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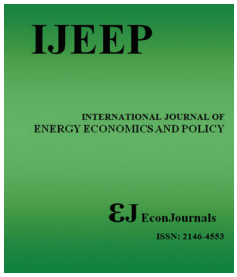

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Green Electricity and Heat Generation in Canada: Implications for Russia

Denis A. Lavrov[1], Svetlana V. Karpova[2], Vladimir I. Avdiyskiy[3]*, Svetlana E. Dubova[4], Svetlana V. Makar[5], Natalia A. Barmenkova[6], Nataliya A. Kazakova[7], Nikolay P. Kushchev[8]

[1]Scientific and Educational Center for Continuing Education and Financial Consulting, Financial University under the Government of the Russian Federation, Moscow, Russia, [2]Experimental Laboratory "Neurotechnology in Management" at the Department "Logistics and Marketing," Financial University under the Government of the Russian Federation, Moscow, Russia, [3]Department of Economic Security and Risk Management, Financial University under the Government of the Russian Federation, Moscow, Russia, [4]Department of Banking and Financial Markets, Financial University under the Government of the Russian Federation, Moscow, Russia, [5]Center for Regional Economy and Interbudgetary Relations, Financial University under the Government of the Russian Federation, Moscow, Russia, [6]Department of Public Administration and Municipal Management, Financial University under the Government of the Russian Federation, Moscow, Russia, [7]Basic Department of Financial and Economic Security, Plekhanov Russian University of Economics, Moscow, Russia, [8]Department of Human Resources Management, Moscow Aviation Institute (National Research University), Moscow, Russia. *Email: vavdiyskiy@bk.ru

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ABSTRACT

Today, green energy is a new key feature of the energy sectors in developed and dynamically developing economies. It can stimulate the development of small and medium-sized businesses, greatly impacts on nature conservation and generates a strong technological impulse. Canada is known as one of the countries with a highly developed green energy and is considered to use most of its resources efficiently. Russia possesses significant reserves of natural resources and has high potential in the field of green energy production; however, the share of green energy in its energy balance is not high. The authors have compared Canada and Russia in terms of climatic conditions, financial situation, potential for green energy and social attitudes towards green energy, and demonstrated the similarity of the two countries. Having conducted a regression analysis of green energy production, the authors have further analyzed the regional potential for green energy development by comparing energy prices and proved that green energy is cheaper in Canada. Based on the obtained results, the authors have developed a system of recommendations for Russia in the field of green electricity and for both countries in the field of green heating. The main findings include the system of recommendations, the reasons for the reluctance of Russian society to introduce green energy, and a regional analysis of the most suitable regions for green transformation.

Keywords: Green energy, Russia, Canada, Electricity, Heating, Strategy
JEL Classifications: O13; Q42

1. INTRODUCTION

Canada has always been one of the main players in the energy market, especially given the recent discovery of significant shale oil and gas reserves (Gapys, 2014). The country is one of the most developed economies in the world, it has access to significant capital resources (Financial Consumer Agency of Canada, 2019) and is rich in natural resources (Sohi, 2019). In general, these factors determine the current state of development of the energy industry in the country, which largely depends on the energy generated from renewable sources and sustainable energy.

At the same time, the country has a relatively harsh climate, and heat generation is a vital challenge for the country's energy sector. The generation of heat from alternative energy sources is a serious problem for modern energy industry (VHK, 2002). Despite this fact, the Canadian energy sector has significant potential and significant success in this field.

Russia is another country studied in the article by comparing natural conditions, resource base, economic situation and the current state of energy production. The choice of countries is explained by a number of similarities in the described below fields, which form a common basis for the development of alternative energy.

The article is aimed at identifying similar and different specifics of the two countries' energy sectors and the development of alternative energy in Russia, as a less successful country in this field.

The authors have studied similarities and differences in factors influencing the development of green energy in the countries, then conducted a regional analysis of energy prices in the studied countries and developed general and region-specific recommendations for the development of green energy in Russia, based on Canada's experience.

The debate on the efficiency of green energy and the effectiveness of green technologies introduction in energy production has lasted for a long time. In the search for a green energy strategy for Russia, the authors have been inspired by Duan et al., (2020), who studied the financial side of green energy and proved the uneconomic nature of photovoltaic energy, which is used by the green transition in Canada – not the best place for solar energy production. This contradiction was also analyzed by Nathwani and Ng (2014), who stated the high costs of green energy transition in the country. Ali (2020) demonstrated the high economic efficiency of green energy production in Canada. Wadström et al. (2019) suggested that the economic situation in the country, and therefore the financial situation, affects the development of green energy in the country. In addition, subsidies that Canada introduces to support green energy development do not always comply with the WTO rules (Charnovitz and Fischer, 2015).

This article also discusses the transformation of Russian green energy. Sadovnikova et al. (2020) stated that conventional energy in the EAEU countries, including Russia, is cheaper than green energy, therefore, its production is uneconomic. Porfiryev (2018) expressed another opinion about the need to develop green technologies in Russia. Bachurinskaya et al. (2020) demonstrated the use of green technologies in the private sector and their insufficient efficiency in Russia; Kapitonov et al. (2016) analyzed the development of green energy in several regions of Russia, however did not provide a comprehensive analysis. Vashchuk and Titov (2016) focused only on clustering without taking into account foreign experience for Russia.

2. METHODOLOGY

The terms "green energy" and "alternative energy" are used to describe a system of energy production methods based on renewable energy sources such as solar, wind, hydropower, biofuels, waste, geothermal and tidal power generation. The term "energy" describes both the production and distribution of electricity and the production and distribution of heat.

The article provides a comparative analysis of the two countries, which allows to give a clear answer to the question of what and how these countries resemble each other. The comparison criterion follows from the nature of the green energy use: firstly, the climatic conditions that shape the demand for electricity and the need for heating, and secondly, the availability of conventional energy resources such as oil and gas (at the current stage of technology development, they are still cheaper than green ones), thirdly, the availability of resources for the production of green energy, especially specific ones, such as geysers and volcanoes or coastlines that provide opportunities for the production of tidal energy. And the last criterion is the attitude of society towards green energy: public-private partnership (PPPs) serves as a powerful tool to accelerate the development of the sector. Having proved the similarity of countries and factors contributing to the development of green energy (mentioned above), the authors analyze economic opportunities and effects from the introduction of green energy in the studied countries.

The methodology is based on regression equations for green energy production. It is obvious that production and especially the creation of economic conditions for the development of green energy requires significant initial investments. The authors consider GDP per energy unit as an endogenous variable, and the production of green energy from sources as an exogenous variable. Based on these regressions, the authors obtain adequate econometric models ($R^2 > 0.95$, $P < 0.05$), which are then transferred to regional electricity prices for final consumers. This assumption is based on the fact that the budgets of both countries are formed according to the federal principle: the budgets of the regions are agglomerated in the state budget, therefore, the costs of energy transferred to GDP are calculated on the same basis: regional costs are the average federal cost (Greer, 2011; Rhodes et al., 2017). The vice versa is also true, therefore, regional costs are derived from the federal ones, therefore, the exogenous variables are the same, and the differences should be neglected due to the centralized regulation of the development of green energy in Russia and similar state policy in this field in Canada.

3. RESULTS

3.1. Comparison of Natural Conditions and Resource Base

When speaking about green energy, the first question to answer is whether green energy is available for use in the country/region. This is required to assess the efficiency of green energy introduction, since traditional sources of energy, such as oil and gas, are easier and cheaper to use if the country has difficult climatic conditions or lacks the opportunities to produce green energy with lower costs than the cost of energy facilities maintenance.

Climatic conditions in Canada range from moderate to harsh. The country has a significant territory, in the south, near the borders

with the United States, the climate is moderate, with moderately cold winters and a relatively large number of sunny days. In the north, the climate is harsh with long cold winters and arctic conditions. Under these conditions, heat generation becomes a vital part of life in the region. In addition, the demand for electricity is higher than that in the south due to the short daylight hours in winter.

The availability of oil and gas in the country is high, since the infrastructure for the distribution of these resources is well developed (Brunner and Axsen, 2020; Avraam et al., 2020). At the same time, the use of green energy is also highly developed, with 18.9% of the country's energy generated from renewable sources (Government of Canada, 2017). Canada is characterized by high activity of local communities in the green energy transition. Indigenous communities also support this initiative, partly because of the ecoENERGY initiative subsidies (Government of Canada, 2016) and partly because of the need for mobile and sustainable energy sources in remote and isolated regions. These initiatives help to implement the government policy in the field of green energy. Notably, the right and responsibility for the use of all natural resources is largely vested in the provincial governments, which tend to shape the local approach to energy use (for example, the Green Energy and Green Economy Act of Ontario [McRobert et al., 2016]).

The availability of resources for green energy production in the country is also high. Canada is rich in forests; therefore, biofuel production is available; given the country's technological development, biofuels can compete with traditional gasoline and other oil-based fuels. The long coastline and high wind speeds (Desrochers and Reed, 2019) allow to suggest that wind energy production is rather cheap. Tidal energy is available, but not widely used due to the complexity of its production technology. The availability of solar energy with modern photovoltaic technology is rather an issue of productivity. Hence, this type of energy is available in Canada with moderate efficiency. The country has a huge potential in hydropower with a high share of local enterprises and local initiative in their creation, small hydropower facilities (with a capacity <50 MW) are spread in the country. At the same time, classical hydroelectric power plants are also widely used. It follows that there are all conditions in the country for the development of green electricity and heat: both the availability of natural resources and suitable conditions in the economic and social areas.

The climate in Russia is similar to the Canadian one. The country is located mainly in areas with a harsh and moderate climate, long cold winters with long periods of short daylight hours are the main characteristic of the northern part of the country. The southern part of the country has a moderate climate and the number of sunny days varies.

The availability of oil and gas in Russia is high; the private sector, especially in small towns and villages in the central part of the country, relies heavily on gas as a heat source (Vanadzina, 2018). At the same time, the availability of electricity and heat in isolated parts of the country (which make up most of its territory due to the low road network density) is low. This leads to the need to create local generating capacities. At the same time, the unified energy system created in the country greatly simplifies the distribution and redistribution of energy, while heat remains a serious problem.

Private initiatives on green energy in Russia are rare (Gielen and Saygin, 2017), in addition, PPPs in this field are not developed. The government today does not pursue an active policy in the field of transition to green energy, but the main steps in this direction have already been taken (Henderson and Mitrova, 2020; Rasoulinezhad et al., 2020).

Classical sources of green energy in Russia – wind, solar and hydropower – are unevenly distributed. Due to different socio-economic conditions, wind and solar energy are considered inefficient in the country by the private sector. In addition, the high production of these energy sources is possible only in the south of Russia, leaving most of the territory with moderate efficiency (Serga et al., 2016). On the other hand, hydropower is widely used, with several of the world's 10 largest hydropower plants located in the country. Geothermal energy is available in the Kamchatka krai, where volcanoes and geysers make it possible to use geothermal energy for both heating and power generation. The use of tidal energy is experimental, just as in Canada. Waste energy is rarely used. Biofuels can be produced on a large scale, but due to the economic orientation towards hydrocarbon production, this field is not developed.

In general, the situation with green energy in Russia is significantly worse than in Canada, however, the resource base is rich and provides opportunities for regional development.

The comparison reveals the following similarities:
1. Similar climatic conditions
2. Difficult climate in winter and the need for reliable sources of heat and electricity
3. Similar resource base, significant reserves of renewable energy sources
4. Similar distribution of the population, concentrated in large cities
5. Long distances between energy producers and final consumers.

The main differences are:
1. Different levels of economic development
2. Different situation with state programs in the field of green energy
3. Different public attitudes and implementation of PPPs initiatives
4. Different structure of energy balance.

As it follows from the comparison, the main measures that should be taken in Russia to increase the use of green energy lie in the economic and social areas.

3.2. Comparison of Green Energy Production and Estimation of Regional Price for Green Energy

Green energy production in Canada and Russia has several similarities and differences that should be identified. Figure 1

shows monthly energy supplies from hydropower, solar, wind and tidal energy, as well as annual energy production from waste.

Figure 1 demonstrates the seasonality of energy supply throughout the year; a radical reduction in the generation of energy from waste in 2013; a radical increase in energy production from wind in 2016, 4) the seasonality of heat and electricity production from solar energy and its growth in 2016 from increasing the efficiency of technologies.

At the same time:

a. Canada does not rely significantly on solar energy due to moderate productivity and efficiency, which leads to a low role of solar energy in heat production in the country
b. Wind energy is the second most important green source of electricity in the country, but it does not even come close to hydropower
c. Biofuels are not widely used in Canada for the production of electricity and heat (Canada Energy Regulator, 2020), while this source of energy is the main source of the generation of heat in the country (the only one, according to IEA [2020a]).

As for Russia, the transformation of the energy sector is proceeding slowly and began much later than in Canada. In this respect, the Canadian experience may be of particular importance for the future of the Russian energy sector. The dynamics of energy production from green sources is shown in Figure 2.

Due to the lack of monthly data, the authors cannot determine the seasonality of energy production and the demand for energy, but based on the comparison of the two countries, the authors have concluded that climatic conditions, especially short daylight hours, form the same seasonality of demand/supply for electricity throughout the year. Other important trends are: (1) the preservation and steady growth of hydropower production, (2) the growing role of wind, sun and biofuels in the country's energy balance, (3) the growing role of the energy production from waste, (4) the growing use of geothermal sources in electricity production.

It follows from the above that:

a. Russia does not rely on new sources of renewable energy; it sticks to traditional hydropower
b. The production of energy from waste plays an important role in the production of renewable energy in the country due to the concentration of green energy facilities near large cities, in the most developed regions such as Moscow, Moscow Oblast, St. Petersburg and Leningrad Oblast
c. Geothermal energy is used quite efficiently in the country, while solar energy was not used until recently
d. Rapid growth in solar and wind energy production may be due to strong lobbying for green transformation, rather than the real efficiency of these sources
e. Biofuels do not play a significant role in the production of electricity in the country, but their share is growing.

In this regard, Russia has several significant differences from Canada, which should be taken into account when forming implications for Russia.

Figure 3 demonstrates the use of green energy sources for heat generation in the countries.

The key conclusions that follow from Figure 3 are:

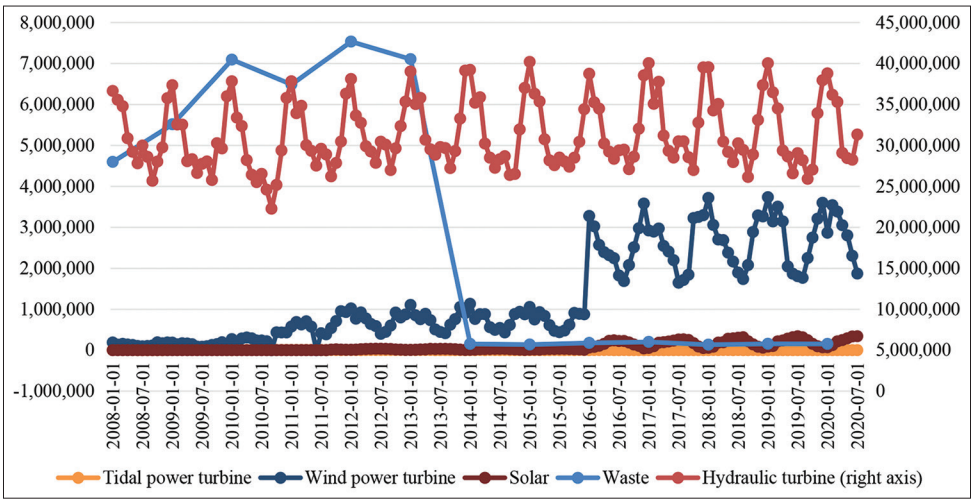
1. Russia has made significant progress in the generation of heat from renewable fuels, mainly from waste
2. The cost of biofuel production in Russia remains high, so the use of this energy source in the country's energy balance remains low
3. Canada's green heat energy sector is underdeveloped despite the spread of solar energy throughout the country.

In this regard, heating based on green energy sources remains a serious barrier to the development of green energy, especially in countries with cold climates such as Russia or Canada.

Let us refer to modeling the impact of green energy on the energy balance and economy of the studied countries. When discussing Canada, it should be noted that the only source of green energy that affects the efficiency of energy production in the country (the main indicator of which is GDP per unit of energy used (y)) is hydropower (x). The regression equation is as follows (1):

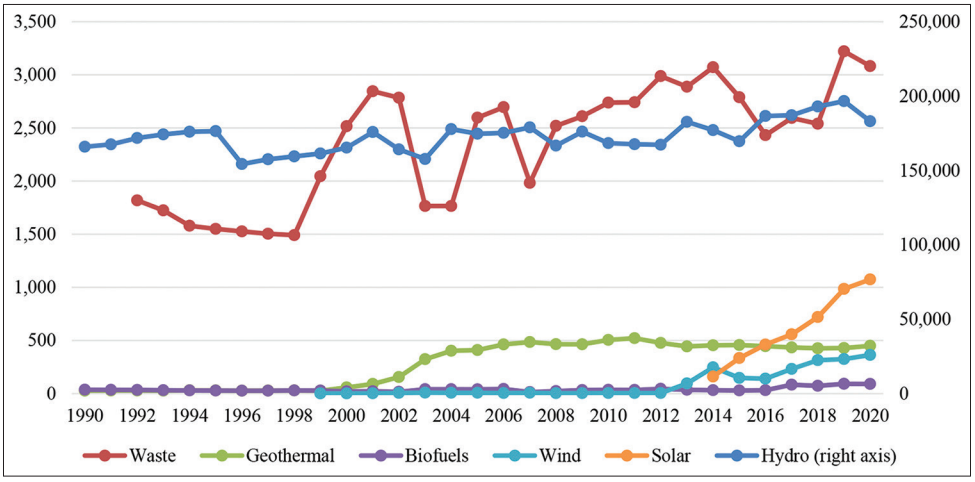
$$y \sim 5{,}48025e{-}09 * x \quad (1)$$

Figure 1: Supply of green energy in Canada, MWh



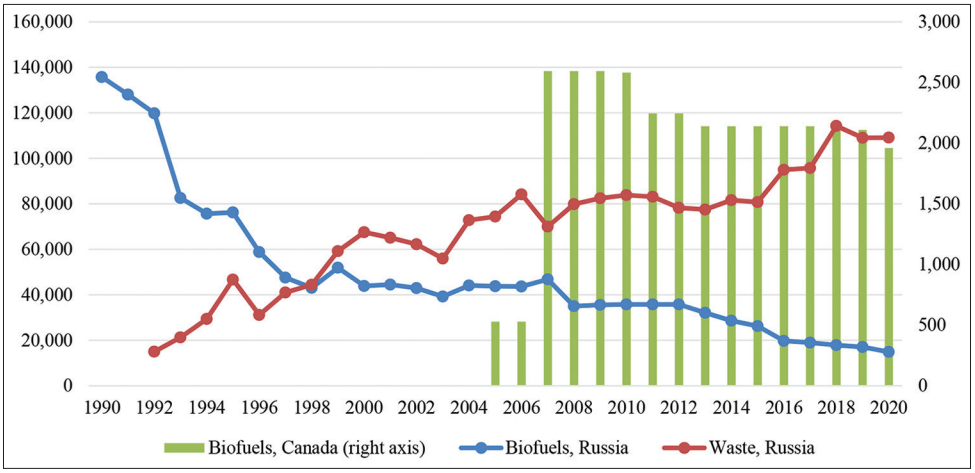
Source: (Statistics Canada, 2020)

Figure 2: Electricity production from green sources in Russia, GWh



Source: (IEA, 2020b)

Figure 3: Heat generation from alternative sources in Russia and Canada



Source: (IEA, 2020a; 2020b)

At the same time, the development of hydropower (x) is determined by wind (z), solar (v) and tidal (b) energy with the following regression (2):

$$x\sim2{,}40742 * z-27{,}6297 * v-685{,}743 * b+3{,}75313e+08 \quad (2)$$

Thus, the impact of green energy on the Canadian economy primarily depends on the development of hydropower, which, in turn, is pushing the development of other sources of green energy, leaving behind only energy from waste, which is unlikely to be green, more precisely, renewable. This system was formed due to the high importance of private initiative in the development of solar and wind energy, as well as due to the lack of financial resources for the development of hydropower in the houshold sector. Hydropower was developed by state authorities, while other forms of green energy followed a general trend.

When discussing Russia, where the initiative for the introduction of green energy comes from the state, the regression for GDP per unit of energy used (y) is as follows (3):

$$y\sim0{,}000188682 * x+0{,}00361865 * v-0{,}00727645*z+0{,}00177839 * c+0{,}000996706 * q+2{,}92499 \quad (3)$$

where waste (x), geothermal energy (v), biofuels (z), wind (c) and solar energy (q) have a small significance for energy efficiency, as can be seen from the small coefficients and a significant constant. In this case, the regression can be formed with hydropower (r) (4):

$$y\sim6{,}11260e-05 * r-6{,}23212 \quad (4)$$

The obtained result demonstrates the low importance of hydropower development in improving the efficiency of the Russian energy sector. Despite the result, the overall importance of hydropower in the country's energy balance can hardly be overestimated (Bogoviz et al., 2020).

To identify the most financially efficient source of energy for development in the studied countries, the authors refer to Tables 1 and 2, which demonstrate the cost of electricity for final consumers in different regions of the countries.

It follows from Table 1 that the deviation of prices in the consumer energy sector in Russia is high, especially taking into account the close to normal distribution of electricity prices.

Table 1: Electricity prices by regions in Russia, rubles/100 kWh

Region	Price	Region	Price	Region	Price	Region	Price	Region	Price
Irkutsk Oblast	106	Tyumen Oblast	277	Tomsk Oblast	336	Kemerovo Oblast	328	Orenburg Oblast	294
Yamalo-Nenets Autonomous Okrug	274	Nenets Autonomous Okrug	509	Chukotka Autonomous Okrug	820	Republic of Bashkortostan	301	Jewish Autonomous Oblast	385
Khanty-Mansiysk Autonomous Okrug–Yugra	278	Moscow	538	Sakha (Yakutia) Republic	589	Kamchatka Krai	669	Republic of Dagestan	248
Murmansk Oblast	268	Zabaykalsky Krai	263	Amur Oblast	364	Komi Republic	460	Tyva Republic	346
Sakhalin Oblast	409	Primorsky Krai	294	Magadan Oblast	749	Republic of Crimea	270	Chechen Republic	262
Republic of Khakassia	208	Novosibirsk Oblast	256	Chelyabinsk Oblast	314	Khabarovsk Krai	443	Sevastopol	311
Krasnoyarsk Krai	248	Saint Petersburg	453	Karelia	338	Leningrad Oblast	407	Moscow Oblast	529
Tatarstan	369	Lipetsk	356	Tula Oblast	414	Vologda Oblast	444	Bryansk Oblast	360
Sverdlovsk Oblast	389	Udmurt Republic	369	Chuvash Republic	325	Saratov Oblast	343	Volgograd Oblast	417
Yaroslavl Oblast	356	Omsk Oblast	386	Kaliningrad Oblast	405	Ulyanovsk Oblast	368	Ryazan Oblast	438
Arkhangelsk	477	Voronezh Oblast	368	Belgorod Oblast	386	Republic of Mordovia	351	Krasnodar Krai	461
Nizhny Novgorod Oblast	358	Kurgan Oblast	332	Kaluga Oblast	460	Smolensk Oblast	378	Kirov Oblast	379
Perm Krai	392	Penza Oblast	339	Rostov Oblast	383	Mari El Republic	366	Republic of Ingushetia	347
Republic of Buryatia	393	Samara Oblast	400	Kursk Oblast	380	Novgorod Oblast	424	Orel Oblast	374
Tver Oblast	423	Tambov Oblast	382	Stavropol Krai	448	Kostroma Oblast	432	Altai Republic	498
Vladimir Oblast	437	Kabardino-Balkar Republic	369	Karachay-Cherkessia Republic	394	Pskov Oblast	425	Republic of Adygea	461
Astrakhan Oblast	472	Northern Ossetia-Alania Republic	395	Altai Krai	392	Ivanovo Oblast	428	Republic of Kalmykia	459

Source: (RIA Rating, 2018)

Table 2 shows peak values in the Northwest Territories and Nunavut, while the other provinces and territories have a relative equal distribution of electricity prices. Further analysis requires an assessment of the influence of factors on prices, which may be estimated by calculating the range of price impact for the final consumer. The results for both countries by energy source are presented in Table 3.

Table 3 shows the current situation and the key problem of green energy in Russia, explaining the reluctance of society to introduce green energy in the country: the costs of green energy introduction for society and final consumer in Russia are significantly higher than in Canada, 1000 and more times higher. The exceptions to the general rule are those types of energy that are not represented in the model – tidal for Russia and waste, geothermal energy and biofuels in Canada.

In this regard, the most promising regions of Russia for the further development of green energy from the point of view of economic efficiency are: Irkutsk Oblast, Republic of Khakassia, Krasnoyarsk Krai, Republic of Dagestan, and the least promising regions are Moscow, Moscow Oblast, Magadan Oblast and the Chukotka Autonomous Okrug.

Frequency analysis allows to divide all regions of Russia into 4 groups: (1) those where costs of green energy transition are less than 3 rubles (2 regions); (2) where costs range from 3 to 4 rubles (10 regions); where costs are from 4 to 7 rubles (66 regions); (3)

Table 2: Electricity prices for final consumers in Canada

Provinces and territories	¢/kWh
Alberta	16.7
British columbia	12.4
Manitoba	9.6
New Brunswick	12.7
Newfoundland and labrador	13.8
Nova Scotia	15.0
Northwest territories	38.7
Nunavut	37.5
Ontario	12.5
Prince edward island	16.8
Quebec	7.3
Saskatchewan	18.2
Yukon territory	14.5
Canada average	17.4

Source: (Urban, 2020)

and those where costs are higher than 7 rubles (7 regions). This division follows from the frequency diagram (Figure 4), where most of the regions lie between the values 4 and 7, and the rest are either extrema (singular points below 3 and above 8), or transitive (between 3 and 4 and between 7 and 8).

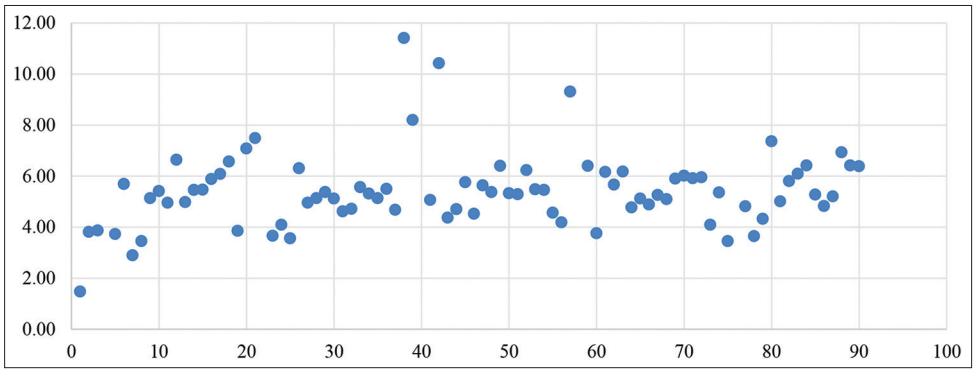
At the same time, green energy for heating in Russia is better developed due to the active use of waste as a renewable energy source. Canada's approach – the use of biofuels – is fundamentally different, since it allows to recycle waste, not incinerate it, therefore, comparing the two countries in this field and making recommendations on this topic is ineffective. However, the Russian

Table 3: Regional dispersion of final costs of green energy production, in rubles

Source of energy	Russia			Canada		
	Coeff.	Min	Max	Coeff.	Min	Max
Hydropower	0.00006	0.006	0.0501	0.000000006	0.00000235	0.00001247
Tidal	0	0	0	0.0000037	0.0016136	0.0085545
Wind	0.00177	0.188	1.4582	0.00000001	0.0000056	0.0000300
Solar	0.00099	0.105	0.8172	0.0000001	0.0000650	0.0003446
Waste	0.00018	0.02	0.1547	0	0	0
Geothermal	0.00361	0.383	2.9672	0	0	0
Biofuel	0.00727	0.771	5.9666	0	0	0
Society costs	0.01392	1.475	11.414	0.0000039	0.001686	0.008941

Source: the authors' calculations

Figure 4: Frequency analysis for Russia's regions



Source: Created by the authors

heating system has solved several serious problems, including the constant renovation process, and can serve as an example of an efficiently developing system.

4. DISCUSSION

As we have shown in the previous section, the cost of green energy in Russia is higher than in Canada, while the higher level of economic development in Canada helps to attract more financial resources for the transition to green energy. In addition, Canada's higher GDP per capita (World Bank, 2020) and lower social costs on green energy allow this sector to attract private investment and develop PPPs.

The development of green energy in Canada's electricity generation sector is better than in Russia; removing barriers, which differ Russia from Canada, is the key to improving the efficiency of Russian green energy sector. Given this, the authors have formulated the following recommendations for Russia in the field of green energy development by category.

4.1. Financial Resources (General and Region-specific Recommendations)

1. Attracting additional energy resources to the green energy sector in Russia is possible through delegating the development of green energy in local communities to the level of municipal or regional authorities
2. Encouraging investment in the development of distant cities and communities through government subsidies, which can be tested in the regions with the cheapest energy, such as Irkutsk Oblast and Krasnoyarsk Krai: the former provides a basis for a greener Baikal coast and has the potential to conduct a regional project, for example, green energy to preserve the wildlife of Lake Baikal, while the latter may launch a similar project for the Yenisei River and has several remote and inaccessible towns and villages. The same refers to Khakassia
3. Dagestan can become a driver for green energy in the Caucasus region by greening tourist attractions. The inflow of financial resources through tourism can be used to build green facilities. Another possible measure is the introduction of a tourism tax for a greener future for the region, which could be used to stimulate the transition to green
4. Moscow and Moscow Oblast may issue green bonds to attract financial resources and ease the burden of transition to green on final consumers
5. Magadan, Chukotka and other regions with harsh natural conditions and expensive energy should abandon the transition to green energy
6. Regions with an average cost of green energy transition (4–7 rubles) should delegate decisions to municipal authorities, since the transition to green energy in these regions is most efficient through a private initiative or the initiative of local communities
7. Regions with a low cost of green energy transition to (<3 rubles) may increase prices for final consumers, so that they can invest in green energy facilities, but their main goal is to create a sustainable basis for future private initiative before the cost of green energy transition rises to 4 rubles
8. Regions with a high cost of green energy transition (>7 rubles) should request financial assistance from the federal budget, but the final price for consumers should not increase, so the decision should be made based on the availability of cheap

and abundant green energy (for example, hydropower in the regions with large rivers). Costly and relatively inefficient green energy facilities should be avoided.

4.2. State Position Regarding the Transition Green Energy (General Recommendations)

1. Russia should adopt a new green energy transition strategy, which should focus on regional development and more efficient use of private sector financial resources. It should stimulate private initiative through the introduction of special discounted tariffs for households producing green energy, sales tariffs for households with overproduction of energy, special incentive subsidies for regions, the development of green energy and improved indicators to measure achievement of planned results (Gavrikova et al., 2019; IFC Russia Renewable Energy Program, 2011)
2. Implementation of regional planning systems for the purpose of transition to green energy in regions with the lowest costs for the introduction of green energy.

4.3. The Change of Public Attitude to Green Energy (General Recommendations)

1. The main problem of Russia in the field of green energy is that the costs of its implementation are transferred to consumers. To solve this problem, the state must subsidize green enterprises, especially SMEs (Teslyuk et al., 2018)
2. Another important measure that needs to be taken is the promotion of green energy through corporate promotion from the largest companies in the energy sector, especially the oil and gas giants Gazprom, Rosneft and Lukoil
3. Introduction of stimulative taxes for green households
4. Introduction of stimulative import tariffs on green energy parts.

4.4. The Transition of the Economy from Oil and Gas to Green Energy Sources; This Requires Significant Changes in the Economy as a Whole, Which May be the Topic of Another Complex Discussion

As to green energy for heating, the current stage of technological development does not allow to construct a massive sustainable green heating system, therefore, the general recommendations for both countries should be as follows:

1. Using non-recyclable waste as a source of heat in large cities where a significant amount of waste is produced
2. Using geothermal energy as the main source of heat in areas where this natural resource is abundant
3. Implementing the same measures of financial support for the industry as for the production of electricity from green sources
4. Using biofuels if they are economically viable – if they are not more expensive than conventional energy sources (biofuel energy is not a carbon-free energy source, so the financial aspect comes first).

Green energy production in Russia can be significantly improved through the transfer of institutional approaches from Canada and their regional implementation. It is clear that further development of green energy sources in large Russian cities, such as Moscow, or highly urbanized regions, for example, Moscow Oblast, is too expensive, and the massive transformation should start with regions with cheap energy. At the same time, energy sources such as waste are urban-specific and require large cities nearby, while other sources of green energy depend on resources and require natural conditions. This means that highly urbanized regions with high costs for the further development of green energy are the most efficient for their use. In the case of Russia, the best options for their implementation are St. Petersburg, Leningrad Oblast, Yekaterinburg and Vladivostok. The overall relevance of the regional analysis lies in the ambiguous approach to green energy adoption. In this regard, the authors propose to use the cost transition methodology developed in this article to select the best regions for the transition to green energy. The dispersion of financial costs in Russia is higher than in Canada, so the differentiated approach should be used; furthermore, the authors advise to delegate green energy decisions to local authorities.

5. CONCLUSION

Natural conditions and the availability of green energy resources are commons feature of both countries. Further, the need for heating brings Canada and Russia closer together in the field of green energy. At the same time, Canada has a more efficient economic system for the development of green energy, its society bears less costs for the transition to green energy and supports the renewable energy introduction. In Russia, the situation is different, and neither the economic nor social areas support the transition to green energy. In this regard, Russia needs to adopt Canadian institutions for the development of green energy.

The great importance and cost of introducing green energy into the economy raise two main questions: which types of green energy should be developed first and where they should be developed. The authors have demonstrated that for Canada, the main source of green energy is hydropower, which, in turn, stimulates the development of wind, solar and tidal energy, the latter being experimental. In Russia, hydropower is the most massive source of green energy, but other types do not directly depend on it. Waste, geothermal energy, biofuels, wind and solar energy are developing in their own way, but today their role in Russia's energy balance is small. To adapt Canadian institutions, the Russian authorities should decide which regions to move to green energy first. For this purpose, the authors have developed an approach based on the regional cost of introducing green energy, which allowed to conclude that Dagestan, Khakassia, Irkutsk Oblast, Krasnoyarsk Krai have the greatest potential for the introduction of green energy, while Moscow and Moscow Oblast, usually mentioned as Russian green energy centers, will face difficulties due to unreasonably high costs. The authors have divided Russia's regions by energy price, which should help in decision-making, and developed an algorithm for the transition to green energy in the country, based on four pillars: attracting financial resources, transforming public policy, involving society in the process and the economy's transition to renewable sources.

Green heating is nearly impossible today, so the authors have developed general recommendations for the further development of this sector. The overall conclusion from comparison is that

Russia should adapt Canada's best practices in order to succeed in its green energy transition and reduce costs, but the transition should be slow and phased, starting with regions with the lowest energy prices.

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