Renewable energy investment attractiveness: Enabling multi-criteria cross-regional analysis from the investors' perspective

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Renewable energy investment attractiveness: enabling multi-criteria cross-regional analysis from the investors' perspective

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Abstract

A review of economic geography studies on renewable energy showed a lack of the investors' perspective in such an analysis that is crucial for both a single investment planning and policy development. This paper introduces a framework for a cross-regional analysis of renewable energy investment attractiveness and illustrates its use on the case of Russia. The attractiveness of each Russian region is analyzed based on four main variables that are used in the construction of an attractiveness indicator. In addition, the indicator takes into consideration the effect of the different renewable energy investment support mechanisms presented in the country. The results allow the comparative analysis of different regions in terms of renewable energy investment attractiveness. The graphical representation of the results enables intuitive understanding and facilitates decision making.

Apart from the direct usefulness of the results to Russian renewable energy market actors, such as investors and policy-makers, the introduced framework can be utilized by the research community and policy-makers for any country with geographical variability to better inform the transition to a low carbon future.

Keywords: Renewable energy, investment attractiveness, cross-regional analysis, Russia

1. Introduction

Governments all over the world have introduced renewable energy (RE) support policies, many of which include financial incentive mechanisms to promote the development of, and investments into RE. The effectiveness of these mechanisms, as well as the profitability of RE investments, are an ongoing topic of discussion in the research community, see e.g. [1]. When national support mechanisms for RE are discussed and analyzed, countries with large territories, such as Russia, face an added layer of complexity due to the different conditions in different areas. Different conditions create different circumstances for RE deployment and may affect how well a "one size fits all" RE support system works in promoting RE investments in different areas. In the Russian context that this research focuses on, factors such as availability of RE resources (wind, sunlight, water) and the demand for more electricity power among others, vary considerably across the Russian territory. The differences between areas create a different profile of RE investments across the country.

This research proposes a framework for a cross-regional analysis of RE investment attractiveness illustrated on and discussed within the Russian context. Four factors that contribute to the attractiveness of new renewable energy investments are considered and incorporated into a holistic "attractiveness indicator", which is then used in analyzing the attractiveness of Russian regions from the investors' perspective. The results of the analyses are visualized as a set of RE investment attractiveness maps that can serve as a guideline for investors in making location decisions. The maps can also be used as a roadmap for policymakers when the efficiency of the RE support mechanisms in place is analyzed from the point of view of the geographical differences between various areas of a single country.

The investors' perspective on RE investments in Russia has previously received some coverage in the academic literature [2-6], but geographical analyses of RE attractiveness in Russia remain inexistent. The conditions within the different Russian territories are all, but homogenous, including varying population densities and variable energy demand between regions. Also, the state of the existing energy infrastructure, including the transmission (of electricity) infrastructure, varies from region to region. These factors should be considered in order for a holistic picture of RE investment attractiveness in Russia to be created.

The remainder of this paper is structured as follows: in the next section, we review the current academic literature on the RE economic geography. This is followed by a short introduction of the case study, the Russian energy market system and RE support instruments. Then four selected factors of investment attractiveness are presented, together with a presentation of how the data was collected, processed, and, most importantly, the framework of investment attractiveness analysis itself. After that, the main results are presented and discussed. Finally, the paper is closed with a summary of conclusions.

2. Economic geography studies on renewable energy

Previous RE economic geography studies have been based on the estimation of geographic potential for RE. The potential emanates from the availability of RE sources within a studied territory, and the technical potential is estimated typically by taking into account factors such as land cover and technology efficiency. Further taking into account economic factors, the technical potential is narrowed down to economically exploitable resources. As noticed by Angelis-Dimakis et al. [10], there is no commonly agreed methodology in this respect for RE, however, factors such as accessibility, cost of technology, and available supporting policies are typically considered.

The above-discussed practice of analysis is commonly used in policy planning across the world, with numerous geographic information systems (GIS) in use to support it and research is often performed by national research centers. In the academic literature, the methods of analysis have been further developed, often with the aim of more holistically capturing the different aspects of the potential in different regions, and in order to increase the geographical specificity of the methodologies used.

Examples of previous academic work on this topic include the spatial mapping of RE potential for India [11] and the first RE potential estimation for Bangladesh [12]. Environmental and political considerations are included in the study of economic RE potential in South-Western Taiwan [13]. A study for Western China specifically targets small-scale RE generation for rural livelihoods and integrates lifecycle costing with GIS methods [14]. A multi-criteria approach with fuzzy quantifiers is implemented to estimate the suitability of large-scale solar photovoltaic (PV) power for Oman [15].

All the above studies have in common that they have the broader aim to support regional energy planning and management. While being useful for policymakers, they provide limited insight for individual investors, since a region with the greatest RE potential is not necessarily the best place for a RE investment, in terms of investment profitability. As an example of this “dilemma”, a study for Crete shows that locations with higher expected investment profitability do not always coincide with the best RE potential [16].

All in all, the academic literature on the economic geography of RE is very limited and concentrates typically on analyzing a single area, or a constrained area. Detailed studies of RE attractiveness in style with this research do not, to the best of our knowledge, exist. Apart from the study by [9] the Russian case has not been examined in light of the economic geography of RE.

3. Energy markets and the renewable energy support system in Russia

In Russia, there are two RE support mechanisms in place, for the wholesale market there is the “capacity mechanism” and for retail markets, there is the “tariff scheme”. Both these mechanisms have their origins in and are built in accordance with, the existing Russian energy market rules.

On the wholesale market, the traded commodities are electricity and capacity. The organization of electricity trading is similar to the well-known Nordic electricity market “Nord pool” and is organized through a day-ahead and a balancing market. The capacity market is different from the Nord Pool - “Capacity is a special commodity that, when purchased, gives the wholesale market participant the right to demand that the capacity seller maintains his generating equipment in a state of availability to generate electricity of a defined quality and in the volume required to meet that participant's needs” [17]. This means that in the capacity market, the energy provider is paid for having existing energy production capacity, not for the actual energy produced.

Most of capacity sales take place in annual competitive auctions of future capacity, where existing power generators submit their bids for a period of one year, starting in three years from the auction date [18]. New planned generation investments can participate in auctions for long-term capacity delivery contracts [19]. This separate mechanism for planned investments ensures timely investments into new energy generation capacity. All electricity buyers on the wholesale market are obliged to purchase capacity at the weighted average price of all short-term and long-term supply-side capacity prices, in the volume corresponding to their peak consumption. Competitive capacity auctions are arranged for the first and the second price zones, see Figure 1.

Figure 1. Zonal division of the Russian electricity and capacity market (based on [17])

This auction mechanism is adopted for supporting RE investments [3]. Launched in 2013 [8], the so-called RE capacity mechanism provides long-term agreements for annually selected wind, solar PV, and small (less than 25MW) hydro-power projects. The mechanism ensures certain investment profitability independently of changing market environment under some requirements. These requirements include a capital cost limit, a local content requirement (share of locally produced equipment), and the electricity production performance. The latter is set in three levels: (i - high) if actually achieved annual average capacity factor is higher than 75% of the set target, full capacity remuneration for the next year is paid; (ii - medium) if the production performance is higher than 50% of the target, 80% remuneration is paid; (iii - low) in other cases no capacity remuneration is paid. The target capacity factors are 27%, 14%, and 38% for wind, solar PV, and small hydro-power respectively. This requirement ensures that only well-performed projects are remunerated and forces project planners to carefully choose the location of a RE power plant. For more details on capacity remuneration calculation procedure and the effects on investment profitability see [3].

On the retail markets, electricity is the only commodity traded. The RE support mechanism, therefore, takes the form of RE tariffs that are paid for the electricity produced. The legislative basis for this mechanism was introduced in 2015 [7]. Regional governments play a pivotal role here, by deciding volumes of capacity to be selected, and tuning the mechanism to fit the local peculiarities. However, the tariff calculation methodology is unified and centrally developed [20]. The geographic coverage of this mechanism is broader than that of the capacity mechanism and it excludes only the Isolated Far East areas (Figure 1).

With respect to the investment size, projects of installed capacity that are higher than 25MW are obliged to participate in the wholesale market, hence falling automatically under the capacity mechanism, whereas projects of the size 5 to 25 MW can choose between the wholesale and the retail markets.

4. The four factors of the investment attractiveness

In order to estimate investment attractiveness across different regions, we employ several factors that are further aggregated into one attractiveness estimate. The factors are chosen, based on the earlier economic geography studies and by taking into account the investor, rather than the policymaker perspective.

Essentially, the first determinant of the investment attractiveness is ***investment profitability***. This factor combines 'resource availability' used to estimate the technical potential and the 'policy availability' factor, for evaluating exploitable resources in geographic studies [10]. ***Region accessibility*** as another investment attractiveness determinant coincides with the generally considered 'accessibility' factor, and reflects technology costs, accounting for the differences in transportation expenses. 'Availability of infrastructure' is commonly included in the estimation of the economic potential of oil and gas resources [22], in this study this determinant is translated into ***electrical network conditions***. The in places obsolete state of the network infrastructure in Russia is known to be an obstacle for new power plants to get connected to the grid [19], therefore selecting it as one of the determinants of investment attractiveness is well justified. Finally, different regions of Russia are characterized by different demand for new installed electrical capacity in general and for RE electricity in particular. The absence of capacity demand blocks market entry to RE investments, therefore, ***demand*** is chosen as the fourth (and final) determinant that we use in this research.

The evaluation of these factors is important from the point of view of performing any sensible analysis – it must be noted that profitability is calculated differently for the wholesale market and for the retail market, and there is also a difference in what underlies the calculation, the variable value estimation used also differ in three out of four cases. Table 1 presents the different factors and their estimation.

Table 1. Factors selected for the evaluation of RE investment attractiveness. The "Effect" indicates whether a factor makes the attractiveness indicator value higher (benefit) or lower (cost).

Factor	Effect	Underlying variable used for estimation	
		For the wholesale market	For the retail market
Investment profitability	benefit	NPV calculation, based on resource availability	Resource availability
Demand for investments	benefit	New capacity demand	Losses in the distribution grid
Region accessibility	cost	Diesel cost	Diesel cost
Network state	cost	Transmission grid obsolescence	Distribution grid obsolescence

4.1. Investment profitability

The profitability of a RE project depends on the resource availability and on the support mechanism. Fixed RE tariffs within the retail market make profitability of RE investments directly dependent on the actual electricity production, while the electricity production performance depends on the availability of the RE resource needed that is, irradiation for solar PV power, wind for wind power, and the availability of flowing water for hydropower. For this reason, the relative resource availability across regions is a good approximation for RE investment profitability in retail markets.

For the wholesale market investments, the RE support mechanism affects the profitability of RE investments in a non-linear manner [3, 5], therefore profitability of a stylized project is estimated for this level of investments as a function of resource availability.

4.1.1. Resource data

The data source is a recent estimation of the RE resources in Russia [9], and it has been aggregated to a regional level. The list of Russian regions (excluding the Crimean and Simferopol) and their geography is shown in Appendix A. Wind speed and solar irradiation data are broken down to each coordinate cell, see Appendix B. Hence, to derive resource estimation for each region, each coordinate cell (or its part) is assigned to a corresponding region. Minimum, maximum, and weighted average values were then calculated for each region. The numerical data is presented in Appendix C. Data about the relative energy density of small rivers is available as region per region minimum and maximum values, see Appendix B. Based on the above data the profitability of RE investments is calculated separately for the wholesale and the retail markets, a summary of the data and the profitability calculations for each of the three types of RE generation is presented in Table 2.

Table 2. Renewable energy resource availability data, data resolution, and conversion to profitability

RE type	Resource availability data	Data resolution	Profitability calculation
Wind	Average annual wind speed (m/s), at 100m	Coordinate cell, aggregated to regions by deriving min, weighted average, and max values	For the wholesale market: (i) conversion to the expected capacity factor, (ii) calculation of NPV for each set of capacity factors while other inputs remain unchanged.
Solar	Average annual solar irradiation for optimally oriented surface ($kWh/m^2/day$)		

			For the retail markets: raw resource data are used due to a linear relationship with profitability.
Hydro	Relative energy density of small rivers (MWh/km^2)	Region (min and max numbers are available)	Raw resource data are taken for both market levels, due to the flexibility of achieving different capacity factors on the same location.

4.1.2. Estimation of capacity factors

Capacity factors are used in the wholesale RE support mechanism as a part of the calculation of the support an investment will receive. A capacity factor is traditionally defined as the actual electricity output over the maximum possible output, assuming that a plant is operational 24 hours per day, 365 days per year with constant resource availability. For an "average" wind farm the definition of the capacity factor is based on the data available regarding the sensitivity of typical wind farm energy production to the annual wind speed [23]. The estimation used, is based on an almost linear relationship between the average wind speed in an area and the capacity factor used for wind power production in that area.

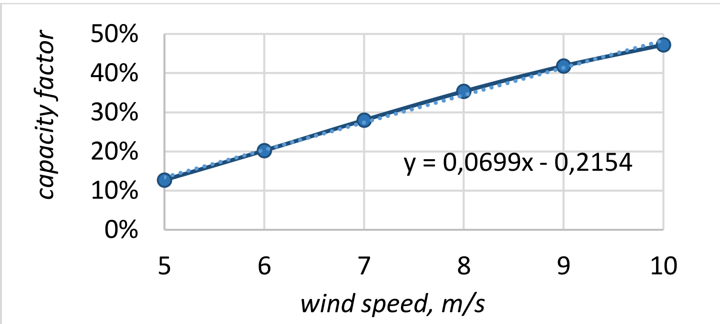

Figure 2. Relationship between average wind speeds and the estimated capacity factors for Russia, based on data from the European Wind Energy Association [23]

For estimating the capacity factor for solar power plants we refer to the technical application paper on photovoltaic plants by Asea Brown Boweri [24] and observe that average solar irradiation count of a region can be converted into solar PV electricity production by multiplying it by an efficiency coefficient, that typically ranges between 0.75 and 0.85 – in this research we use the value 0,8.

The estimation of the capacity factors for small run-of-the-river power plants region per region is not a good way to go, because one can achieve different capacity factors on a given river, with the same flow conditions. For example, if the installed capacity of hydro-power plant is chosen to be able to handle the peak flow energy, then most of the time such a plant will work at full capacity and the capacity factor would be lower – in a similar way a lower capacity can be chosen and the plant will always (when enough flow is available) run at full capacity. For this reason, we have chosen to use the raw data of the relative energy density of small rivers as a representation of the relative attractiveness of different regions in terms of hydro resources.

The capacity factors for wind power and solar power are calculated as triplets to account for the imprecision involved: minimum, average (weighted mean), and maximum, of resource availability, is expressed for each region.

4.1.3. Profitability estimation

Profitability estimation is performed for wind and solar PV projects under the wholesale market capacity mechanism support. The estimation is performed for different *resource availabilities* that determine the electricity production performance, with all other factors being kept unchanged. As was shown in the previous studies [3, 5], the variability of the market conditions has only a minor effect on investment profitability under the Russian RE support mechanism. The factors causing variability include the electricity production performance, the capital expenses level, and the local content requirement (amount of locally produced goods) of project equipment and services. While the local content factor is independent of the region and depends on managerial choices, regional differences in capital costs are captured by a region´s accessibility factor.

The investment model presented in [5] is used and the NPV is calculated for each capacity factor (minimum, weighted mean, and maximum) for each region. Other inputs (and input variable values) used in the model are: project size (set at 10MW), commissioning year (set at 2020), capital expenses (set equal to the limits for 2018 = 109451 rub/kW for wind and 103157 rub/kW solar), discount rate (set at 12,5%), wholesale day-ahead market electricity price (set at 2 rub/kWh), inflation coefficient (set at 1,1), and the local reference rate (set at 10%).

4.2. Demand for investments

Demand for new RE investments on the Russian wholesale market can be characterized by the overall demand for new installed capacity in different zones of the Russian energy system. On the retail market, the demand for new RE investment is defined by the support mechanism. Regional utilities are obliged to purchase electricity from RE power plants in order to cover electricity losses in the regional distribution grid. Therefore, losses in distribution grids express the demand for RE investments in retail markets.

The Russian energy system is broken down to seven unified power systems (UPS), these do not "overlap" with the price zones of the energy market. Their geography is presented in Figure 3 and the overall installed capacity of the power plants in each UPS is shown in Table 3. The most energy-intensive UPS are the "Center" and the "Ural", followed by "Siberia", "Mid-Volga", "North-West", "South", and "East", which is the least intensive UPS.

Figure 3. Zonal division of the Russian unified power system

Table 3. Capacity demand and grid losses in the UPS

Unified power system	Total installed capacity of power plants, 2011, GW	Capacity demand 2020-2030, GW	Losses in distribution grids in 2011, GWh
North-West	15,10	11,54	7 473
Center	37,92	28,67	18 474
Mid-Volga	15,73	9,68	6 940
South	12,34	9,54	8 773
Ural	36,01	25,92	10 742
Siberia	28,1	9,05	14 709
East	4,37	1,92	3 994

Indicators such as the “demand for new capacity” and “grid conditions” are estimated by the Russian Ministry of Energy for each UPS. Estimated new power capacity demand for the period 2020-2030 is based on the forecasted consumption growth, estimated (climate) temperature changes, and on data on planned decommissioning of existing power plants [25]. According to these indicators, the largest capacity demand is expected in the “Center” and “Ural” UPS.

Electricity losses in distribution grids characterize the demand for new installed RE capacity in the retail markets. The loss estimates were presented by the Ministry of Energy in a 2011 Report on the Russian power sector [26]. On the retail level, new RE investments are most welcome in “South” and “East” UPS. Here, both of these demand estimates are intentionally taken into account in absolute values, since they represent the market volume.

4.3. Region accessibility

Russia possesses a vast territory and some regions are characterized by poor accessibility that is due to reasons such as remoteness (Far East) and/or isolation caused by a lack of means of transportation (e.g., the Nenets Autonomous District, where the major deliveries take place by using temporary winter roads). Region accessibility affects equipment transportation expenses that contribute to the overall project capital costs.

Relative accessibility of regions in terms of both remoteness and isolation is directly reflected in the fuel prices because the variation of the fuel cost across regions is mainly defined by the difference in transportation costs. For this reason, we have chosen the price of diesel to represent the relative accessibility of a region. Data on the retail diesel costs across regions are taken from the statistics of the Russian Central Dispatching Department of the Fuel and Energy Complex on August 2017. The diesel costs range from 34 to 52 rubles per liter and are presented in Figure 4.

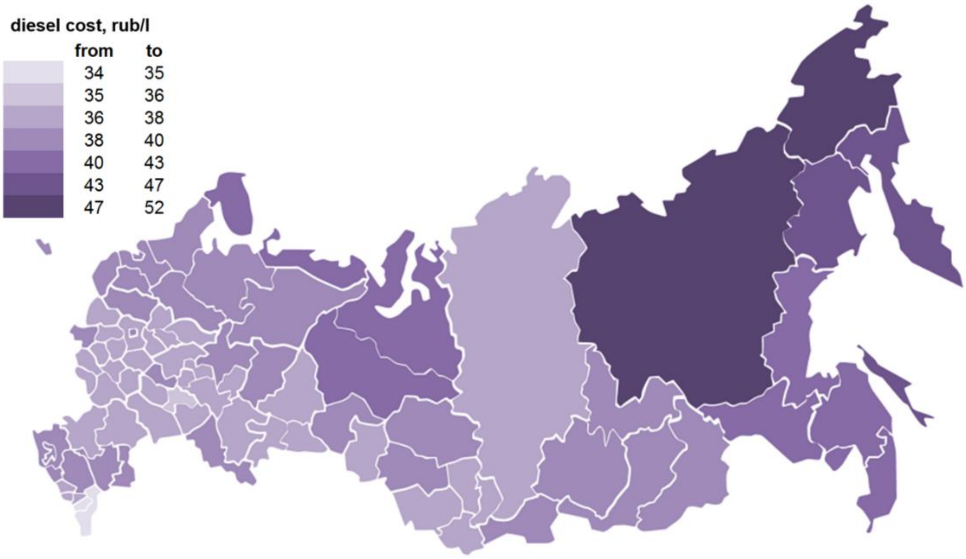

Figure 4. Average retail diesel cost, rub./l

The “East” and the “Far East” regions have the highest diesel cost due to their remoteness. However, such areas as “North Ural”, “North-West”, parts of “Siberia” and “South” also have a relatively high diesel costs due to isolation issues. Altogether, diesel cost seems to be a fairly good benchmark for region accessibility. The numerical data that we refer to is presented in Appendix D.

4.4. Network state

Network state is characterized by the age of the electrical grid used. Since the physical delivery of electricity within the wholesale market transactions occurs primarily via transmission grids, the obsolescence of the transmission grid is used as the factor determining the network state for the wholesale market. On the retail markets the electricity delivery occurs in distribution networks, and obsolescence of the distribution grid is the indicator for the network state in retail markets.

Data on transmission and distribution grid obsolescence is available across the UPS for the year 2011 [26]. For the transmission grid, the technical obsolescence is estimated for the distribution grids and the numbers shown in Table 4 represent a share of lines that are in an unsatisfactory condition.

Table 4. Transmission and distribution grid obsolescence [26]

Unified power system	Transmission grid obsolescence	Share of distribution lines in unsatisfactory conditions
North-West	63,9%	7,7%
Center	76,1%	11,2%
Mid-Volga	73,5%	9,9%
South	63,5%	9,4%
Ural	71,7%	8,3%
Siberia	64,3%	10,2%
East	55,8%	14,8%

The transmission grids in Central areas of Russia, specifically Central, Mid-Volga and in the Ural UPS seem to be in the worst condition. Whereas the distribution grids have worn out to the greatest extent in East, Center, and the Siberia UPS.

5. Attractiveness indicator calculation procedure

The above presented four factors are used in the creation of an indicator that serves as an estimate of investment attractiveness (for a region). The creation of a single "attractiveness indicator" value is based on the aggregation of the factor values by using the fuzzy weighted averaging operator (FWA). FWA allows one to handle fuzzy numbers that allow treating the imprecise information that is available for the profitability variable considered in the indicator. To get the final "indicator value" as a single number we defuzzify the result from the FWA aggregation with Kaufmann index [27]. The choice of the aggregation operator used is based on the want to preserve simplicity. We acknowledge that many other aggregation possibilities exist and refer the reader interested in possible alternatives to see, e.g., [28, 29]. Calculation of the indicator value can be presented as a four-step "algorithm" as follows:

Step 1. Data normalization. All values for each factor are normalized into the [0,1] range by min-max normalization defined as:

$$x_{f\,norm} = \frac{x_f - min}{max - min}, \quad (1)$$

where x_f is a value of a particular factor f.

Step 2. Transformation into comparable scales. The benefit criteria (profitability and demand) remain as they are, while the complement is used for the cost criteria (region accessibility and "network state"). In our case, both these criteria are represented by crisp (single) numbers, the transformation can be simplified into

$$x_{f\,cost} = 1 - x_{f\,norm} \quad (2)$$

Step 3. Aggregation is done with the FWA operator

$$a_i = \sum_{f=1}^{n} w_f \hat{x}_{f_i} \quad (3)$$

where $\sum_{f=1}^{n} w_f = 1$.

Herewith crisp values x are converted into fuzzy numbers $x = (x_1, x_2, x_3)$ assuming $x_1 = x_2 = x_3 = x$. The hydro resource values, where only x_1 and x_3 are available, the average of x_1 and x_3 is calculated and used as x_2. All four factors are assumed to be equally important, thus the weight of each factor w_f is equal to 0,25 and the aggregation converges to a simple arithmetic mean. In reality, for example, the failure of investments to reach profitability in any given area would most likely make such an area non-attractive – we acknowledge that the weights of the factors are an issue worth further attention.

Step 4. Defuzzification of the resulting fuzzy number. The resulting fuzzy numbers are converted into a single number indicator value by applying the Kaufmann index that for triangular fuzzy numbers takes the following form

$$\tilde{a} = \frac{a_1 + 2a_2 + a_3}{4} \quad (4)$$

Let us illustrate this aggregation procedure with data for a wind-farm investment for Altai krai region on the retail market, Table 5.

Table 5. Illustration of the aggregation of the Altai krai region for a retail wind case

<table>
<tr><td></td><td colspan="3">Profitability (wind speed)</td><td colspan="3" rowspan="2">Demand</td><td colspan="3" rowspan="2">Region accessibility</td><td colspan="3" rowspan="2">Network state</td></tr>
<tr><td></td><td>min</td><td>mean</td><td>max</td></tr>
<tr><td>Factor values</td><td>5,26</td><td>5,94</td><td>6,44</td><td colspan="3">9,43%</td><td colspan="3">35,51</td><td colspan="3">10,2%</td></tr>
<tr><td>Step 1. Normalization</td><td>0,16</td><td>0,27</td><td>0,36</td><td colspan="3">0,74</td><td colspan="3">0,20</td><td colspan="3">0,35</td></tr>
<tr><td>Step 2. Scale</td><td>0,16</td><td>0,27</td><td>0,36</td><td colspan="3">0,74</td><td colspan="3">0,80</td><td colspan="3">0,65</td></tr>
<tr><td>Step 3. Fuzzification</td><td>0,16</td><td>0,27</td><td>0,36</td><td>0,74</td><td>0,74</td><td>0,74</td><td>0,80</td><td>0,80</td><td>0,80</td><td>0,65</td><td>0,65</td><td>0,65</td></tr>
<tr><td>Step 3. Weights</td><td colspan="3">0,25</td><td colspan="3">0,25</td><td colspan="3">0,25</td><td colspan="3">0,25</td></tr>
<tr><td rowspan="2"></td><td colspan="12">Aggregated fuzzy number</td></tr>
<tr><td colspan="4">a_1</td><td colspan="4">a_2</td><td colspan="4">a_3</td></tr>
<tr><td>Step 3. FHWA</td><td colspan="4">0,586</td><td colspan="4">0,615</td><td colspan="4">0,636</td></tr>
<tr><td>Step 4 Defuzzification</td><td colspan="12">0,613</td></tr>
</table>

First, raw values are normalized using the minimum and maximum values of the whole factor value range. For example, maximum and minimum for the network state are 7,7% and 14,8% respectively. Therefore, the normalized network state for the Altal krai becomes:

$$\frac{10{,}2\% - 7{,}7\%}{14{,}8\% - 7{,}7\%} = 0{,}35 \quad (5)$$

Since the network state is a cost factor, meaning that the higher the share of the distribution grid in unsatisfactory conditions, the lower the investment attractiveness, the value is transformed to a comparable scale by

$$1 - 0{,}35 = 0{,}65 \quad (6)$$

In order to be able to apply the FWA operator, this single number is transformed to a fuzzy number by simply assigning this value to all possibilities [0,65 0,65 0,65].

The aggregated fuzzy number is derived by applying the FWA. In particular, the minimum value is obtained by calculating the sum of the products of the low values of all factors and their respective weights

$$a_1 = 0{,}16 * 0{,}25 + 0{,}74 * 0{,}25 + 0{,}80 * 0{,}25 + 0{,}65 * 0{,}25 = 0{,}586 \quad (7)$$

The same operation is conducted for the medium and the maximum values.

Defuzzification of the triangular fuzzy number is done by calculating the Kauffmann index (4) and a single number indicator value is obtained:

$$\frac{0{,}586 + 0{,}615 * 2 + 0{,}636}{4} = 0{,}613 \quad (8)$$

The indicator value alone does not tell much, however, when indicator values for different regions are compared, one will gain an understanding of the relative investment attractiveness of different regions with respect to the different energy types. Normalized factor values and the final indicator values of RE investment attractiveness are presented in Appendices E and F. We discuss them further in the next section.

6. Investment attractiveness indicator results

The investment attractiveness indicator values are used to color-code regions on a set of two times three maps of Russia, one map for each of the six combinations of electricity markets (wholesale and retail) and the three considered RE resources (hydro, solar, wind). The indicator value also considers both existing Russian RE support mechanisms. The maps are presented in Figure 5-Figure 10, where the darker the color, the more attractive region is. The black borders on the map represent the borders between different UPS, in accordance with Figure 3. Maps for the wholesale market, in addition, display the overall capacity of already selected RE projects (in MW) within the past auctions (years 2013-2018) across regions. These numbers are also presented in Table 6.

Table 6. Capacity (MW) of RE projects selected for the wholesale market 2013-2018

UPS / Region	Installed capacity, MW		
	Wind	**Solar**	**Hydro**
Center		**75**	
Belgorod oblast		30	
Lipetsk oblast		45	
Mid-Volga	**416**	**360**	
Samara oblast		180	
Saratov oblast		180	
Tatarstan republic	100		
Ulyanovsk oblast	316		
North-West	**351**		**50**
Karelia republic			50
Murmansk oblast	351		
Siberia		**540**	
Altai krai		60	
Altay republic		40	
Buryat republic		190	
Irkutsk oblast		30	
Khakassia republic		5	
Omsk oblast		100	
Zabaikalsky krai		115	
South	**2152**	**662**	**110**

Adygeya republic	250		
Astrakhan oblast	183	108	
Dagestan republic		20	
Kalmykia republic	175	124	
Karachay-Cherkessia republic			79
Krasnodar krai	860		
Rostov oblast	504		
Stavropol krai	103	190	31
Volgograd oblast	77	220	
Ural	**336**	**721**	
Bashkortostan republic		176	
Chelyabinsk oblast		120	
Kurgan oblast	40		
Orenburg oblast	106	425	
Perm krai	190		
Grand Total	**3254**	**2358**	**160**

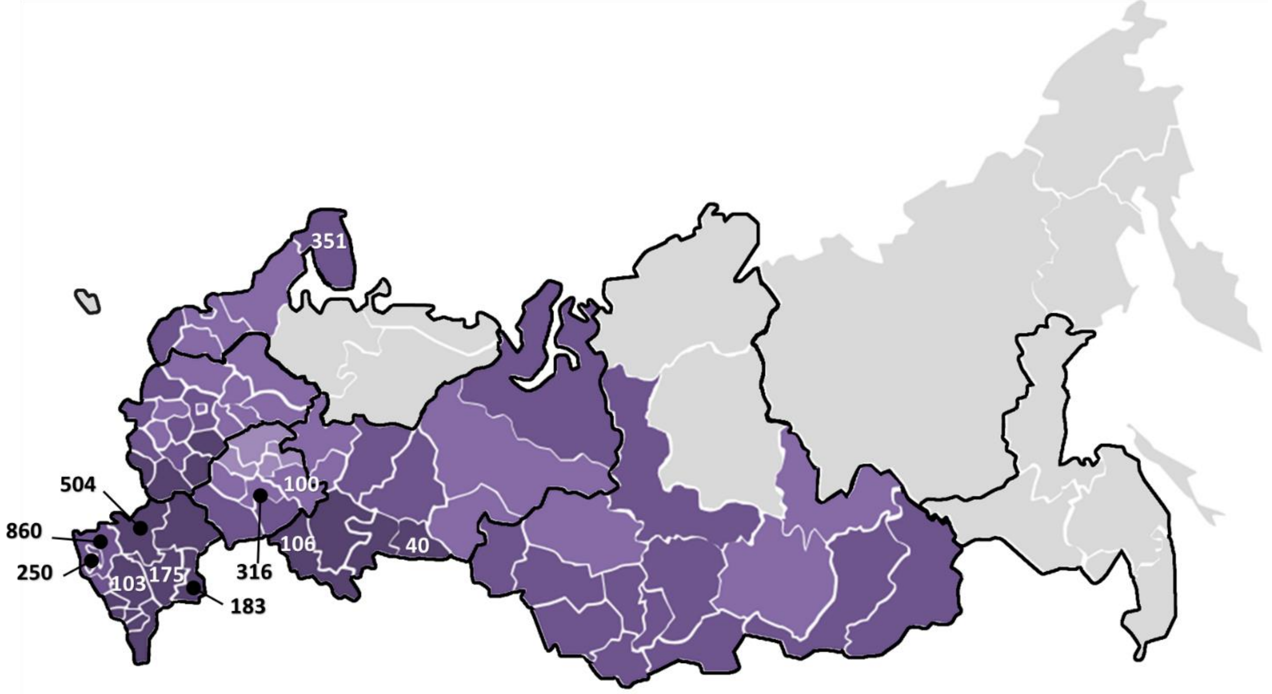

Figure 5. Wind power investment attractiveness in the wholesale market

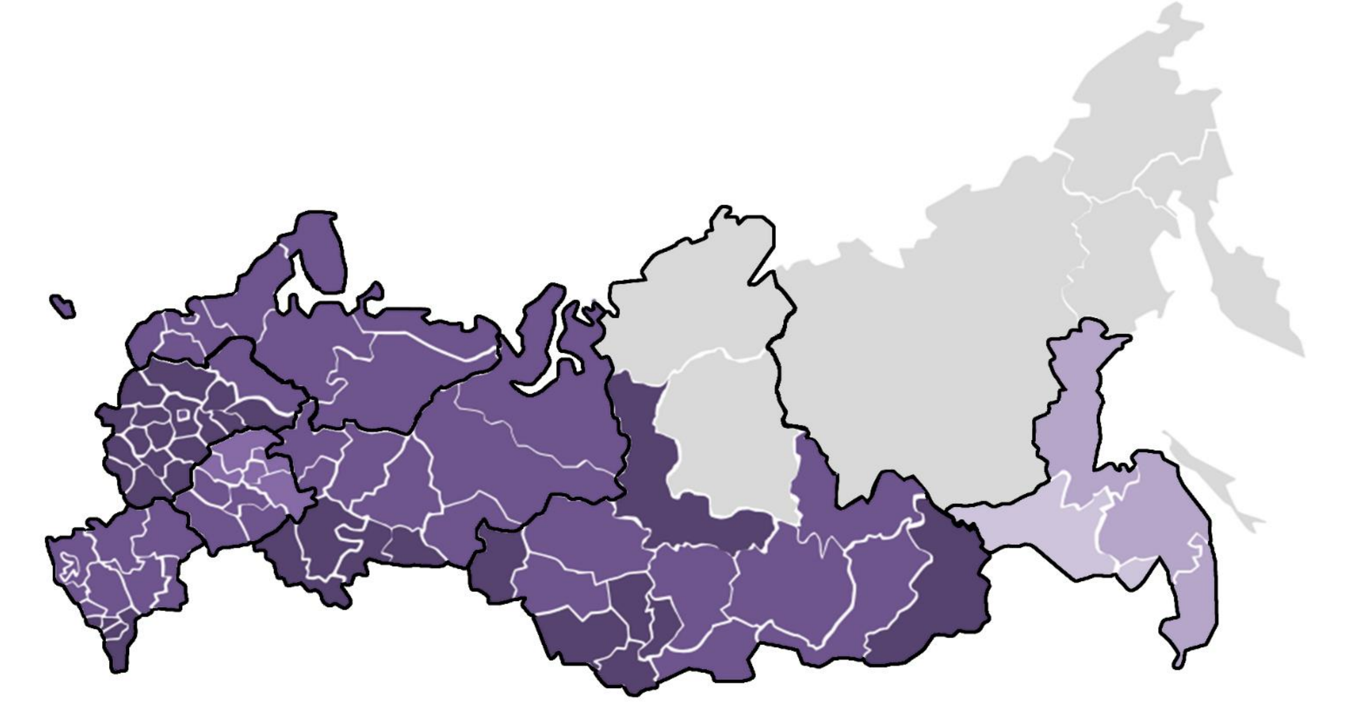

Figure 6. Wind power investment attractiveness in the retail markets

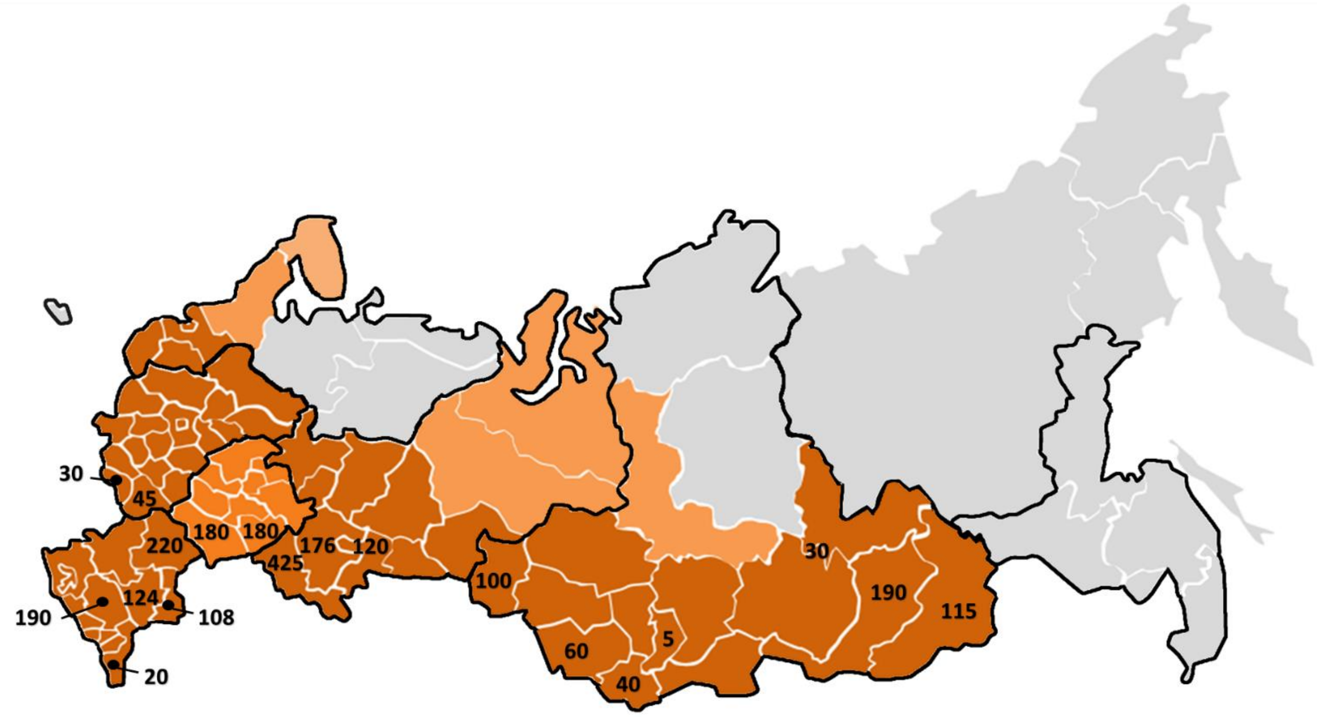

Figure 7. Solar power investment attractiveness in the wholesale market

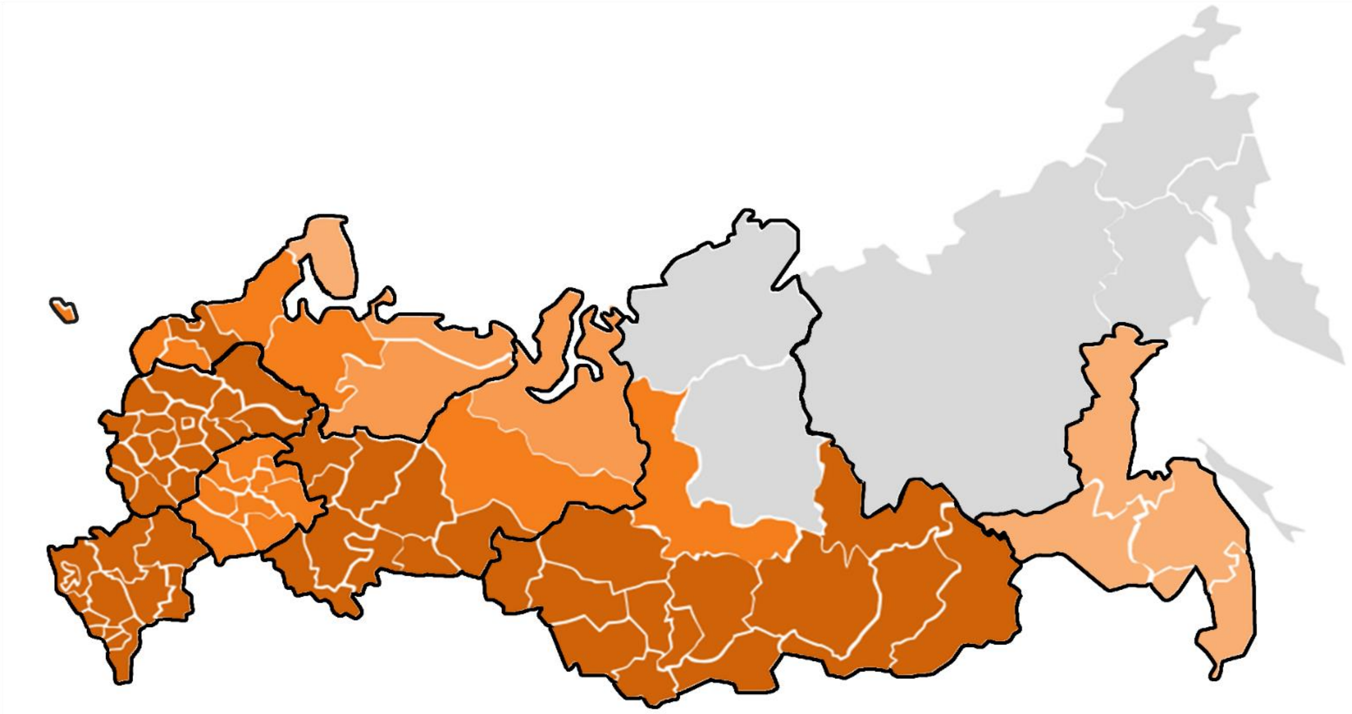

Figure 8. Solar power investment attractiveness in the retail markets

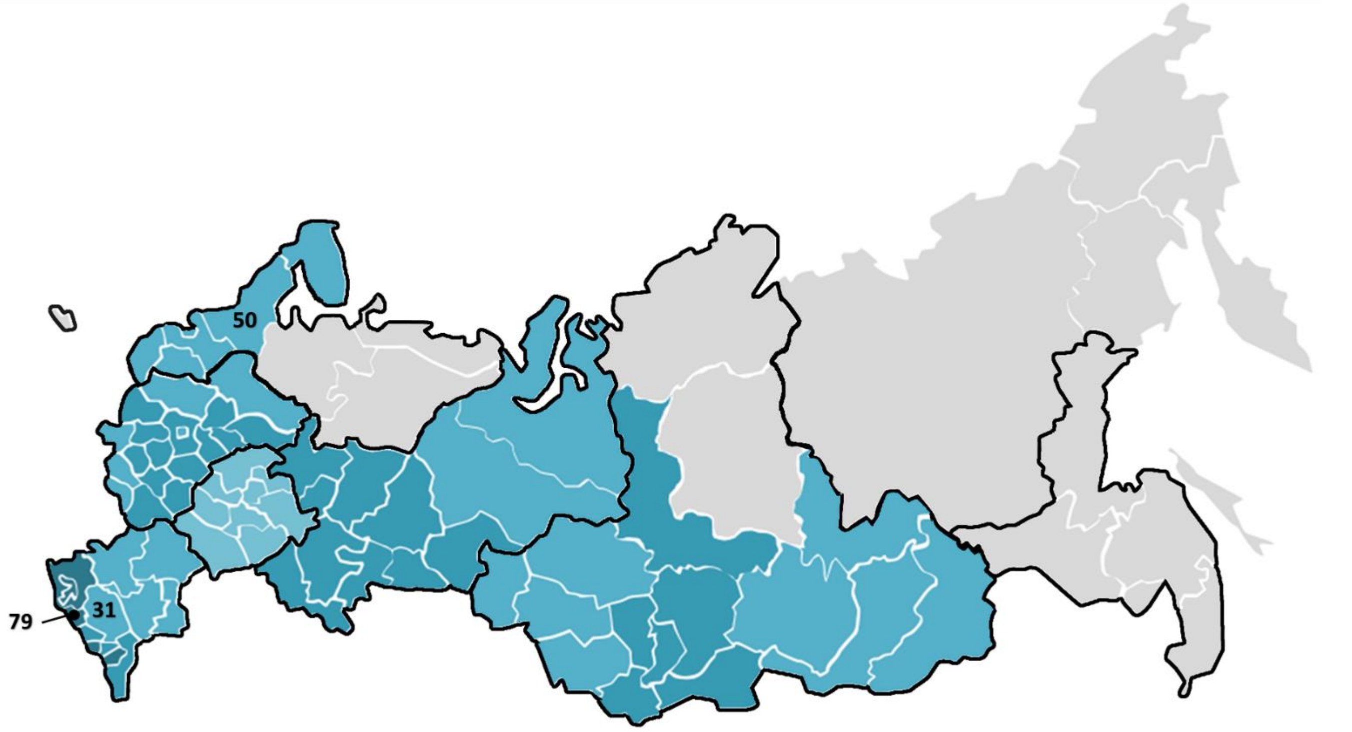

Figure 9. Small hydropower investment attractiveness in the wholesale market

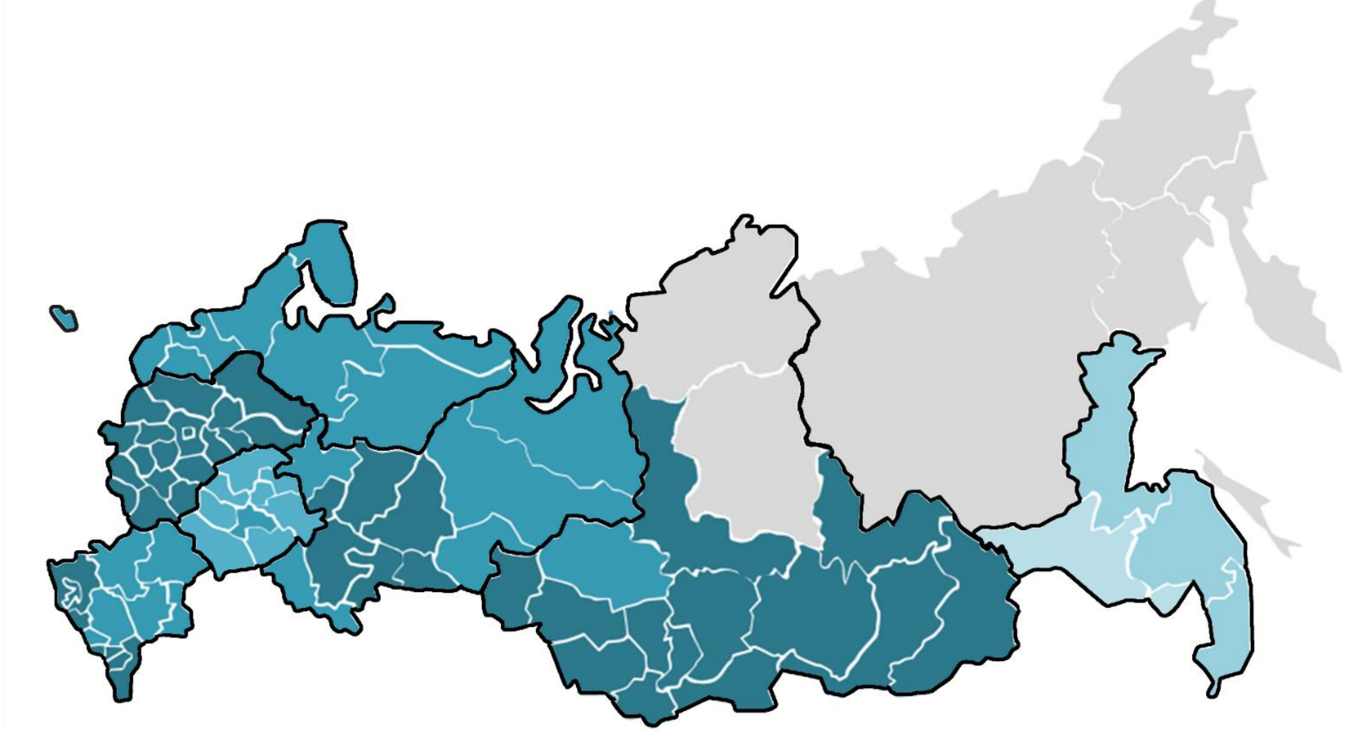
Figure 10. Small hydropower investment attractiveness in the retail markets

Instead of discussing the results specifically for each of the 83 Russian regions, this discussion is built around the seven zones of the Russian energy system and their attractiveness for RE investments. The interested reader may find detailed information on each and every considered region from the tables and maps provided. The average RE investment attractiveness estimates for each Russian UPS is shown in Figure 11.

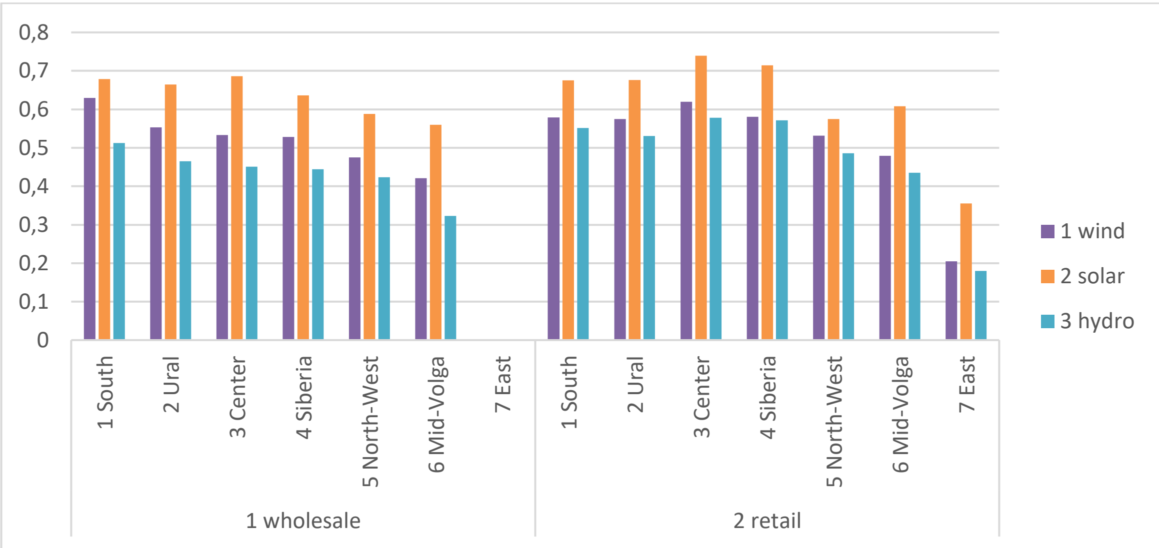

Figure 11. Average investment attractiveness of the different Russian UPS

In general, RE investments would appear to be slightly more attractive on the retail markets than in the wholesale markets. This difference is due to the difference in the demand and grid condition factors for the retail versus the wholesale markets, see Figure 12. We want to point out that these results also depend on the uniform weighting used and note that if other weights are used the results may be different.

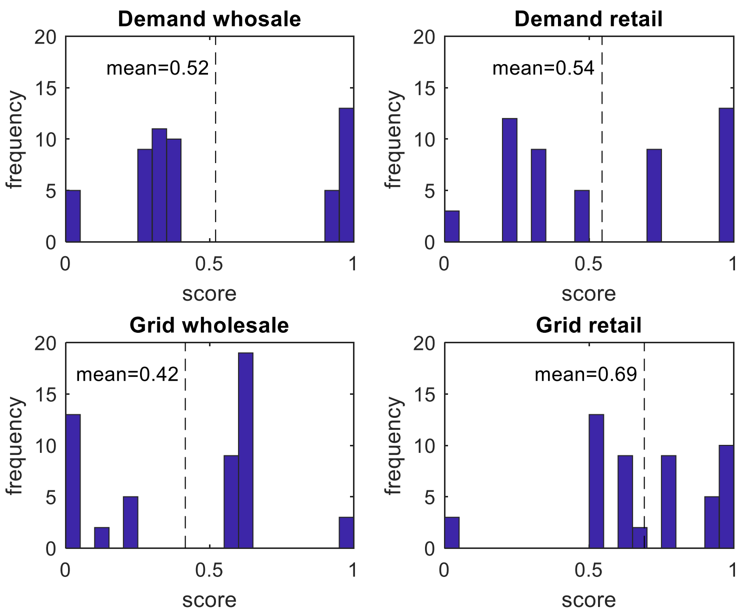

Figure 12. Distribution of scores for demand and grid conditions

Based on the analyses we discuss the attractiveness of each Russian UPS for RE investments:

The ***South UPS*** represents a very attractive area for RE investments. The UPS is easily accessible, with transmission and distribution networks in that are in relatively good conditions, and with vast resource availability. On the wholesale market, the South UPS accounts for more than half of all the in the auctions selected RE capacity. More than 2GW of wind power, 662MW of solar PV power, and 110MW of small hydropower are to be introduced here within the capacity mechanism support.

The ***Ural UPS***, where the most energy-intensive industry in Russia is located, is the second largest UPS after the Center UPS when measured in terms of total power capacity. The accessibility of the Ural UPS area varies from the high accessibility in the South of the area to low accessibility in the North, accessibility is particularly low in the Khanty-Mansi precinct and the Yamalo-Nenets precinct. In the mentioned two regions, there is a limited railway and road access and most products are delivered to these areas by water (rivers) and by winter roads. This fact, put together with the relatively low RE resource availability, contributes to the low investment attractiveness in these two precincts. Nonetheless, high new capacity demand and good wind and solar conditions in the Southern part of the UPS make it attractive for investments. A total of 336MW of wind power and of 721MW of solar PV power projects have been selected for this area. With respect to the network conditions, the transmission grid in the area is relatively obsolete, whereas the share of aged distribution lines is low. Investments within the retail markets are relatively more attractive than in the wholesale market of the, in this UPS.

The ***Center UPS*** possesses the biggest market potential for both wholesale and the retail markets. The highest new capacity demand is found in this area and explained by the very high energy intensity of the area and by the high anticipated levels of industrial and population growth that consequently lead to high electricity demand. The Center UPS has the highest electricity losses in distribution grids, a fact that raises the question of grid modernization, while it also creates a high demand for RE power on the retail markets. The above, coupled with the easy accessibility of the UPS creates a favorable investment environment, despite the rather moderate resource availability. In practice, only some solar PV projects have applied for the capacity support so far in this UPS.

The ***Siberia UPS*** is the largest UPS in terms of area and the third largest in terms of energy density. Despite the remoteness, the accessibility of the regions in the UPS is relatively high, due to the well-developed railway connections and plentiful waterways. The state of the electrical network in the UPS is relatively good, however, due to the long distances, the losses in the distribution grids are high. The losses create a demand for RE investments on the retail market level. The UPS is rich with hydropower potential, with sunlight (Southern regions), and has favorable wind conditions (in the North). So far, only solar PV projects with the capacity of 540MW are planned in the Southern regions of Siberia UPS.

The ***North-West UPS*** is characterized by a relatively moderate RE investment attractiveness. The North of the UPS, in particular, the Murmansk oblast, is rich with wind power resources (high wind speeds). In the 2017 auction, a 201MW wind farm project by Enel Russia and four projects with the total of 150MW of installed capacity by Fortum Energy were selected to be built by 2021 and by 2022 respectively. Small hydropower is less attractive in the UPS, however, in the 2017 auction RusHydro received capacity support for two small hydropower plants (25MW each) in Karelia Republic. Solar power becomes more attractive towards the South of the UPS. The UPS is characterized by moderate accessibility that gets worse the more to the North one goes. It has the least share of the distribution lines in the unsatisfactory condition that explains the relatively higher attractiveness of investments in the retail markets, compared to the wholesale markets.

Table 7. Summary of the discussion on investment attractiveness of the different UPS

UPS	Discussion summary
South	Very attractive, easy access, good network, and high availability of resources. Total of almost 3 GW of RE projects has been selected under capacity auctions.
Ural	Attractive area, high capacity demand, in the Southern part good accessibility and good wind and solar conditions, the Northern part has low accessibility. Total selected project capacity exceeds 1GW.
Center	The most attractive UPS in the retail market. The highest demand for new capacity. High accessibility, moderate availability of resources. Total selected project capacity is 75MW.
Siberia	Relatively good accessibility and grid conditions. High losses in the distribution grids due to long distances create high demand for RE investments in the retail markets. Total selected project capacity is 540MW that is limited to solar power in the South of the area.
North-West	Moderate investment attractiveness. Rich with wind potential in the North. Total selected project capacity is 400MW.
Mid-Volga	Moderately low RE investment attractiveness. Limited demand for new RE investments and ridden with obsolete grid conditions. Good accessibility. Total selected project capacity is 776MW.
East	The least attractive UPS, due to poor grid conditions, low demand, and remoteness. No projects have been targeted at this area within the RE capacity scheme.
Far East	No electricity market, no RE support in place. The potential for small-scale hybrid RE power plants.

According to the results, the ***Mid-Volga UPS*** has a moderately low RE investment attractiveness. Wind and solar resources in the UPS can be described as average, while hydro resources are poor. The UPS has the second highest transmission grid obsolescence in Russia, while a share equal to the average of the country of distribution lines in unsatisfactory condition. There is relatively low new capacity demand and market potential for retail market level investments. Nonetheless, the easy accessibility of the UPS opens the doors for RE investments. A total 360MW of solar PV projects are selected for the Southern part of the UPS and 416 MW of wind power is planned in the middle part.

The ***East UPS*** is the smallest in terms of energy capacity. It has the worst grid conditions, the lowest demand (absolute losses in distribution grids), and it is the most difficult to access (lowest accessibility), due to remoteness. In spite of vast RE resources, these factors make it the least attractive for RE investments.

There is no electricity market in the ***Isolated Far East*** regions. This vast area is scarcely populated and only lightly industrialized. The electricity supply of settlements is mostly organized by local spot diesel generation. Nonetheless, this area possesses the potential for distributed hybrid wind-diesel and solar-diesel generators, as well as, run-of-river hydro and geothermal power. More information about off-grid RE power generation in the Far East can be found in [30].

The above discussion is summarized in Table 7.

Conclusions

This paper has concentrated on creating and illustrating a framework for a cross-regional analysis of RE investment attractiveness. The main idea was to construct an indicator of RE investment attractiveness that reflects several important factors in a single number and takes the investors' perspective rather than the economic potential point of view. The factors considered in the indicator include investment profitability, demand for investments, regional accessibility, and electrical network state.

The profitability factor takes into consideration the resource availability and the effects of a RE support mechanism. Demand for the investments is defined by using a combination of support policy requirements and the estimated future capacity demand in each region. Regional accessibility is estimated by using diesel price as a proxy for the costs of delivering goods and services to each region. The network state reflects how well functioning the electric grid in the area is and how much hardship the investments to be would experience from network deterioration. For the purposes of simplicity, the factors are assumed to have equal weights. Different weights can be used to adjust relative importance of the factors. The results are graphically presented as color-coded maps to enable fast and intuitive understanding. The indicator values, and so the maps, are constructed for different technology types and RE support mechanism designs.

The paper presents how the RE attractiveness indicator is constructed in detail and numerically shows how the calculation mechanics takes place on the example of Russia. The quality of the data used is limited, but sufficient for comparative purposes on the regional level.

This research contributes to both academia and RE industry with the framework for RE investment attractiveness estimation and cross-regional analysis. While the results of this study can be of direct use for the Russian RE sector investors and policymakers, the analytical framework can be utilized for investment or policy planning in other countries.

Acknowledgement

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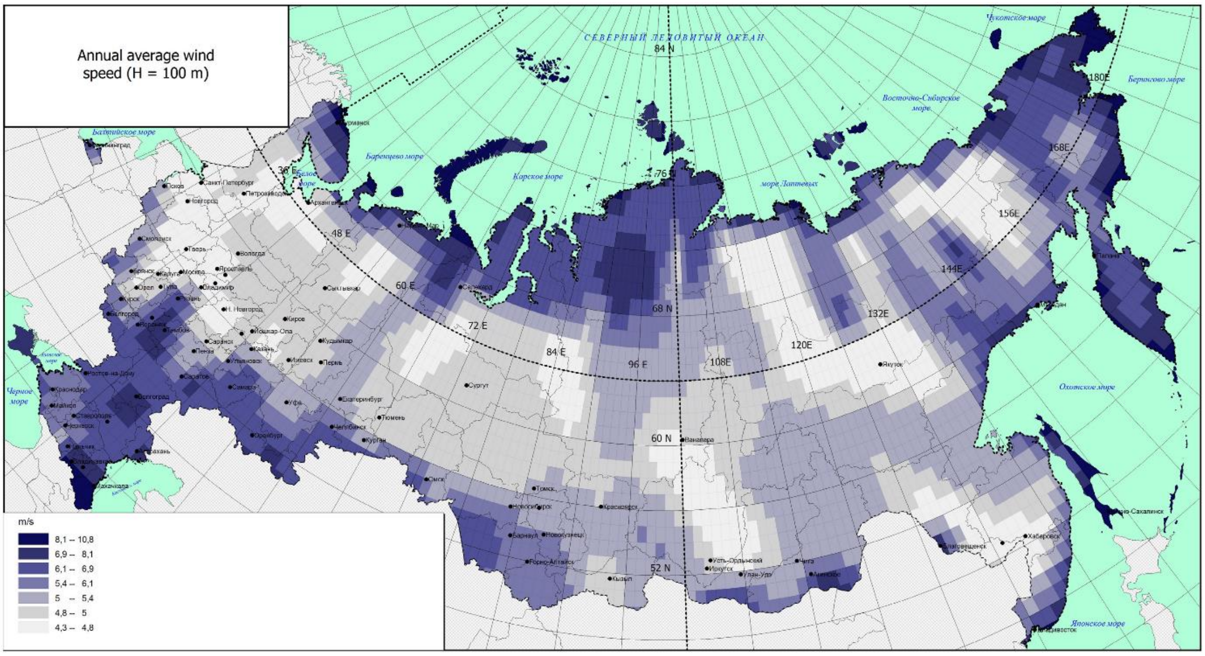
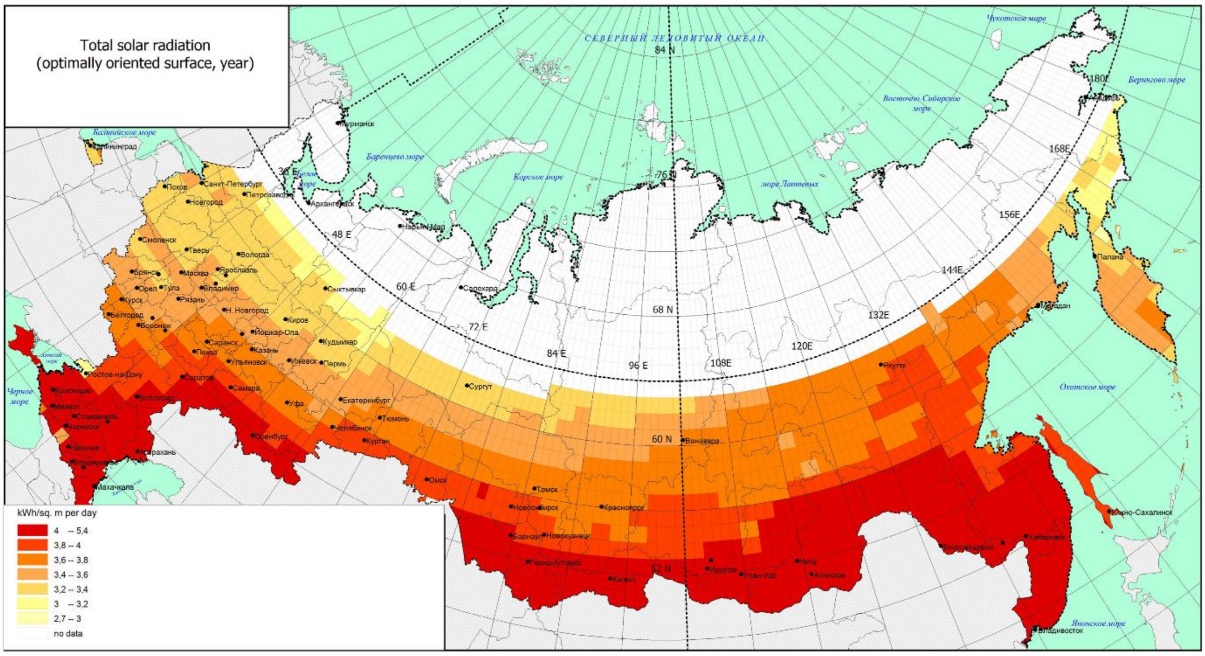
Appendix A. Regions

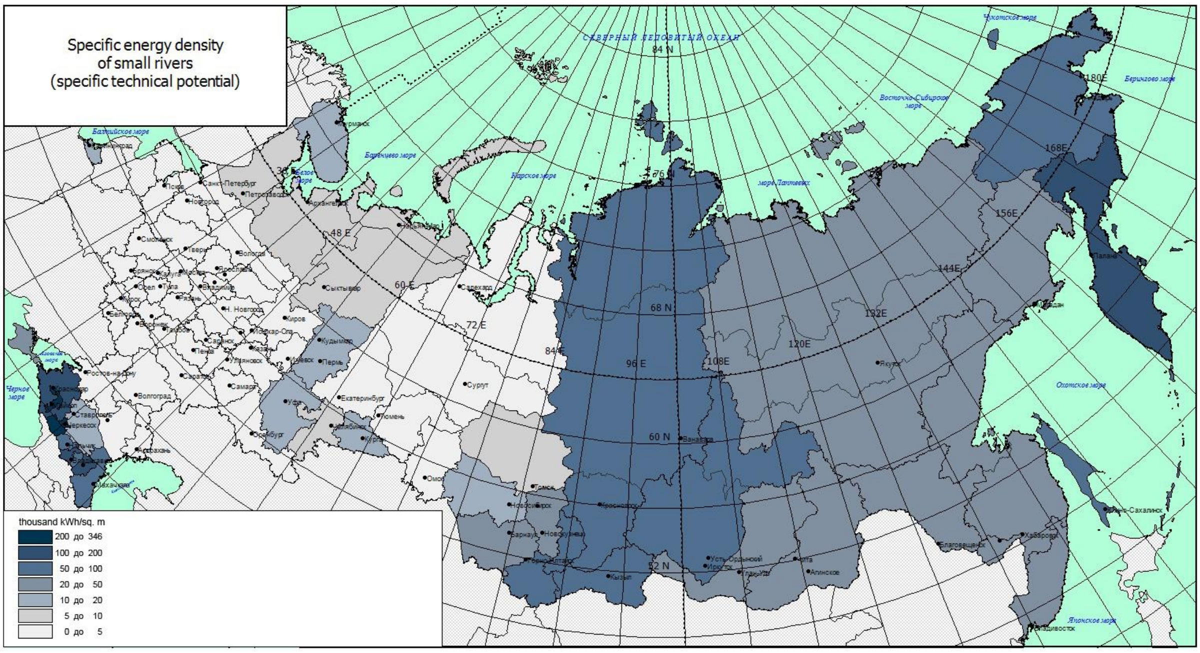
#	Region	#	Region	#	Region
1	Altai krai	27	Kurgan oblast	56	Sakha republic
2	Amur oblast	28	Kursk oblast	57	Tatarstan republic
3	Arkhangelsk oblast	29	Leningrad oblast	58	Tuva republic
4	Astrakhan oblast	30	Lipetsk oblast	59	Udmurt republic
5	Belgorod oblast	31	Magadan oblast	60	Khakassia republic
6	Bryansk oblast	32	Moskovskaya oblast	61	Chuvashia republic
7	Vladimir oblast	33	Murmansk oblast	62	Rostov oblast
8	Volgograd oblast	34	Nenets okrug	63	Ryazan oblast
9	Vologda oblast	35	Nizhegorodskaya oblast	64	Samara oblast
10	Voronezh oblast	36	Novgorod oblast	65	Saratov oblast
11	Moscow	37	Novosibirsk oblast	66	Sakhalin oblast
12	Saint-Petersburg	38	Omsk oblast	67	Sverdlovsk oblast
13	Jewish autonomous oblast	39	Orenburg oblast	68	North Ossetia republic
14	Zabaikalsky krai	40	Orlovskaya oblast	69	Smolensk oblast
15	Ivanovo oblast	41	Penza oblast	70	Stavropol krai
16a	Irkutsk oblast (North)	42	Perm krai	71	Tambov oblast
16b	Irkutsk oblast (South)	43	Primorye krai	72	Tver oblast
17	Kabardino-Balkaria republic	44	Pskov oblast	73	Tomsk oblast
18	Kaliningrad oblast	45	Adygeya republic	74	Tula oblast
19	Kaluga oblast	46	Altay republic	75	Tyumen oblast
20	Kamchatka krai	47	Bashkortostan republic	76	Ulyanovsk oblast
21	Karachay-Cherkessia republic	48	Buryat republic	77a	Khabarovsk krai (North)
22	Kemerovo oblast	49	Dagestan republic	77b	Khabarovsk krai (South)
23	Kirov oblast	50	Ingushetia republic	78	Khanty-Mansi okrug
24	Kostroma oblast	51	Kalmykia republic	79	Chelyabinsk oblast
25	Krasnodar krai	52	Karelia republic	80	Chechnya republic
26a	Krasnoyarsk krai (North)	53	Komi republic	81	Chukotka okrug
26b	Krasnoyarsk krai (Middle)	54	Mari El republic	82	Yamalo-Nenets okrug
26c	Krasnoyarsk krai (South)	55	Mordovia republic	83	Yaroslavl oblast

Appendix B. RE resources

Maps of the Atlas of RE sources in Russia [9]. Can be accessed also via http://gisre.ru/






Specific energy density
of small rivers
(specific technical potential)
thousand kWh/sq. m
200 до 346
100 до 200
50 до 100
20 до 50
10 до 20
5 до 10
0 до 5

Appendix C. Resource data

#	Region	Average annual wind speed at 100m (m/s)			Average annual solar irradiation for optimally oriented surface (kWh/m²/day)			Relative energy density of small rivers (MWh/km²)	
		min	mean	max	min	mean	max	min	max
1	Altai krai	5,26	5,94	6,44	3,87	4,08	4,33	20	50
2	Amur oblast	4,54	4,99	6,92	3,85	4,22	4,53	20	50
3	Arkhangelsk oblast	4,67	4,88	6,20	0,00	1,40	3,26	5	10
4	Astrakhan oblast	6,17	6,63	7,43	4,07	4,23	4,52	0	5
5	Belgorod oblast	5,38	6,17	6,70	3,63	3,72	3,81	0	5
6	Bryansk oblast	4,79	5,52	6,13	3,31	3,45	3,49	0	5
7	Vladimir oblast	4,64	4,81	5,18	3,45	3,50	3,58	0	5
8	Volgograd oblast	5,74	6,76	7,50	3,73	3,98	4,19	0	5
9	Vologda oblast	4,71	4,85	4,91	3,20	3,27	3,35	0	5
10	Voronezh oblast	6,09	6,79	7,20	3,66	3,75	3,89	0	5
11	Moscow	4,77	4,77	4,77	3,44	3,44	3,44	0	5
12	Saint-Petersburg	4,67	4,67	4,67	3,39	3,39	3,39	0	5
13	Jewish autonomous oblast	4,53	4,58	5,17	4,29	4,40	4,52	20	50
14	Zabaikalsky krai	5,02	5,43	7,63	3,56	4,30	4,69	20	50
15	Ivanovo oblast	4,64	4,70	4,81	3,39	3,43	3,49	0	5
16	Irkutsk oblast (North)	4,77	5,06	5,34	3,49	3,50	3,75	50	100
16	Irkutsk oblast (South)	4,64	4,93	5,42	3,69	3,86	4,20	50	100
17	Kabardino-Balkaria republic	5,36	6,09	6,99	3,58	4,17	5,34	50	100
18	Kaliningrad oblast	5,24	6,03	8,29	0,00	3,14	3,69	10	20
19	Kaluga oblast	4,72	4,84	5,27	3,31	3,38	3,46	0	5
20	Kamchatka krai	5,11	6,82	9,91	0,00	2,81	3,69	100	200
21	Karachay-Cherkessia republic	5,36	5,61	5,95	3,58	4,13	5,01	200	346
22	Kemerovo oblast	5,01	5,29	5,68	3,65	3,82	4,02	20	50
23	Kirov oblast	4,69	4,84	4,94	3,24	3,38	3,57	0	5
24	Kostroma oblast	4,67	4,85	4,91	3,28	3,36	3,45	0	5
25	Krasnodar krai	5,67	5,95	6,83	3,78	4,21	5,01	200	346
26	Krasnoyarsk krai (North)	4,61	6,51	8,43	0,00	0,00	0,00	50	100
26	Krasnoyarsk krai (Middle)	4,67	5,14	7,08	0,00	1,51	3,77	50	100
26	Krasnoyarsk krai (South)	4,96	5,08	5,31	3,68	3,80	4,19	50	100
27	Kurgan oblast	4,88	5,55	6,33	3,65	3,85	3,96	10	20

#	Region	Average annual wind speed at 100m (m/s)			Average annual solar irradiation for optimally oriented surface (kWh/m²/day)			Relative energy density of small rivers (MWh/km²)	
		min	mean	max	min	mean	max	min	max
28	Kursk oblast	4,93	5,45	6,09	3,48	3,61	3,66	0	5
29	Leningrad oblast	4,63	4,72	4,83	3,21	3,36	3,43	0	5
30	Lipetsk oblast	5,01	6,47	7,22	3,52	3,58	3,65	0	5
31	Magadan oblast	4,39	5,43	7,50	0,00	1,78	3,65	20	50
32	Moskovskaya oblast	4,69	4,98	6,27	3,38	3,46	3,55	0	5
33	Murmansk oblast	5,01	6,37	9,36	0,00	0,00	0,00	10	20
34	Nenets okrug	5,37	6,93	9,15	0,00	0,00	0,00	5	10
35	Nizhegorodskaya oblast	4,68	4,78	4,94	3,42	3,54	3,65	0	5
36	Novgorod oblast	4,67	4,73	4,89	3,27	3,31	3,37	0	5
37	Novosibirsk oblast	4,83	5,37	6,48	3,71	3,90	4,54	10	20
38	Omsk oblast	4,89	5,30	6,65	3,51	3,72	3,98	0	5
39	Orenburg oblast	5,77	6,63	7,90	3,74	4,11	4,33	0	5
40	Orlovskaya oblast	4,79	4,94	5,01	3,41	3,51	3,57	0	5
41	Penza oblast	5,09	5,38	6,08	3,74	3,81	3,95	0	5
42	Perm krai	4,84	4,98	5,11	3,05	3,31	3,55	10	20
43	Primorye krai	4,56	5,91	8,75	4,20	4,79	5,32	20	50
44	Pskov oblast	4,67	5,12	5,70	3,32	3,36	3,42	0	5
45	Adygeya republic	5,67	5,77	6,34	3,78	4,27	5,01	200	346
46	Altay republic	5,42	5,60	5,73	4,02	4,33	4,70	50	100
47	Bashkortostan republic	4,91	5,56	7,05	3,52	3,77	4,17	10	20
48	Buryat republic	4,64	5,17	6,34	3,69	4,14	4,57	20	50
49	Dagestan republic	6,30	8,23	10,26	4,03	4,15	5,01	50	100
50	Ingushetia republic	6,99	7,72	9,08	4,30	4,41	4,54	50	100
51	Kalmykia republic	6,28	6,74	7,50	4,00	4,20	4,43	0	5
52	Karelia republic	4,71	4,83	5,13	0,00	1,09	3,41	5	10
53	Komi republic	4,72	5,12	7,65	0,00	0,75	3,32	5	10
55	Mari El republic	4,72	4,84	4,94	3,47	3,55	3,57	0	5
55	Mordovia republic	4,79	4,92	5,11	3,61	3,66	3,77	0	5
56	Sakha republic (North)	4,34	5,29	8,19	0,00	0,00	0,00	20	50
56	Sakha republic (Middle)	4,32	5,03	6,80	0,00	1,29	3,83	20	50
56	Sakha republic (South)	4,48	5,00	5,93	3,59	3,77	3,93	20	50
57	Tatarstan republic	4,69	5,32	6,20	3,55	3,67	3,77	0	5

#	Region	Average annual wind speed at 100m (m/s)			Average annual solar irradiation for optimally oriented surface (kWh/m^2/day)			Relative energy density of small rivers (MWh/km^2)	
		min	mean	max	min	mean	max	min	max
58	Tuva republic	4,91	5,16	5,75	3,84	4,32	4,87	50	100
59	Udmurt republic	4,76	4,83	4,88	3,39	3,49	3,56	0	5
60	Khakassia republic	5,09	5,30	5,62	3,65	3,91	4,20	50	100
61	Chuvashia republic	4,86	4,94	5,04	3,57	3,64	3,68	0	5
62	Rostov oblast	5,92	6,54	7,47	3,82	3,97	4,08	0	5
63	Ryazan oblast	4,89	5,98	6,94	3,43	3,51	3,74	0	5
64	Samara oblast	5,98	6,47	6,68	3,74	3,93	4,05	0	5
65	Saratov oblast	5,29	6,35	7,20	3,78	4,02	4,24	0	5
66	Sakhalin oblast	6,73	8,21	9,89	3,81	3,91	4,11	50	100
67	Sverdlovsk oblast	4,82	5,02	5,14	3,05	3,42	3,72	0	5
68	North Ossetia republic	6,17	7,21	8,19	4,30	4,59	5,34	100	200
69	Smolensk oblast	4,72	5,18	6,02	3,30	3,38	3,46	0	5
70	Stavropol krai	5,70	6,21	6,99	4,07	4,24	4,31	10	20
71	Tambov oblast	5,59	6,80	7,22	3,57	3,70	3,88	0	5
72	Tver oblast	4,67	4,76	5,29	3,27	3,37	3,42	0	5
73	Tomsk oblast	4,83	4,91	5,16	3,36	3,55	3,86	5	10
74	Tula oblast	4,83	5,24	5,90	3,38	3,45	3,52	0	5
75	Tyumen oblast	4,82	4,94	5,51	3,43	3,61	3,91	0	5
76	Ulyanovsk oblast	4,96	5,66	6,53	3,68	3,78	4,05	0	5
77	Khabarovsk krai (North)	4,63	5,55	7,64	3,55	3,83	4,18	20	50
77	Khabarovsk krai (South)	4,56	5,04	6,73	3,92	4,17	4,47	20	50
78	Khanty-Mansi okrug	4,71	4,89	6,62	0,00	1,83	3,54	0	5
79	Chelyabinsk oblast	5,08	5,96	6,74	3,52	3,78	4,08	5	10
80	Chechnya republic	6,99	7,78	9,28	4,30	4,40	4,66	100	200
81	Chukotka okrug	4,49	7,02	10,26	0,00	0,14	3,20	50	100
82	Yamalo-Nenets okrug	4,67	5,84	9,10	0,00	0,02	3,30	0	5
83	Yaroslavl oblast	4,64	4,69	4,74	3,33	3,38	3,45	0	5

Appendix D. Diesel price across regions

#	Region	Price, rub/l	#	Region	Price, rub/l	#	Region	Price, rub/l
1	Altai krai	37,51	29	Leningrad oblast	38,17	57	Tatarstan republic	36,93
2	Amur oblast	40,97	30	Lipetsk oblast	37,85	58	Tuva republic	39,02
3	Arkhangelsk oblast	39,04	31	Magadan oblast	45,2	59	Udmurt republic	37,26
4	Astrakhan oblast	38,1	32	Moskovskaya oblast	37,37	60	Khakassia republic	37,85
5	Belgorod oblast	37,96	33	Murmansk oblast	42,75	61	Chuvashia republic	36,55
6	Bryansk oblast	38,05	34	Nenets okrug	40,9	62	Rostov oblast	37,48
7	Vladimir oblast	37,18	35	Nizhegorodskaya oblast	37,66	63	Ryazan oblast	36,05
8	Volgograd oblast	37,47	36	Novgorod oblast	38,53	64	Samara oblast	36,3
9	Vologda oblast	39,74	37	Novosibirsk oblast	38,51	65	Saratov oblast	36,87
10	Voronezh oblast	37,64	38	Omsk oblast	36,48	66	Sakhalin oblast	45,9
11	Moscow	38,32	39	Orenburg oblast	39	67	Sverdlovsk oblast	37,74
12	Saint-Petersburg	38,36	40	Orlovskaya oblast	36,5	68	North Ossetia republic	37,9
13	Jewish autonomous oblast	40,82	41	Penza oblast	36,42	69	Smolensk oblast	37,93
14	Zabaikalsky krai	38,95	42	Perm krai	38,85	70	Stavropol krai	38,05
15	Ivanovo oblast	36,05	43	Primorye krai	40,75	71	Tambov oblast	37,35
16	Irkutsk oblast	39,58	44	Pskov oblast	38,7	72	Tver oblast	38,17
17	Kabardino-Balkaria republic	37,88	45	Adygeya republic	38,8	73	Tomsk oblast	39,1
18	Kaliningrad oblast	39,2	46	Altay republic	37,78	74	Tula oblast	37,91
19	Kaluga oblast	36,85	47	Bashkortostan republic	37,31	75	Tyumen oblast	39,65
20	Kamchatka krai	46,89	48	Buryat republic	38,86	76	Ulyanovsk oblast	35,75
21	Karachay-Cherkessia republic	38	49	Dagestan republic	34,5	77	Khabarovsk krai (North)	40,32
22	Kemerovo oblast	36,56	50	Ingushetia republic	36,5	78	Khabarovsk krai (South)	40,32
23	Kirov oblast	38,97	51	Kalmykia republic	38,1	78	Khanty-Mansi okrug	41,68
24	Kostroma oblast	37,62	52	Karelia republic	39,44	79	Chelyabinsk oblast	37,43
25	Krasnodar krai	38,11	53	Komi republic	39,825	80	Chechnya republic	34
26	Krasnoyarsk krai	37,72	54	Mari El republic	36,35	81	Chukotka okrug	50
27	Kurgan oblast	37,23	55	Mordovia republic	38,47	82	Yamalo-Nenets okrug	41,88
28	Kursk oblast	37,98	56	Sakha republic	51,4	83	Yaroslavl oblast	36,66

Appendix E. Normalized and scaled factors and final investment attractiveness indicator values for RE investments on the wholesale market

#	Region	Profitability									Demand	Access	Grid	**Investment attractiveness**		
		wind			solar			hydro								
		min	mean	max	min	mean	max	min	mean	max				**wind**	**solar**	**hydro**
1	Altai krai	0,59	0,63	0,79	0,96	0,97	0,97	0,06	0,10	0,14	0,30	0,80	0,58	**0,58**	**0,66**	**0,44**
4	Astrakhan oblast	0,78	0,80	0,85	0,97	0,97	0,98	0,00	0,01	0,01	0,31	0,76	0,62	**0,63**	**0,67**	**0,43**
5	Belgorod oblast	0,60	0,78	0,81	0,95	0,96	0,96	0,00	0,01	0,01	1,00	0,77	0,00	**0,63**	**0,68**	**0,44**
6	Bryansk oblast	0,03	0,61	0,78	0,94	0,95	0,95	0,00	0,01	0,01	1,00	0,77	0,00	**0,57**	**0,68**	**0,44**
7	Vladimir oblast	0,02	0,03	0,59	0,95	0,95	0,95	0,00	0,01	0,01	1,00	0,82	0,00	**0,50**	**0,69**	**0,46**
8	Volgograd oblast	0,62	0,81	0,85	0,96	0,96	0,97	0,00	0,01	0,01	0,31	0,80	0,62	**0,63**	**0,67**	**0,44**
9	Vologda oblast	0,02	0,03	0,03	0,94	0,94	0,95	0,00	0,01	0,01	1,00	0,67	0,00	**0,42**	**0,65**	**0,42**
10	Voronezh oblast	0,77	0,81	0,83	0,95	0,96	0,96	0,00	0,01	0,01	1,00	0,79	0,00	**0,65**	**0,69**	**0,45**
11	Moscow	0,02	0,02	0,02	0,95	0,95	0,95	0,00	0,01	0,01	1,00	0,75	0,00	**0,44**	**0,67**	**0,44**
12	Saint-Petersburg	0,02	0,02	0,02	0,95	0,95	0,95	0,00	0,01	0,01	0,38	0,75	0,60	**0,44**	**0,67**	**0,44**
14	Zabaikalsky krai	0,58	0,60	0,86	0,95	0,97	0,98	0,06	0,10	0,14	0,30	0,72	0,58	**0,56**	**0,64**	**0,42**
15	Ivanovo oblast	0,02	0,02	0,03	0,95	0,95	0,95	0,00	0,01	0,01	1,00	0,88	0,00	**0,48**	**0,71**	**0,47**
16	Irkutsk oblast (North)	0,02	0,58	0,60	0,95	0,95	0,96	0,14	0,22	0,29	0,30	0,68	0,58	**0,50**	**0,63**	**0,44**
16	Irkutsk oblast (South)	0,02	0,03	0,60	0,95	0,96	0,97	0,14	0,22	0,29	0,30	0,68	0,58	**0,43**	**0,63**	**0,44**
17	Kabardino-Balkaria republic	0,60	0,77	0,82	0,95	0,97	1,00	0,14	0,22	0,29	0,31	0,78	0,62	**0,61**	**0,67**	**0,48**
19	Kaluga oblast	0,02	0,03	0,59	0,94	0,95	0,95	0,00	0,01	0,01	1,00	0,84	0,00	**0,50**	**0,70**	**0,46**
21	Karachay-Cherkessia republic	0,60	0,61	0,63	0,95	0,97	0,99	0,58	0,79	1,00	0,31	0,77	0,62	**0,58**	**0,67**	**0,62**
22	Kemerovo oblast	0,04	0,60	0,62	0,95	0,96	0,96	0,06	0,10	0,14	0,30	0,85	0,58	**0,55**	**0,67**	**0,46**
23	Kirov oblast	0,02	0,03	0,03	0,94	0,95	0,95	0,00	0,01	0,01	0,90	0,71	0,22	**0,46**	**0,69**	**0,46**
24	Kostroma oblast	0,02	0,03	0,03	0,94	0,95	0,95	0,00	0,01	0,01	1,00	0,79	0,00	**0,45**	**0,68**	**0,45**
25	Krasnodar krai	0,62	0,63	0,81	0,96	0,97	0,99	0,58	0,79	1,00	0,31	0,76	0,62	**0,59**	**0,67**	**0,62**
26	Krasnoyarsk krai (Middle)	0,02	0,59	0,83	0,00	0,04	0,96	0,14	0,22	0,29	0,30	0,79	0,58	**0,54**	**0,48**	**0,47**
26	Krasnoyarsk krai (South)	0,03	0,58	0,60	0,95	0,96	0,97	0,14	0,22	0,29	0,30	0,79	0,58	**0,53**	**0,66**	**0,47**
27	Kurgan oblast	0,03	0,61	0,79	0,95	0,96	0,96	0,03	0,04	0,06	0,90	0,81	0,22	**0,61**	**0,72**	**0,49**
28	Kursk oblast	0,03	0,60	0,77	0,95	0,95	0,95	0,00	0,01	0,01	1,00	0,77	0,00	**0,57**	**0,68**	**0,44**

#	Region	Profitability									Demand	Access	Grid	**Investment attractiveness**		
		wind			solar			hydro								
		min	mean	max	min	mean	max	min	mean	max				**wind**	**solar**	**hydro**
29	Leningrad oblast	0,02	0,02	0,03	0,94	0,95	0,95	0,00	0,01	0,01	0,38	0,76	0,60	**0,44**	**0,67**	**0,44**
30	Lipetsk oblast	0,04	0,80	0,84	0,95	0,95	0,95	0,00	0,01	0,01	1,00	0,78	0,00	**0,60**	**0,68**	**0,45**
32	Moskovskaya oblast	0,02	0,04	0,78	0,95	0,95	0,95	0,00	0,01	0,01	1,00	0,81	0,00	**0,51**	**0,69**	**0,45**
33	Murmansk oblast	0,04	0,79	0,95	0,00	0,00	0,00	0,03	0,04	0,06	0,38	0,50	0,60	**0,53**	**0,37**	**0,38**
35	Nizhegorodskaya oblast	0,02	0,03	0,03	0,95	0,95	0,95	0,00	0,01	0,01	0,32	0,79	0,13	**0,32**	**0,55**	**0,31**
36	Novgorod oblast	0,02	0,02	0,03	0,94	0,94	0,95	0,00	0,01	0,01	0,38	0,74	0,60	**0,44**	**0,67**	**0,43**
37	Novosibirsk oblast	0,03	0,60	0,80	0,96	0,96	0,98	0,03	0,04	0,06	0,30	0,74	0,58	**0,53**	**0,65**	**0,42**
38	Omsk oblast	0,03	0,60	0,81	0,95	0,96	0,96	0,00	0,01	0,01	0,30	0,86	0,58	**0,56**	**0,67**	**0,44**
39	Orenburg oblast	0,62	0,80	0,87	0,96	0,97	0,97	0,00	0,01	0,01	0,90	0,71	0,22	**0,65**	**0,70**	**0,46**
40	Orlovskaya oblast	0,03	0,03	0,04	0,95	0,95	0,95	0,00	0,01	0,01	1,00	0,86	0,00	**0,47**	**0,70**	**0,47**
41	Penza oblast	0,59	0,60	0,77	0,96	0,96	0,96	0,00	0,01	0,01	0,32	0,86	0,13	**0,49**	**0,57**	**0,33**
42	Perm krai	0,03	0,04	0,59	0,77	0,94	0,95	0,03	0,04	0,06	0,90	0,72	0,22	**0,50**	**0,69**	**0,47**
44	Pskov oblast	0,02	0,59	0,62	0,94	0,95	0,95	0,00	0,01	0,01	0,38	0,73	0,60	**0,54**	**0,67**	**0,43**
45	Adygeya republic	0,62	0,62	0,79	0,96	0,97	0,99	0,58	0,79	1,00	0,31	0,72	0,62	**0,58**	**0,66**	**0,61**
46	Altay republic	0,60	0,61	0,62	0,96	0,97	0,98	0,14	0,22	0,29	0,30	0,78	0,58	**0,57**	**0,66**	**0,47**
47	Bashkortostan republic	0,03	0,61	0,83	0,95	0,96	0,97	0,03	0,04	0,06	0,90	0,81	0,22	**0,61**	**0,72**	**0,49**
48	Buryat republic	0,02	0,59	0,79	0,95	0,97	0,98	0,06	0,10	0,14	0,30	0,72	0,58	**0,52**	**0,64**	**0,42**
49	Dagestan republic	0,79	0,89	1,00	0,96	0,97	0,99	0,14	0,22	0,29	0,31	0,97	0,62	**0,70**	**0,72**	**0,53**
50	Ingushetia republic	0,82	0,86	0,94	0,97	0,97	0,98	0,14	0,22	0,29	0,31	0,86	0,62	**0,67**	**0,69**	**0,50**
51	Kalmykia republic	0,79	0,81	0,85	0,96	0,97	0,97	0,00	0,01	0,01	0,31	0,76	0,62	**0,63**	**0,67**	**0,43**
52	Karelia republic	0,02	0,03	0,59	0,00	0,03	0,95	0,01	0,02	0,03	0,38	0,69	0,60	**0,46**	**0,48**	**0,42**
54	Mari El republic	0,02	0,03	0,03	0,95	0,95	0,95	0,00	0,01	0,01	0,32	0,86	0,13	**0,33**	**0,57**	**0,33**
55	Mordovia republic	0,03	0,03	0,59	0,95	0,95	0,96	0,00	0,01	0,01	0,32	0,74	0,13	**0,34**	**0,54**	**0,30**
57	Tatarstan republic	0,02	0,60	0,78	0,95	0,95	0,96	0,00	0,01	0,01	0,32	0,83	0,13	**0,44**	**0,56**	**0,32**
58	Tuva republic	0,03	0,59	0,62	0,96	0,97	0,99	0,14	0,22	0,29	0,30	0,71	0,58	**0,51**	**0,64**	**0,45**
59	Udmurt republic	0,02	0,03	0,03	0,95	0,95	0,95	0,00	0,01	0,01	0,90	0,81	0,22	**0,49**	**0,72**	**0,48**
60	Khakassia republic	0,59	0,60	0,61	0,95	0,96	0,97	0,14	0,22	0,29	0,30	0,78	0,58	**0,56**	**0,65**	**0,47**

#	Region	Profitability									Demand	Access	Grid	**Investment attractiveness**		
		wind			solar			hydro								
		min	mean	max	min	mean	max	min	mean	max				**wind**	**solar**	**hydro**
61	Chuvashia republic	0,03	0,03	0,58	0,95	0,95	0,95	0,00	0,01	0,01	0,32	0,85	0,13	**0,37**	**0,56**	**0,33**
62	Rostov oblast	0,63	0,80	0,85	0,96	0,96	0,97	0,00	0,01	0,01	0,31	0,80	0,62	**0,63**	**0,67**	**0,44**
63	Ryazan oblast	0,03	0,77	0,82	0,95	0,95	0,96	0,00	0,01	0,01	1,00	0,88	0,00	**0,62**	**0,71**	**0,47**
64	Samara oblast	0,77	0,80	0,81	0,96	0,96	0,96	0,00	0,01	0,01	0,32	0,87	0,13	**0,53**	**0,57**	**0,33**
65	Saratov oblast	0,60	0,79	0,83	0,96	0,96	0,97	0,00	0,01	0,01	0,32	0,84	0,13	**0,51**	**0,56**	**0,32**
67	Sverdlovsk oblast	0,03	0,58	0,59	0,77	0,95	0,96	0,00	0,01	0,01	0,90	0,79	0,22	**0,59**	**0,70**	**0,48**
68	North Ossetia republic	0,78	0,84	0,89	0,97	0,98	1,00	0,29	0,43	0,58	0,31	0,78	0,62	**0,64**	**0,67**	**0,54**
69	Smolensk oblast	0,02	0,59	0,77	0,94	0,95	0,95	0,00	0,01	0,01	1,00	0,77	0,00	**0,57**	**0,68**	**0,45**
70	Stavropol krai	0,62	0,78	0,82	0,97	0,97	0,97	0,03	0,04	0,06	0,31	0,77	0,62	**0,61**	**0,67**	**0,44**
71	Tambov oblast	0,61	0,81	0,84	0,95	0,95	0,96	0,00	0,01	0,01	1,00	0,81	0,00	**0,64**	**0,69**	**0,45**
72	Tver oblast	0,02	0,02	0,60	0,94	0,95	0,95	0,00	0,01	0,01	1,00	0,76	0,00	**0,48**	**0,68**	**0,44**
73	Tomsk oblast	0,03	0,03	0,59	0,95	0,95	0,96	0,01	0,02	0,03	0,30	0,71	0,58	**0,44**	**0,63**	**0,40**
74	Tula oblast	0,03	0,59	0,63	0,95	0,95	0,95	0,00	0,01	0,01	1,00	0,78	0,00	**0,56**	**0,68**	**0,45**
75	Tyumen oblast	0,03	0,03	0,61	0,95	0,95	0,96	0,00	0,01	0,01	0,90	0,68	0,22	**0,49**	**0,69**	**0,45**
76	Ulyanovsk oblast	0,03	0,62	0,80	0,95	0,96	0,96	0,00	0,01	0,01	0,32	0,90	0,13	**0,47**	**0,58**	**0,34**
78	Khanty-Mansi okrug	0,02	0,03	0,80	0,00	0,05	0,95	0,00	0,01	0,01	0,90	0,56	0,22	**0,47**	**0,48**	**0,42**
79	Chelyabinsk oblast	0,58	0,63	0,81	0,95	0,96	0,97	0,01	0,02	0,03	0,90	0,80	0,22	**0,65**	**0,72**	**0,49**
80	Chechnya republic	0,82	0,87	0,95	0,97	0,97	0,98	0,29	0,43	0,58	0,31	1,00	0,62	**0,70**	**0,73**	**0,59**
82	Yamalo-Nenets okrug	0,02	0,63	0,94	0,00	0,00	0,94	0,00	0,01	0,01	0,90	0,55	0,22	**0,55**	**0,48**	**0,42**
83	Yaroslavl oblast	0,02	0,02	0,02	0,94	0,95	0,95	0,00	0,01	0,01	1,00	0,85	0,00	**0,47**	**0,70**	**0,46**

Appendix F. Normalized and scaled factors and final investment attractiveness indicator values for RE investments on the retail markets

#	Region	Profitability									Demand	Access	Grid	**Investment attractiveness**		
		wind			solar			hydro								
		min	mean	max	min	mean	max	min	mean	max				**wind**	**solar**	**hydro**
1	Altai krai	0,16	0,27	0,36	0,72	0,76	0,81	0,06	0,10	0,14	0,74	0,80	0,65	**0,61**	**0,74**	**0,57**
2	Amur oblast	0,04	0,11	0,44	0,72	0,79	0,85	0,06	0,10	0,14	0,00	0,60	0,00	**0,19**	**0,35**	**0,18**
3	Arkhangelsk oblast	0,06	0,09	0,32	0,00	0,26	0,61	0,01	0,02	0,03	0,24	0,71	1,00	**0,52**	**0,56**	**0,49**
4	Astrakhan oblast	0,31	0,39	0,52	0,76	0,79	0,85	0,00	0,01	0,01	0,33	0,76	0,76	**0,56**	**0,66**	**0,47**
5	Belgorod oblast	0,18	0,31	0,40	0,68	0,70	0,71	0,00	0,01	0,01	1,00	0,77	0,51	**0,65**	**0,74**	**0,57**
6	Bryansk oblast	0,08	0,20	0,30	0,62	0,65	0,65	0,00	0,01	0,01	1,00	0,77	0,51	**0,62**	**0,73**	**0,57**
7	Vladimir oblast	0,05	0,08	0,14	0,65	0,65	0,67	0,00	0,01	0,01	1,00	0,82	0,51	**0,60**	**0,75**	**0,58**
8	Volgograd oblast	0,24	0,41	0,54	0,70	0,74	0,78	0,00	0,01	0,01	0,33	0,80	0,76	**0,57**	**0,66**	**0,47**
9	Vologda oblast	0,07	0,09	0,10	0,60	0,61	0,63	0,00	0,01	0,01	1,00	0,67	0,51	**0,57**	**0,70**	**0,55**
10	Voronezh oblast	0,30	0,42	0,48	0,69	0,70	0,73	0,00	0,01	0,01	1,00	0,79	0,51	**0,68**	**0,75**	**0,58**
11	Moscow	0,08	0,08	0,08	0,64	0,64	0,64	0,00	0,01	0,01	1,00	0,75	0,51	**0,58**	**0,73**	**0,57**
12	Saint-Petersburg	0,06	0,06	0,06	0,63	0,63	0,63	0,00	0,01	0,01	0,24	0,75	1,00	**0,51**	**0,66**	**0,50**
13	Jewish autonomous oblast	0,04	0,04	0,14	0,80	0,82	0,85	0,06	0,10	0,14	0,00	0,61	0,00	**0,17**	**0,36**	**0,18**
14	Zabaikalsky krai	0,12	0,19	0,56	0,67	0,80	0,88	0,06	0,10	0,14	0,74	0,72	0,65	**0,59**	**0,72**	**0,55**
15	Ivanovo oblast	0,05	0,06	0,08	0,63	0,64	0,65	0,00	0,01	0,01	1,00	0,88	0,51	**0,61**	**0,76**	**0,60**
16	Irkutsk oblast (North)	0,08	0,12	0,17	0,65	0,65	0,70	0,14	0,22	0,29	0,74	0,68	0,65	**0,55**	**0,68**	**0,57**
16	Irkutsk oblast (South)	0,05	0,10	0,19	0,69	0,72	0,79	0,14	0,22	0,29	0,74	0,68	0,65	**0,54**	**0,70**	**0,57**
17	Kabardino-Balkaria republic	0,18	0,30	0,45	0,67	0,78	1,00	0,14	0,22	0,29	0,33	0,78	0,76	**0,54**	**0,67**	**0,52**
18	Kaliningrad oblast	0,15	0,29	0,67	0,00	0,59	0,69	0,03	0,04	0,06	0,24	0,70	1,00	**0,57**	**0,60**	**0,50**
19	Kaluga oblast	0,07	0,09	0,16	0,62	0,63	0,65	0,00	0,01	0,01	1,00	0,84	0,51	**0,61**	**0,74**	**0,59**
21	Karachay-Cherkessia republic	0,18	0,22	0,27	0,67	0,77	0,94	0,58	0,79	1,00	0,33	0,77	0,76	**0,52**	**0,66**	**0,66**
22	Kemerovo oblast	0,12	0,16	0,23	0,68	0,72	0,75	0,06	0,10	0,14	0,74	0,85	0,65	**0,60**	**0,74**	**0,59**
23	Kirov oblast	0,06	0,09	0,10	0,61	0,63	0,67	0,00	0,01	0,01	0,47	0,71	0,92	**0,55**	**0,68**	**0,53**
24	Kostroma oblast	0,06	0,09	0,10	0,61	0,63	0,65	0,00	0,01	0,01	1,00	0,79	0,51	**0,60**	**0,73**	**0,58**
25	Krasnodar krai	0,23	0,27	0,42	0,71	0,79	0,94	0,58	0,79	1,00	0,33	0,76	0,76	**0,54**	**0,67**	**0,66**

#	Region	Profitability									Demand	Access	Grid	**Investment attractiveness**		
		wind			solar			hydro								
		min	mean	max	min	mean	max	min	mean	max				**wind**	**solar**	**hydro**
26	Krasnoyarsk krai (Middle)	0,06	0,14	0,46	0,00	0,28	0,71	0,14	0,22	0,29	0,74	0,79	0,65	**0,59**	**0,62**	**0,60**
26	Krasnoyarsk krai (South)	0,11	0,13	0,17	0,69	0,71	0,78	0,14	0,22	0,29	0,74	0,79	0,65	**0,58**	**0,72**	**0,60**
27	Kurgan oblast	0,09	0,21	0,34	0,68	0,72	0,74	0,03	0,04	0,06	0,47	0,81	0,92	**0,60**	**0,73**	**0,56**
28	Kursk oblast	0,10	0,19	0,30	0,65	0,68	0,69	0,00	0,01	0,01	1,00	0,77	0,51	**0,62**	**0,74**	**0,57**
29	Leningrad oblast	0,05	0,07	0,09	0,60	0,63	0,64	0,00	0,01	0,01	0,24	0,76	1,00	**0,52**	**0,66**	**0,50**
30	Lipetsk oblast	0,12	0,36	0,49	0,66	0,67	0,68	0,00	0,01	0,01	1,00	0,78	0,51	**0,65**	**0,74**	**0,57**
32	Moskovskaya oblast	0,06	0,11	0,33	0,63	0,65	0,66	0,00	0,01	0,01	1,00	0,81	0,51	**0,62**	**0,74**	**0,58**
33	Murmansk oblast	0,12	0,34	0,85	0,00	0,00	0,00	0,03	0,04	0,06	0,24	0,50	1,00	**0,54**	**0,43**	**0,45**
34	Nenets okrug	0,18	0,44	0,81	0,00	0,00	0,00	0,01	0,02	0,03	0,24	0,60	1,00	**0,58**	**0,46**	**0,47**
35	Nizhegorodskaya oblast	0,06	0,08	0,10	0,64	0,66	0,68	0,00	0,01	0,01	0,20	0,79	0,69	**0,44**	**0,59**	**0,42**
36	Novgorod oblast	0,06	0,07	0,10	0,61	0,62	0,63	0,00	0,01	0,01	0,24	0,74	1,00	**0,51**	**0,65**	**0,50**
37	Novosibirsk oblast	0,09	0,18	0,36	0,69	0,73	0,85	0,03	0,04	0,06	0,74	0,74	0,65	**0,58**	**0,72**	**0,54**
38	Omsk oblast	0,10	0,16	0,39	0,66	0,70	0,75	0,00	0,01	0,01	0,74	0,86	0,65	**0,61**	**0,74**	**0,56**
39	Orenburg oblast	0,24	0,39	0,60	0,70	0,77	0,81	0,00	0,01	0,01	0,47	0,71	0,92	**0,63**	**0,71**	**0,53**
40	Orlovskaya oblast	0,08	0,10	0,12	0,64	0,66	0,67	0,00	0,01	0,01	1,00	0,86	0,51	**0,62**	**0,75**	**0,59**
41	Penza oblast	0,13	0,18	0,30	0,70	0,71	0,74	0,00	0,01	0,01	0,20	0,86	0,69	**0,49**	**0,62**	**0,44**
42	Perm krai	0,09	0,11	0,13	0,57	0,62	0,66	0,03	0,04	0,06	0,47	0,72	0,92	**0,55**	**0,68**	**0,54**
43	Primorye krai	0,04	0,27	0,75	0,79	0,90	1,00	0,06	0,10	0,14	0,00	0,61	0,00	**0,24**	**0,38**	**0,18**
44	Pskov oblast	0,06	0,13	0,23	0,62	0,63	0,64	0,00	0,01	0,01	0,24	0,73	1,00	**0,53**	**0,65**	**0,49**
45	Adygeya republic	0,23	0,24	0,34	0,71	0,80	0,94	0,58	0,79	1,00	0,33	0,72	0,76	**0,52**	**0,66**	**0,65**
46	Altay republic	0,19	0,22	0,24	0,75	0,81	0,88	0,14	0,22	0,29	0,74	0,78	0,65	**0,60**	**0,75**	**0,60**
47	Bashkortostan republic	0,10	0,21	0,46	0,66	0,71	0,78	0,03	0,04	0,06	0,47	0,81	0,92	**0,61**	**0,73**	**0,56**
48	Buryat republic	0,05	0,14	0,34	0,69	0,77	0,86	0,06	0,10	0,14	0,74	0,72	0,65	**0,57**	**0,72**	**0,55**
49	Dagestan republic	0,33	0,66	1,00	0,75	0,78	0,94	0,14	0,22	0,29	0,33	0,97	0,76	**0,68**	**0,72**	**0,57**
50	Ingushetia republic	0,45	0,57	0,80	0,81	0,82	0,85	0,14	0,22	0,29	0,33	0,86	0,76	**0,64**	**0,69**	**0,54**
51	Kalmykia republic	0,33	0,41	0,54	0,75	0,79	0,83	0,00	0,01	0,01	0,33	0,76	0,76	**0,57**	**0,66**	**0,47**
52	Karelia republic	0,07	0,09	0,14	0,00	0,20	0,64	0,01	0,02	0,03	0,24	0,69	1,00	**0,51**	**0,55**	**0,49**

#	Region	Profitability									Demand	Access	Grid	**Investment attractiveness**		
		wind			solar			hydro								
		min	mean	max	min	mean	max	min	mean	max				**wind**	**solar**	**hydro**
53	Komi republic	0,07	0,13	0,56	0,00	0,14	0,62	0,01	0,02	0,03	0,24	0,67	1,00	**0,53**	**0,53**	**0,48**
54	Mari El republic	0,07	0,09	0,10	0,65	0,67	0,67	0,00	0,01	0,01	0,20	0,86	0,69	**0,46**	**0,61**	**0,44**
55	Mordovia republic	0,08	0,10	0,13	0,68	0,68	0,71	0,00	0,01	0,01	0,20	0,74	0,69	**0,44**	**0,58**	**0,41**
57	Tatarstan republic	0,06	0,17	0,32	0,66	0,69	0,71	0,00	0,01	0,01	0,20	0,83	0,69	**0,48**	**0,60**	**0,43**
58	Tuva republic	0,10	0,14	0,24	0,72	0,81	0,91	0,14	0,22	0,29	0,74	0,71	0,65	**0,56**	**0,73**	**0,58**
59	Udmurt republic	0,07	0,09	0,09	0,63	0,65	0,67	0,00	0,01	0,01	0,47	0,81	0,92	**0,57**	**0,71**	**0,55**
60	Khakassia republic	0,13	0,17	0,22	0,68	0,73	0,79	0,14	0,22	0,29	0,74	0,78	0,65	**0,58**	**0,72**	**0,60**
61	Chuvashia republic	0,09	0,10	0,12	0,67	0,68	0,69	0,00	0,01	0,01	0,20	0,85	0,69	**0,46**	**0,61**	**0,44**
62	Rostov oblast	0,27	0,37	0,53	0,72	0,74	0,76	0,00	0,01	0,01	0,33	0,80	0,76	**0,57**	**0,66**	**0,47**
63	Ryazan oblast	0,10	0,28	0,44	0,64	0,66	0,70	0,00	0,01	0,01	1,00	0,88	0,51	**0,67**	**0,76**	**0,60**
64	Samara oblast	0,28	0,36	0,40	0,70	0,74	0,76	0,00	0,01	0,01	0,20	0,87	0,69	**0,53**	**0,62**	**0,44**
65	Saratov oblast	0,16	0,34	0,48	0,71	0,75	0,79	0,00	0,01	0,01	0,20	0,84	0,69	**0,52**	**0,62**	**0,43**
67	Sverdlovsk oblast	0,08	0,12	0,14	0,57	0,64	0,70	0,00	0,01	0,01	0,47	0,79	0,92	**0,57**	**0,70**	**0,54**
68	North Ossetia republic	0,31	0,49	0,65	0,81	0,86	1,00	0,29	0,43	0,58	0,33	0,78	0,76	**0,59**	**0,69**	**0,57**
69	Smolensk oblast	0,07	0,15	0,29	0,62	0,63	0,65	0,00	0,01	0,01	1,00	0,77	0,51	**0,61**	**0,73**	**0,57**
70	Stavropol krai	0,23	0,32	0,45	0,76	0,79	0,81	0,03	0,04	0,06	0,33	0,77	0,76	**0,55**	**0,66**	**0,48**
71	Tambov oblast	0,21	0,42	0,49	0,67	0,69	0,73	0,00	0,01	0,01	1,00	0,81	0,51	**0,67**	**0,75**	**0,58**
72	Tver oblast	0,06	0,07	0,16	0,61	0,63	0,64	0,00	0,01	0,01	1,00	0,76	0,51	**0,59**	**0,72**	**0,57**
73	Tomsk oblast	0,09	0,10	0,14	0,63	0,66	0,72	0,01	0,02	0,03	0,74	0,71	0,65	**0,55**	**0,69**	**0,53**
74	Tula oblast	0,09	0,15	0,27	0,63	0,65	0,66	0,00	0,01	0,01	1,00	0,78	0,51	**0,61**	**0,73**	**0,57**
75	Tyumen oblast	0,08	0,10	0,20	0,64	0,68	0,73	0,00	0,01	0,01	0,47	0,68	0,92	**0,54**	**0,68**	**0,52**
76	Ulyanovsk oblast	0,11	0,23	0,37	0,69	0,71	0,76	0,00	0,01	0,01	0,20	0,90	0,69	**0,51**	**0,63**	**0,45**
77	Khabarovsk krai (North)	0,05	0,21	0,56	0,66	0,72	0,78	0,06	0,10	0,14	0,00	0,64	0,00	**0,22**	**0,34**	**0,18**
77	Khabarovsk krai (South)	0,04	0,12	0,41	0,73	0,78	0,84	0,06	0,10	0,14	0,00	0,64	0,00	**0,20**	**0,36**	**0,18**
78	Khanty-Mansi okrug	0,07	0,10	0,39	0,00	0,34	0,66	0,00	0,01	0,01	0,47	0,56	0,92	**0,53**	**0,57**	**0,49**
79	Chelyabinsk oblast	0,13	0,28	0,41	0,66	0,71	0,76	0,01	0,02	0,03	0,47	0,80	0,92	**0,61**	**0,72**	**0,55**
80	Chechnya republic	0,45	0,58	0,84	0,81	0,82	0,87	0,29	0,43	0,58	0,33	1,00	0,76	**0,68**	**0,73**	**0,63**

#	Region	Profitability									Demand	Access	Grid	**Investment attractiveness**		
		wind			solar			hydro								
		min	mean	max	min	mean	max	min	mean	max				**wind**	**solar**	**hydro**
82	Yamalo-Nenets okrug	0,06	0,26	0,80	0,00	0,00	0,62	0,00	0,01	0,01	0,47	0,55	0,92	**0,57**	**0,52**	**0,48**
83	Yaroslavl oblast	0,05	0,06	0,07	0,62	0,63	0,65	0,00	0,01	0,01	1,00	0,85	0,51	**0,60**	**0,75**	**0,59**