared with the use of fossil fuel since deliveries of the latter are expensive and unreliable.

What, however, can we consider to be the proven experience of Russia in the use of RES in the national economy? According to O.S. Popel, the Chairman of the Scientific Council of the Russian Academy of Sciences on nonconventional renewable energy sources and the head of the laboratory for RES and power supply of the Joint Institute of high temperatures of the Russian Academy of Sciences, Russia has become one of the world leading wooden pellet producing economies (2 mill t per annum), yet the products are mainly exported to Europe (Popel, 2011). At the same time, we can note certain positive results in constructing tidal energy devices based on original national designs. In addition, a number of companies specialize in the large-scale development, production and export of photoelectric converters.

If we consider the potential application of RES by volume, we can find various and often discrepant data: for example, according to I.S. Kozhukhovsky, the General Director of Energy Forecasting Agency "APBE", the technical potential of alternative sources of energy accounts for about 4600 billion t of the equivalent amount of coal (3320 billion toe.), whereas the economic potential, i.e. the economically justified volume of their usage, is 300 million, here (210 billion toe.) or about 30% of Russia’s annual consumption (Kozhukhovsky, 2012). According to “RusHydro”, which is a Holding Company that maintains the majority of large and medium Russian hydroelectric power stations (Pavlov, 2012), the general technical potential for the generation of electric power alone appears to be slightly lower than the figures specified above: it exceeds 45 trillion kW-h, which amounts to about 4000 billion toe. “RusHydro” estimates the economic potential also as a smaller volume than "APBE", only at the level of 1566 billion kW-h, which corresponds to about 135 million toe. Apart from this, it allocates "industrial potential", which means, apparently, assessing the possibilities for the use of renewable energy by industrial enterprises. Other available data provided by "RusHydro" includes a detailed structure of potential energy production for separate types of renewable energy source (Table 5).

Table 5. Potential of energy production using renewable energy sources in Russia

	Potential, bill. kW-h		
	Technical	Economic	Industrial
Small HPS (<25 MW)	372	205	6-10
Wind PS	6517	326	70-90
Geothermal PS	34905	335	40-60
Biomass PS	412	203	90-130
Tidal PS	253	61.6	16-45
Solar HPS	2714	435	5-10
Total	45173	1566	227-342

Source: Calculated from data of JSC “RusHydro”, 2010 – Pavlov, M., Renewable energy and sustainable economic development. Opportunities for Russia. ESKO (Electronic journal of energy service company “Ecological Systems”), №6, June 2012. http://esco.co.ua/journal/2012_6/art277.htm

Here, the technical potential for the full deployment of RES can cover the nation’s total energy production: this is possible in Russia by using modern advanced and projected technical means. The economic potential here is the contribution of the technical potential estimated as economically feasible. Finally, the industrial potential is the level of electric power generation that can be employed by industrial enterprises. Table 5 shows that the structure of technical potential is represented mostly by geothermal energy and wind sources; however, their economic potential does not significantly exceed the economic potential of the use of other types of RES, and even concedes priority to the economic potential of solar energy. In general, biomass, which rates low in technical potential, has the greatest weight in industrial potential. Despite the high technical potential of solar energy, the forecast of its use in the short run is far from optimistic. Industry can use about 227-342 billion kW-h, which is equal to 40-60% of industry’s general power consumption. Thus, biomass and wind sources seem to be industry’s most probable sources of renewable energy.

Table 6. Summarized data on electricity production from renewable energy sources (RES) in Russia, 2010

Types of RES	Generation capacity, MW	Power generation, mill. kW-h	Share in economic potential, %
Wind ES	13.2	14.2	0.04
Small HPS (<25 MW)	700	2800	1.37
Geothermal PS	81.2	474	0.14
Solar PS	0	0	0.00
Tidal PS	1.1	1.2	0.00
Biomass PS	520	2600	1.28
Total	**1315.5**	**5889.4**	**0.46**
Share of RES in total electricity production, %	0.57	0.58	

Sources: Calculated from data of Table 5 and data from "Elaboration of Program of Modernization of Power Sector of Russia for the period up to 2020", JSC G. M. Krzhizhanovsky Energy Institute, Moscow, 2011, p. 115.

In 2011, the G. M. Krzhizhanovsky Energy Institute developed the Program for the modernization of Russia's electric power industry for the period until 2020. The authors were able to offer an assessment of RES production by types, which can certainly be added to the IEA estimates and the data discussed above. Unlike the latter, the data shown in Table 6 include only electricity generation, i.e. without heat and exported biomass. Another difference is that it takes into account only small hydropower plants with the power capacity of less than 25 MW. Thus, in 2010 the use of all renewable energy sources made it possible to generate only about 5889.4 billion kW-h, which amounted to only 0.6% of its total output[iii].

A comparison of these data with the indicators of the potential use of RES given above testifies to the insignificant use of the latter. Actually, Russia does not use solar energy for electricity production, although in some areas solar collectors are used for heating dwellings. When wind and tidal power plants are used, their use is quite insignificant, and only small hydropower and biomass use their economic potential for more than 1%.

4. Reasons why Russia lags behind in developing RES: economic non-competitiveness, institutional failure, and lack of infrastructure

Why does Russia, unlike most other countries, use RES so insignificantly? Generally speaking, there are several serious reasons for this:

- the non-competitiveness of RES projects in the existing market environment in comparison with the projects based on the use of fossil types of organic fuel;

- a number of institutional barriers associated with the lack of regulations necessary to stimulate the use of RES in electric power and the absence of both federal and regional programs to support large-scale use of RES;

- lack of infrastructure required for the successful development of an electric power industry based on RES, as well as an insufficient level and quality of scientific background for its development; the lack of an appropriate database of potential renewable energy sources as well as an authentic database on projects already realized; the absence of normative, technical and methodical documentation and the software necessary for the design, construction and operation of power plants using RES; insufficient staffing and a lack of mechanisms to draw on public resources for the development of electric power industry though the use of RES.

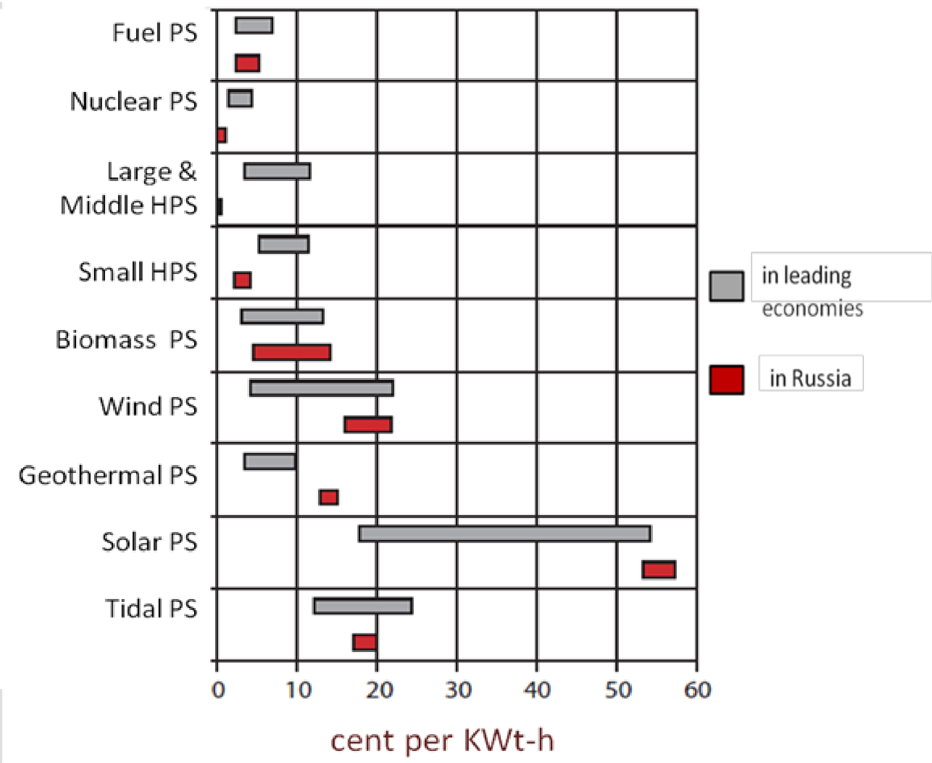

Figure 1. Electricity Production Cost in Leading World Economies and in Russia, 2007

Source: Doklad o razvitii chelovecheskogo kapitala v Rossijskoj Federatsii 2009. Energetika i ustojchivoe razvitie. UNDP, Moskva, 2010 (Report on Human Capital Development in Russian Federation 2009. Energy and Sustainable Development, UNDP Russia, Moscow, 2010, p. 123. (In Russ.)).
Prepared using data from IEA, EFC “APEEC” and JSC “RusHydro”,

According to data based on the materials provided by the International Energy Agency, EFC "APEEC" and JSC "RusHydro", (Report on Human Capital, 2010, p. 123 - see Figure 1), the cost of electric power drawn from RES is on average much higher in Russia than in other countries; this difference is especially notable in the case of solar, geothermal and wind energy. Of such sources, Russia can take advantages of small hydropower only, with the production cost of one kilowatt-hour at traditional power plants here being lower than abroad, which can be explained by cheaper fuel, a high share of cogeneration and favorable conditions for large scale hydro generation. The competitive economic conditions for the development of RES in Russia are thus much less favorable than in other leading countries of the world.
The institutional environment in the Russian electric energy sector is the result mainly of two federal laws:

– The Law "On Energy Saving and Raising Energy Efficiency" of November 23, 2013

– The Federal Law "On Electric Energy Sector (revised)" of March 26, 2003 N 35-FL

These laws support the use of RES by providing:

- the opportunity to set feed-in tariffs or markups for RE;

– state guarantees and budget compensations for access to the grid;

– the chance for the network companies to purchase all renewable energy produced (e.g. by using green certificates).

Yet in practice, however, the specified possibilities for RES development are not taken up. The main reason for this is an extremely lengthy and expensive certification procedure. In particular, in Belgorod, it took a leading company developing RES[iv] – a well-established company with strong lobbing power – a year to obtain a certificate to build a pilot solar power station. As a rule, local grids are reluctant to connect to RES plants due to their unstable character and the low quality of the energy produced (Table 7).

Table 7. Energy Capacity Utilization at Power Plants (%)

Fuel PS in Russia	52,9
Large Hydro PS	40
Small Hydro PS	~ 45
Wind PS	~ 25-40
Solar PS	~ 20

Source: Kozhukhovkij, I.S., Place of Renewable Energy Sources in Total Energy Balance of Russia. Agency for Forecasting Electric Energy Balance, Moscow, 2012, http://www.electrowind.ru/images/vozobn-istochn-v-energetike-rossii.pdf

5. Government promises to support RES and what is expected

An important feature of Russian society is that most companies and organizations tend to perceive the government's advisory recommendations as directives. From this perspective, one cannot but admit that the formation of expectations and forecasts for RES development has been greatly influenced by the Federal Decree of January 8, 2009 No. 1-p "The main directions for the state policy to improve energy efficiency from renewable energy sources for the period up to 2020". This document set down that "state policy in the sphere of energy efficiency from renewable energy sources is an integral part of the energy policy of the Russian Federation and determines the purposes, directions and activities of the state bodies and public authorities for the development of energy industry from renewable energy sources", and assigned to the Ministry for Energy of the Russian Federation the responsibility of coordinating the activity of the Federal executive authorities in implementing the stated policy.

The main purpose of this directive is to increase the energy efficiency of the national economy by introducing high technologies and innovative equipment. The document also establishes target indicators of RES development as a share of electricity production from RES in the total generation of electric energy: for 2010 – 1.5%, 2015 – 2.5% and 2020 – 4.5%. The last figure shows that the capacity of electricity generation will amount to approximately 14700 MW, while electric energy production will reach 50 billion kW-h.

Private-state partnership is expected to finance the implementation of state policy, and the government means to support the enterprises producing energy from renewable energy (except for hydroelectric power stations of more than 25 MW) by

- establishing and regularly adjusting the size and validity periods for markups to the energy equilibrium wholesale electricity/power price to determine the electricity price;

- obligating the wholesale electric energy buyers/consumers to purchase the specified volume of electric energy from RES;

- improving legal regimes for the use of natural resources in the construction and operation of electricity generating plants/facilities based on RES.

In addition, the government has promised "to use the mechanisms for providing additional support of the renewable energy sector in compliance with the budget legislation of the Russian Federation".

The Federal Decree of January 8, 2009 No. 1-p has also established the following measures to increase the network and infrastructural support for the development of electric energy production to be derived from RES:

- improvement of scientific and engineering (i.e. technological services) support in production, realization and consumption of renewable energy;

- the use of potential capacity of domestic industry for the specified purposes;

- creation and development of the information environment and the expert and consulting engineering network as well as information support for the development of RES;

- development of normative, technical and methodical documentation for the design, construction and operation of power plants generating energy from RES;

- stimulation of electric energy consumers to increase the use of renewable energy.

Around the same time, the Russian government initiated the design of two more state programs aimed at facilitating RES development – the State Program of the Russian Federation "Energy efficiency and energy development", adopted in 2013, and "The program to modernize the electricity sector of Russia for the period until 2020", although this has not yet been accepted.

While the two programs contain similar subprograms of RES development and, judging by the contents, they generally correspond to the Federal Decree of January 8, 2009 No. 1-p., both of them focus mainly on the existing realities in the sphere of renewable energy production, i.e. weak competitiveness, high institutional barriers and insufficient infrastructure; consequently, their target parameters are less optimistic. As a further consequence, the modernization program provides for the installation of only 3062 MW from all sources, with 4400 MW of installed capacity from RES to be reached by 2020. The "Energy efficiency and energy development" program goes even further and provides for the installation of about 9000 MW of power capacity over the period until 2020, which will make it possible to increase the generation of electric energy from RES up to 2.5% of its total output.

One further document that deals with RES development – “General scheme of allocation of electric power facilities for the period up to 2030”– has been published by the Energy Forecasting Agency "APBE" and was approved at the government meeting of the Russian Federation on June 3, 2010. However, the measures specified in it do not seem to be sufficient to achieve the targets and their associated indicators set forth in the Federal Decree adopted on January 8, 2009 No. 1-p. The more recent document offers two scenarios of the dynamics of RES input capacities – basic and maximum.

Table 8. The Structure of RES Installed Power Generation Capacities according to “General layout of electric power facilities for the period up to 2030” (%)

	2010	By 2030	
		Basic	Maximum
Total in ths. kW	1315.5	7400	15600
Wind ES	1.0	26.6	48.9
Small HPS (<25 MW)	53.2	27.4	20.5
Geothermal PS	6.2	4.1	2.9
Solar PS	0.0	0.0	0.0
Tidal PS	0.1	0.2	0.1
Biomass PS	39.5	41.7	27.6
In Total	100.0	100.0	100.0

Sources: Joint data from “Elaboration of Program of Modernization of Power Sector of Russia for the period up to 2020”, JSC G. M. Krzhizhanovsky Energy Institute, Moscow, 2011, p. 115 & Kozhukhovkij, I.S., Place of Renewable Energy Sources in Total Energy Balance of Russia. Agency for Forecasting Electric Energy Balance, Moscow, 2012, http://www.electrowind.ru/images/vozobn-istochn-v-energetike-rossii.pdf

Table 8 shows that according to the basic or the minimum scenario only 6.1 million kW of generation capacity will be installed, whereas in the maximum scenario, it will be 14.3 million kW. Although these figures are less optimistic in terms of prospective use of RES, it seems relevant nonetheless to mention that since the government measures to support the development of RES still remain unclear, these forecasts are made on the basis of regional suggestions.

The minimum scenario suggests that there will be a 5.6 fold increase in the use of RE as installed power generation capacity, while the maximum scenario presupposes a 12 fold increase. But even in this case, the share of RES in Russia's total power generation capacity will not exceed 4.0-5.0%. Wind power plants are expected to make the highest contribution to RES capacity increment, while biomass and small hydro power plants will take the second and the third positions. At the same time, since the share of biomass and small hydro energy power plants in the total RE will decrease to the advantage of wind energy, the development of wind energy is highly likely to be the main direction that RES will take in our country.

The prospects for the development of wind energy in Russia have attracted the special attention of the experts, and consequently non-government organizations and independent experts are today developing a special program – "The general scheme of allocation of wind power facilities in Russia for the period up to 2030" (Nikolaev, 2013). The writers of this document estimate that the technical potential of wind power until 2020 and 2030 will be 7 and 30 GW of the generating power with an annual output of 17.5 and 85 billion kW-h, respectively, which considerably exceeds the figures estimated in the more general and already accepted program, "General scheme of allocation of electric power facilities for the period up to 2030". Taking into account the world experience, the authorities have selected the most energetic and cost-effective wind farms with the power capacity of 30-50 MW based on modern wind turbines of 2-3 MW as the first stations for the industrial development of electric power in Russia. This forecast relies on the supposition that wind farms are located mainly in the areas where production cost of electric energy generated at wind farms is lower than the cost of electric power generated at thermal power plants (using gas and coal) under construction, with the use efficiency coefficients of installed capacity of wind farms exceeding 30%(Nikolaev et. al., 2008).

6. Some model analysis

Undoubtedly, the possibility and efficiency of RES largely depends on the microeconomic environment, i.e. the situation in a certain district defined by the existence and quality of the type of the renewable energy source, the energy needs of the district, as well as the availability and the cost of traditional fuel and energy resources. At the same time, it seems relevant to take into account the average costs of RES involvement in economic turnover and energy balance. These conditions are formed at macroeconomic or zone levels and influence the competitiveness of RES proceeding from the practical availability of technologies to supply local energy needs, as well as the technical characteristics of all possible energy sources, including both traditional and renewable sources.

To assess the consequences and efficiency of the distribution of various production technologies and energy consumption, IEIE SB RAS[1] uses an economic inter-region and inter-sector forecast model that includes the energy sector of the economy with energy products in physical units – OMMM-Energy (optimization multi-sector multi-district model that includes energy with energy products in physical units) developed on the basis of the well-known model proposed by A.G. Granberg (Granberg, 1973).

OMMM-Energy is an optimization multi-sector multi-region model (MRIO model) that includes energy with energy products in physical units, and concerns both inter-sector and inter-region relations of national energy sector. It is a composition of two sub-models for the time periods 2008-2020 and 2021-2030, and views the dynamics of investment as a non-linear function adapted with the help of linearization techniques (Suslov, 2014).

The model covers 45 products, 8 of them energy products: rough oil, gas, coal, dark petroleum products, light petroleum products, products of coal processing, electricity, and heat. It also incorporates 6 large regions of Russia: the European region, the Ural region, the Tyumen region, Western Siberia, Eastern Siberia, and the Far Eastern region.

The model includes non-energy sectors that are important for a given energy sector analysis: drilling for oil and gas, pipelines (as a kind of transport), production of special equipment for energy production, transportation, and petroleum chemistry.

The model comprises some peculiarities of energy production and consumption, which distinguishes it from a canonical OMMM:

[1] Institute of Economics and Industrial Engineering of Siberian Branch of Russian Academy of Sciences

- ✓ oil and gas reserves are monitored: the model fixes the annual output to the volume of reserves ratio; output growth is followed by investment into the reserves;
- ✓ diminishing returns to scale in oil and gas extraction sector are included,
- ✓ substitution between different kinds of energy is considered: 20 types of technology that produce heat and electricity are incorporated for each region.

The model makes it feasible to evaluate any complex consequences and the efficiency of policy measures in the sphere of energy production, processing and consumption. Earlier, it was applied to evaluate the economic consequence of:

- ❑ concentration of energy-intensive production in Southern Siberia;
- ❑ gasification in Southern Siberia;
- ❑ reduction in energy intensity of production in the national economy;
- ❑ introduction of heat pumps technology in different regions.

The latest calculations carried out on the basis of OMMM-Energy were aimed at identifying permissible and economically justified cost limits of installed electricity generation facilities using RES. We made several variants of calculations for each of the region specified in OMMM-Energy to analyze how power generation from renewable sources (RES power generation) could impact on the national economy and regions of such power generation. The technique applied is – the different technologies of RES power generation (RES technologies) were incorporated into the models; on the base of priori guesses, the upper bound of a presumable volume of power generated by untraditional capacities were set; investment intensities of power generation were set with their initial values referred to standard power generation technologies used by traditional thermal stations; and then investment intensities were step-by-step increased to the level when the RES technologies become uncompetitive to traditional ones and, therefore, unavailable in the solution of the problem.

So, two ranges of costs per unit of generation capacity were obtained for each region. The first one is such that power generation from renewable sources is obviously efficient and its application is limited only by technological and natural conditions. Another range is that one when RES technologies can compete with traditional ones and the choice of sources and RES technologies depends on the certain technological, natural, and economic conditions.

Table 9. Variants of Economic Development Indices as Function of RES Generation Capacities

European part of Russia						
RES power generation cost, thousands US $* / 1 MW	2,1	2,3	2,6	2,8	3,1	
RES power generation, bln. kWt-h.	21,8	8,1	5,8	5,5	1,2	0,0
Incremental GDP growth per 1000 RES kWth, US $ (2007)	19	21	25	38	-3	
Incremental households' consumption growth per 1000 kWth of RES power generation, bln kWth	7	12	10	4	4	
Incremental investment growth per 1000 kWt-h of RE power generation, bln kWth	12	9	16	34	-7	
Energy saved per 1000 kWth, t.o.e.	0,160	0,160	0,211	0,254	0,261	
Western Siberia						
RES power generation cost, thousands US $* / 1 MW	2,1	2,3	2,6	2,8	3,1	3,9
RES power generation, bln. kWt-h.	21,8	8,1	7,2	5,6	4,0	1,2
Incremental GDP growth per 1000 RES kWth, US $ (2007)	32	25	27	31	37	3
Incremental households' consumption growth per 1000 kWth of RES power generation, bln kWth	11	16	12	8	3	2
Incremental investment growth per 1000 kWt-h of RE power generation, bln kWth	22	9	16	22	34	1
Energy saved per 1000 kWth, t.o.e.	0,155	0,219	0,206	0,257	0,303	0,288

* Including cost of installation
Source: Model calculations

Two regions – the European part of Russia and Western Siberia – showed the most interesting results. The results show that both ranges in these regions are nearly equal – the first range, being in the cost of 1 kW, is equal up to US $2.1 thousand and another range – from US $2.1 thousand up to nearly US $3.1 thousand for the European part of Russia and US $3.9 thousand for Western Siberia. Thus, the RES power generation with the cost per 1 kW up to $2.1 thousand could be regarded undoubtedly efficient. The RES technologies incorporated in the model with investment intensities higher than above mentioned are available in the solution with their production lower than their upper limits. At that, if the investment intensity changes from US $ 2.1 до US $ 2.3 thousand the production sharply drops with further retarding deviation from maximum (see Table 9). It is just the range where renewable sources can compete with tradition ones as renewables lose their economic attractiveness due to growing cost of the equipment and installation.

For the purpose of our study, we increased the RES investment intensities step-by-step to analyze how they would change the total investment in the economy. Such total investment changes take place mostly due to two factors. The first one is higher investments per RES fresh capacities which make the total investments in the economy higher and the second one – the exclusion of traditional power generation technologies and, therefore, a drop in their fuel supply that results in lower total investments.

To summarize our RES generation efficiency analysis, we have found out that there are two levels of justified cost limits of installed electricity generation for the regions included in the model. The first one equals to USD 2100 per 1 kW, which equals to USD 2100 per 1 kW, which means that, given the estimated long-run *average* conditions, the production technologies of electric energy derived from RES requiring investment per 1 kW that are *lower* the specified level seem to be economically feasible and could dominate traditional generating technologies. Thus, their application is constrained rather by technical and natural conditions. The second level of cost limits equals to USD 3100 per 1 kW for European Russia and up to USD 3900 for Western Siberia. That means that given the estimated conditions the production technologies of electric energy derived from RES which require investments that are *higher* the specified levels seem to be neither economically justified nor feasible. The technologies of electric energy derived from RES with the costs of their installation *between* the estimated first and second levels of cost limits of installed electricity generation seem to compete with traditional power generating technologies.

The range between these levels includes the average expected price on electricity generated by RES, which the State Program of the Russian Federation "Energy efficiency and energy development" establishes at the level of RUB 75 thousand per 1 kW. We believe that this fact shows that probably RES development in Russia requires special attention and support from the government.

7. Summary

1. Since Russia is an energy abundant country, a number of favorable conditions exist for the development of RES. Russia's extremely large surface area is a specific reason for believing that it will be able to increase both the use of RES and the share of the resources in the energy balance and electricity generation of the country.

2. Although, in general, renewable energy sources are less competitive than traditional energy technologies, there are regions where RES based technologies are effective even at the present time. Probably, in the future, the situation in the country will change to the advantage of RES.

3. It is doubtful, however, that the role of renewable energy sources in Russia will ever be as important as in Europe, Japan, Northern America, or in most other countries, but the importance of RES is highly likely to grow in Russia as well.

4. In order to facilitate RES development, the Russian government should elaborate and carry out drastic measures to support energy produced from RES.

5. The current Russian legislation provides for the possibility to set feed-in tariffs, promises the government's support for the access to grid with budget compensations, and guarantees to oblige network companies to purchase all the RE produced (e.g. through the use of green certificates).

6. The main reason why these institutional regulations in the energy sector do not work is because of the extremely lengthy and expensive certification procedure that they have to undergo. As a rule, local grids are reluctant to connect to RES plants due to what managers believe to be their unstable character and law quality energy.

7. Electricity and capacity supply contracts (which guarantee investment return) on a competitive basis seem to be a key factor in the successful promoting of RES, but the required legislation has not yet been developed.

[i] This concept coincides to energy sector of economy

[ii] [ii] Russian Statistical Agency

[iii] According to another source in 2011 the volume of electricity production from RES increased up to 8.4 bill. kW-h. or about 0.8% from the total generation, which equaled to 1058 bill. kW-h. - State Program of the RF «Energy efficiency and energy development» (2013), p. 162, Access: http://www.minenergo.gov.ru/upload/iblock/d6c/d6c2bd083f7a808423b3b21c3069de39.pdf

[iv] The solar station of AltEnerg in Belgorod came into operation on October 1, 2010; its peak rated power accounts for 100 kW. It is a pilot plant with two different prototypes of equipment amounting to 1320 modules: amorphous and polycrystal, with a total active surface of 1230.2 square meters.