

Article

Assessment of the Territorial Energy Security in the Context of Energy Systems Integration

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Abstract: Our paper tackles the timely and highly-debated issue of assessment of the level of energy security for Russia’s territorial entities. Our analysis is carried out from the perspective of economic and management threats to reliable power supply for consumers caused by the process of integration of energy systems and the expansion of market regulation mechanisms. In particular, we focus on the creation and integration of energy systems using a case study of the remote territorial entity represented by Russia’s Far Eastern region that present a topic of special interest with respect to the subject and the scope of this research. We define and build the methods that might be used for determining the economically justified level of energy security under the market economy conditions based on ensuring a balance of interests between territorial government bodies and territorial generating companies in the process of forming a strategy for the development of a territorial energy system. Our results clearly demonstrate that current electricity tariffs and prices for the end consumers at the remote territorial entities, such as the Russian Far Eastern region, pose a threat to energy security since they are underestimated due to social and political concerns and often lead to unprofitable power generation. We argue that political consideration aside, energy systems creation and integration should be made viable and sustainable not only in Russia, but also in other countries. Our outcomes show that a more reasonable energy tariff policy might be appropriate when relevant stakeholders and policy-makers attempt to create conditions for the advanced development of remote industrial areas.

Keywords: energy security; economic feasibility; energy system; profitability; geopolitics; energy markets

1. Introduction

Energy security represents an endeavor of the extremely important national and economic significance. One can say that it determines the key priorities and the economic activities of any given state [1]. With regard to the above, Cherp [2,3] points out that valid definitions of energy security should include relevant social actors, describe mechanisms for distinguishing between primary and secondary concerns and search for pathways to constructively channel possible disagreements. At the same time, the activities of the state in the energy sector are traditionally included in its economic

functions and are being limited to such issues as the control of natural monopolies which is a clear underestimation of the importance of energy for economic growth [4–8].

One would probably agree that the activities of the state in the energy realm should aim at ensuring the reliability and continuous flow and operation of energy systems at various organizational levels, as well as at fostering the sustainable development of this sector which under current problems and challenges to energy security might guarantee the preparedness of the country and its territorial entities to any energy-related challenges in the future. In this case, the control of economic relations arising in the process of functioning and development of territorial energy systems for their integration and strengthening of energy linkages become the key mechanism of state management at the territorial level under market conditions [9]. Such representation of the state's activity allows us to identify its energy function through the lines of economic activities aimed at ensuring the reliable functioning and sustainable development of territorial energy systems, formation of markets for energy resources and products, as well as regulation of the legal relationships of their participants and marginal prices for goods and services [10].

The adopted market model of energy management which is typical for territorial entities that can be found in such vast and complex countries as the Russian Federation features an open type of energy system and requires robust coordination of strategies for the development of power facilities by the energy enterprises and the territorial government bodies which manage these facilities [11–14]. This is crucial in order to provide the sufficient, as well as feasible level of energy security for responding to external and internal challenges in reliability and efficiency of integrated energy supply to local consumers for medium and long-term perspectives [15–17].

A conflict of interest that arises from the existence of the energy market that generates different ideas about the efficiency of the energy sector at various levels of its facilities (both regional facilities and energy enterprises) results in a mismatch of the territorial energy management system [18]. The operating economy (i.e., the best possible use of fuel and energy resources as well as the low production cost of energy products) that ensures the required level of reliability represents the efficiency criterion of the energy sector seen from the point of view of the state. Based on this approach one can see how Augutis et al. [19–24] outline and describe the assessment technologies that help to measure this efficiency criterion of energy security.

At the same time, the profitability, in other words the correspondence of business facilities with a competitive technological infrastructure that allows them to derive a profit in various trade sectors of the energy markets, including the use of market power tools, takes the place of this efficiency criterion on behalf of the energy enterprises [25–28]. Demski et al. [29] or Cox [30] show that failure to take into account the above factor in the formation of a regional energy policy leads to ineffectiveness of mechanisms for the implementation of energy programs. Moreover, the conditions specified in the energy strategy under which energy enterprises would be able to fulfill the state's requirements for the energy sector become unattainable. In other words, the energy strategy of the region is deprived of the ability to perform its management functions in the view of the impossibility of achieving the specified goals within the established timeframe turning into a framework document [31]. This would inevitably predetermine not only the distortions in the energy sector development from the scientifically grounded directions laid down into the strategy, but also the formation of completely different trajectories of its evolution caused by unexplained causal links which increases the uncertainty and, accordingly, rises the likelihood of emerging threats to the energy security [32].

In this paper, we employ a unique case study that embeds the assessment of the energy security level for the Far Eastern economic region located in the furthestmost Western boundaries of Russia. The region represents vast and uncultivated territory which has recently come under the attention of the Russian central government with a purpose of developing its resources and launching resettlement programs intended to make it economically viable [33]. Creation and integration of energy systems plays a crucial role in these endeavors.

This paper is structured as follows: Section 2 provides a comprehensive literature review using an overview of many similar studies from the research literature. Section 3 describes economic justification of the energy security level. Section 4 outlines the model for determining an economically justified level of energy security and their impact on the cost of energy production for the consumer. Section 5 briefly describes the subject of our case study and reports the main results of the empirical model. Finally, Section 6 concludes the paper with the discussions of our results and their comparisons to similar studies and provides some closing remarks.

2. Literature Review

In general, energy security, which is usually defined in the research literature as the set of energy aspects of national security, typically determines a condition of the country's security against the threats to reliable fuel and energy supply, which is one of the state's priorities [34–36]. The conceptual apparatus of energy security is based on the concepts of national security and reliability [37–39]. For example, Benjamin Sovacool [40] points out that energy security consists of the interconnected factors including availability, affordability, efficiency, sustainability, and proper governance. Moreover, Sovacool and colleagues come to an agreement on the fact that conceptualizing and measuring energy security is a complex topic that might be very country-dependent and tied to local culture and habits which makes it very complex and robust for studying and calling for local comprehensive case studies that would allow shedding somewhere more light on its nature and scope [41–44].

From the standpoint of the national security concept, energy security expresses its energy aspects and reflects the contribution of energy to its security [45]. With regard to the above, Kiriyama and Kajikawa [46] or Umbach [47] present a multilayered analysis of energy security research and the energy supply process as well as draw implications for global energy security. Moreover, there are various methodologies of energy security [48,49] as well as a plethora of methods, indicators, and measures often used in the research literature [50–57]. Smart grids or nuclear energy security are of a special interest [58,59]. In addition, system dynamics approach is often involved for assessing the whole complexity of these issues [60].

Inherently, energy security is part of the economic security that characterizes the security of economic relations [61,62]. It is realized through economic mechanisms and allocated to a separate category because of the determining influence of energy on the national economy development (Figure 1).

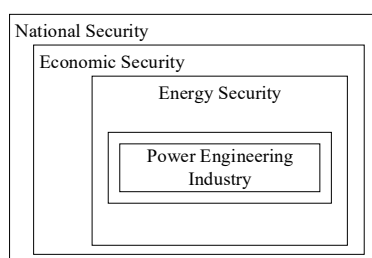


Figure 1. Energy security within the structure of state national security.

From the standpoint of the concept of reliability, energy security characterizes the continuity of the process of energy supply to consumers, usually in the form of electricity supply. Strielkowski et al. [63] describe the case of the household photovoltaics and the electricity market in the United Kingdom when this electricity supply is distorted due to the badly designed energy tariffs. In addition, Rhodes et al. [64] contemplate over the unwillingness of the private sector to shift from the existing energy paradigm. Moreover, in various very relevant studies, Kyriakopoulos and Arabatzis or Kyriakopoulos et al. point out at the regional electricity consumption using a case study of Greece and demonstrate how the and renewable energy sources (RES) can enter into the picture [65–67]. At the same time, if reliability is a characteristic of the energy system of a territorial entity, then energy security characterizes the condition of a territorial entity, achieved by the continuous power supply (see Table 1).

Table 1. Comparative analysis of the reliability and energy security concepts.

Characteristic	Reliability	Energy Security
Category	Property	Status
Affiliation	The power system and its elements	Territorial and administrative formation of various levels
Events	Mass or single failures of energy system elements	Realization of threats to the state of consumers' energy security
Causes of events	Failures of equipment and control systems, as well as the human factor	Technogenic, socio-political and economic
Consequences of events	Decrease in production efficiency and undersupply of energy resources and products (including mass production)	The energy crisis of territorial formation and the weakening of economic and national security

Safety is the key category in the conceptual apparatus of energy security. It represents a condition achieved by ensuring the following three objectives:

- deficit-free resource supply for territorial entities;
- economic affordability of energy products for local consumers; and
- availability of technologies that allow to manage the reliable and efficient operation of the territorial energy system in the presence of existing environmental constraints [68–70].

Hence, Hoffmann [71] or McPherson and Tahseen [72] show how energy security can be characterized by the categories such as resource sufficiency, economic affordability, as well as technological allowability. Moreover, it has been proposed to clarify the concept of energy security based on the following considerations:

First, the widespread use of market-based energy management mechanisms by the state resulted in privatization and transfer of a large part of the business assets of power systems to private owners [73]. In order to make sure that the stable operation of the industry is reached, these mechanisms require assurance of economic efficiency of energy production and formation of profit margins that allow energy enterprises to implement the technological modernization and innovative development programs [74].

Second, the economic affordability of energy resources and products becomes the upper limiting threshold for resource sufficiency and technological efficiency reflecting the amount of available energy resources, the economy of their production processes and the transformation into energy products [75]. It also becomes obvious that in the sector of energy, the economic limit in market conditions is reached earlier than the resource and technological limits.

Therefore, we propose the characterization of energy security at the territorial level as a condition of protection of the territorial unit of the country from threats to reliable fuel and energy supply achieved by ensuring the functioning of its energy system in market conditions in accordance with the principles of consumer affordability of energy products and economic profitability of its production.

This clarification of what the energy security is, allows us to consider the economic and managerial problems of its provision more comprehensively. These problems represent the key issues in the context of the ongoing globalization and liberalization of energy markets.

Thence, comparing our research with similar existing studies, one can conclude that its main value-added is two-fold: First, we build and test an empirical model presented in the sections that follow for determining the economically grounded level of energy security of the country's territorial entities. Second, we employ a novel case study of the interesting Far Eastern region of Russia to prove out point. Additionally, our study shows that one of the main threats is the globalization of energy sector manifested through the integration of territorial energy systems. One can see that this integration leads to an increase in the usage of market-based energy sector management mechanisms and consequently to an increase in the number of management entities with conflicting interests. According to our model, energy security is achieved through ensuring economic affordability of energy

products for the consumer and profitability of territorial generating companies. In accordance with this, we determine the cost of energy products which must be formed in the regions to ensure their uninterrupted power supply in market conditions.

3. Economic Justification of the Energy Security Level

According to the above clarification of the energy security and its definition, we might characterize it as a condition for the protection of the territorial unit of the country from threats to reliable fuel and energy supply achieved by ensuring the functioning of its energy system in market conditions in accordance with the principles of consumer affordability of energy products and economic profitability of its production.

On one hand, energy security is determined by the economic profitability of the energy production. On the other hand, it is determined by its affordability to the consumer. The economic profitability of production through its expense and profitable parts expresses components that are important for energy security, such as territorial resource sufficiency, production and economic efficiency of the energy system, and reliability of energy supply. Therefore, affordability of energy products to consumers through the values of marginal prices for energy products characterizes the level of social-and-economic development of a territorial-and-administrative entity.

Our methods and algorithms are based on the mathematical principles of relative compensation typically used in game theory and various optimization problems. To the best of our knowledge, the models of the economically justified level of energy security in accordance with the economic criteria of energy security have never been used in the research literature before, so we had to design our empirical models ourselves from a scratch. Our model is based on the solution of the game about what price for energy products should be established at the market in order to ensure a compromise of interests of energy sector management entities under the market conditions. This task is performed in order to rationally determine the agents' behavior with the restrictions on resources. It is initially assumed that the selected model parameters have a significant impact on the cost of production (i.e., they are functionally related).

In general, an assessment of the energy security level can be obtained based on analysis of the cost value of energy production for the consumer and its structure (see Equation (1)):

$$\begin{cases} P = PC + MP \leq LP \\ MP \geq PC \cdot RR \end{cases} \quad (1)$$

where P is the cost of energy products, PC the production costs, MP is the marginal profit, LP is the limit price, and RR is the required profit rate.

The price of energy products should not exceed the limit price guaranteeing economic affordability of products for the end user by the government in accordance with the level of social-and-economic development of the territorial-and-administrative entity. Therefore, marginal profit of energy enterprises should correspond to profitability, which allows an enterprise to attract investments for renewal of capital assets, quality improvement and provision of product competitiveness.

One can say that the interests of the state and the power business are contradictory. If consumer affordability of energy products is a partial criterion of the state, then it is the economic profitability of production for energy enterprises.

The above contradiction can be surmounted by harmonizing the economic criteria imposed by the state and the businesses through the development of a generalized efficiency criterion that is broken into partial criteria. Finding the extreme value of the generalized criterion function makes it possible to determine the cost of energy production, at which the balance of interests is achieved. The larger the value of the generalized criterion, the higher the level of energy security. Hence, it is considered that an economically justified level of energy security would be achieved at the cost of energy production that maximizes the generalized criterion function.

We represent a generalized criterion reflecting the energy security level as a multiplicative function of two partial criteria (see Equation (2)):

$$J_{ES}(P) = J_G(P) \times J_B(P) = (LP - P) \times (MP - PC \times RR) = (LP - P) \times (P - PC - PC \times RR) \quad (2)$$

where J_G —the state's partial criterion characterizing the remoteness of the energy production cost from the limit value; and J_B —partial criterion of the power business, characterizing the excess of marginal profit of the required profitability level from the sale of energy products.

The above expression does not include the cost of energy product transmission. Taking into account the fact that transmission of energy products is a strictly regulated type of activity in the energy sector that reflects the social responsibility of the state for the cost of this predominantly natural monopoly service, only a part of transmission costs expressed as the prescribe rate value is accounted for the consumer. The other part is compensated from the regional budget, which is often drawn up mostly due to tax revenues from industrial power enterprises. Thus, a partial criterion of the state should include a component that takes into account the amount of tax deductions from added cost for energy products, and a partial criterion for the power business should include the tariff for its transmission (see Equation (3)):

$$J_{ES}(P) = J_G(P) \times J_B(P) = (LP - P + D \times (P - PC - T)) \times (P - T - PC \times (1 + RR)) \quad (3)$$

where D —tax burden rate for industrial power enterprises, and T —transmission rate for energy product.

An economically justified level of energy security would be determined by the energy product costs at which, taking into account the constraints, the generalized criterion will have its maximum value (see Equations (4) and (5)):

$$J_{ES}^0(P^0) = \max_P \{J_{ES}^0(P)\} \quad (4)$$

$$\begin{cases} P \leq LP \\ P \geq PC(1 + RR) + T \\ TC \leq T + D(P - PC - T) \\ PC > 0, 0 < T \leq TC, 0 < RR < 1, 0 < D < 1 \end{cases} \quad (5)$$

where TC is actual transmission costs.

In the sections that follow, we would compute the model using the actual data from an interesting case study of the Russia's Far Eastern region. This choice is due to the large variety of energy systems of the Far Eastern region of Russia, which are both open and geographically isolated entities, which allows us to more widely consider the issue of the effectiveness of the proposed evaluation model. Furthermore, a significant argument in favor of the choice of the Far Eastern region is that the development of its economy is a national priority of Russia, for the implementation of which a separate federal executive body was formed—the Ministry for the Development of the Russian Far East. Since the stable development of the economy is impossible without constantly developing energy, the issue of improving the quality of managing the development of the region's energy systems to ensure energy security in the medium- and long-term is paramount, which currently requires its solution. Already, the energy management system of the Far East is faced with the problem of ensuring reliable energy supply to consumers, which is confirmed by the large-scale violations in the unified energy system of the East in 2017, which resulted in consumers without electricity from the Amur Region, the Trans-Baikal, Primorsky and Khabarovsk Territories (more than 1.5 million people).

4. Determining the Energy Security Level

In order to analyze the impact of the territorial energy systems integration on the energy security level, we consider the correlation between parameters of the proposed model for determining an

economically justified level of energy security and their impact on the cost of energy production for the consumer (Figure 2):

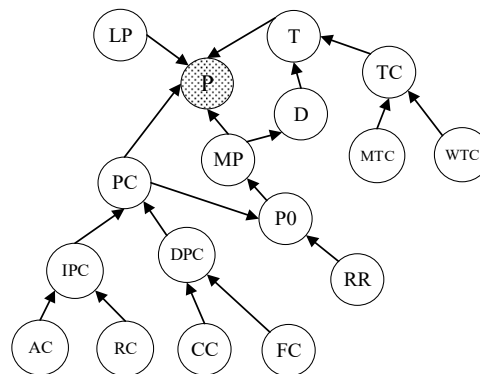


Figure 2. Parameters of the model for assessment of an economically justified level of energy security.

The cost of energy products for the consumer P in the market conditions is determined by the marginal profit MP and the production costs PC of a generating enterprise, the transmission rate T , and the established limit price level LP applicable within the territorial administrative entity. Therefore, the marginal profit MP at market pricing depends on the established equilibrium market price P_0 , which is determined by the production costs PC and their profit rates under prevailing demand conditions. Production costs are divided into direct production costs DPC (determined by the fuel cost FC and the cost of its transformation into energy products CC) and general-purpose costs IPC (including depreciation AC and maintenance costs RC). The transmission rate T largely depends on the actual transmission costs TC (determined by the material costs MTC and the cost of losses WTC) and tax deductions D from the profits of generating enterprises that compensate for part of these costs.

The association diagram presented in Figure 3 that follows made it possible to develop an algorithm for analyzing the energy security level of territorial-and-administrative entities, presented in the Figure 3.

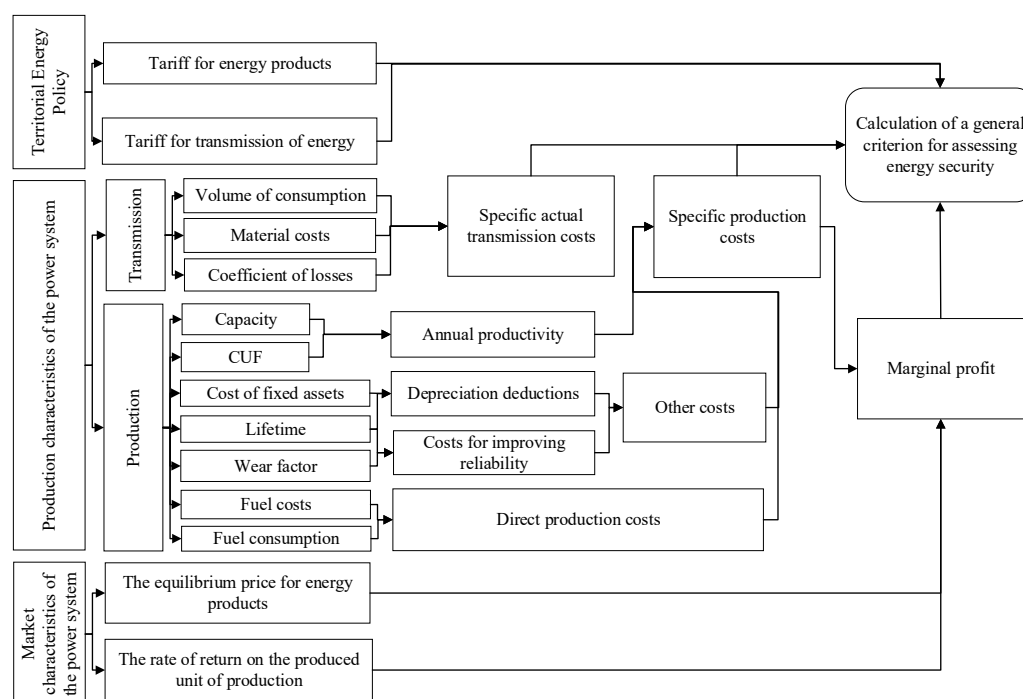


Figure 3. An algorithm for analyzing the energy security level of the territorial-and-administrative entities.

5. Empirical Model: A Case Study of Far Eastern Region

Here, it seems appropriate to focus on the case study that would include an example of the remote region or territory. In order to implement our empirical model that enables the assessment of the energy security level, we have selected an example of the Russia's Far Eastern region.

Our selection of this territorial entity is not random. The region has been long in focus on the Russian national as well as on the international arena due to its geopolitical significance, its remoteness from the main power centers, as well as due to its richness in natural resources [76,77].

Far Eastern region of Russia (Federal Far Eastern region) was established as a territorial entity in 2000. It is a vast piece of land with a territory amounting at 6169 thousand square kilometers (36% of Russian territory). In the same time, the region is one of the scarcest populated regions on the planet—there are only 6.1 million people residing on its territory. The region is divided into nine districts (Amur region, Jewish Autonomous region, Kamchatka krai, Magadan region, Primorsky krai, Saha Republic, Sakhalin oblast, Khabarovsk region, and Chukotsky Autonomous District), as well as a Far Eastern special economic region [78]. Most of its districts represent untouched and pristine places boasting by breathtaking natural beauty and wonders.

Far Eastern regions borders on China and North Korea as well as has a long sea border with Japan and United States. It is extremely rich in natural resources, about 25% of the regional economy is devoted on the extraction of fossil fuels, ores, metals, and gems. Figure 4 below presents an overview of the economic activity by sectors, as well the location of special economic zones and the territories of advanced development (denoted as “TAD”).

However, what makes it particularly interesting is a Russian government initiative launched by the Federal Law issued on the 1 June 2016 and aimed at attracting people and resources to the resettlement to the region with a purpose of its development and cultivation. The law and the initiative envisaged to issue 1 hectare (10,000 m²) of land at the Far Eastern district to any Russian citizen free of charge under the conditions that the new owner would be using it for building a residential dwelling, farming, or entrepreneurial activities [79]. In addition, advantageous mortgages were promised in order to help to build infrastructure at the newly acquired lands. The initiative met with moderate interest among Russian population, although many individuals decided to give it a try. It has been reported that a Hollywood martial arts film star and American actor and producer Steven Seagal (who received a Russian citizenship in November 2016) also decided to take part in the initiative receiving his own hectare at the Far Eastern region [80].

Resettlement of the Far Eastern region and its industrialization require the development of well-functioning energy systems that are non-existent in its most parts. The issues with energy pose many security issues that need to be tackled at all levels. The issue of electric energy and its prices is of special importance, since it states the main sources of energy in the region needed both by residential dwellings and the entrepreneurial subjects [81]. The possible solution might be the usage of renewables energy sources (RES) which requires substantial investments and support. In general, RES lack wide acclaim in Russian and are often perceived as the costly alternative to cheap oil and gas [82–84]. Therefore, it appears important to be able to assess the energy security level with a help of the empirical model such as we have just constructed and presented in the previous section.

Hereinafter, we will present the main results and outcomes from our model defined in Equations (1)–(5). Table 2 that follows presents an assessment of the energy security level for the territorial entities of the Far Eastern economic region according to the proposed algorithm that emerges from our empirical model.

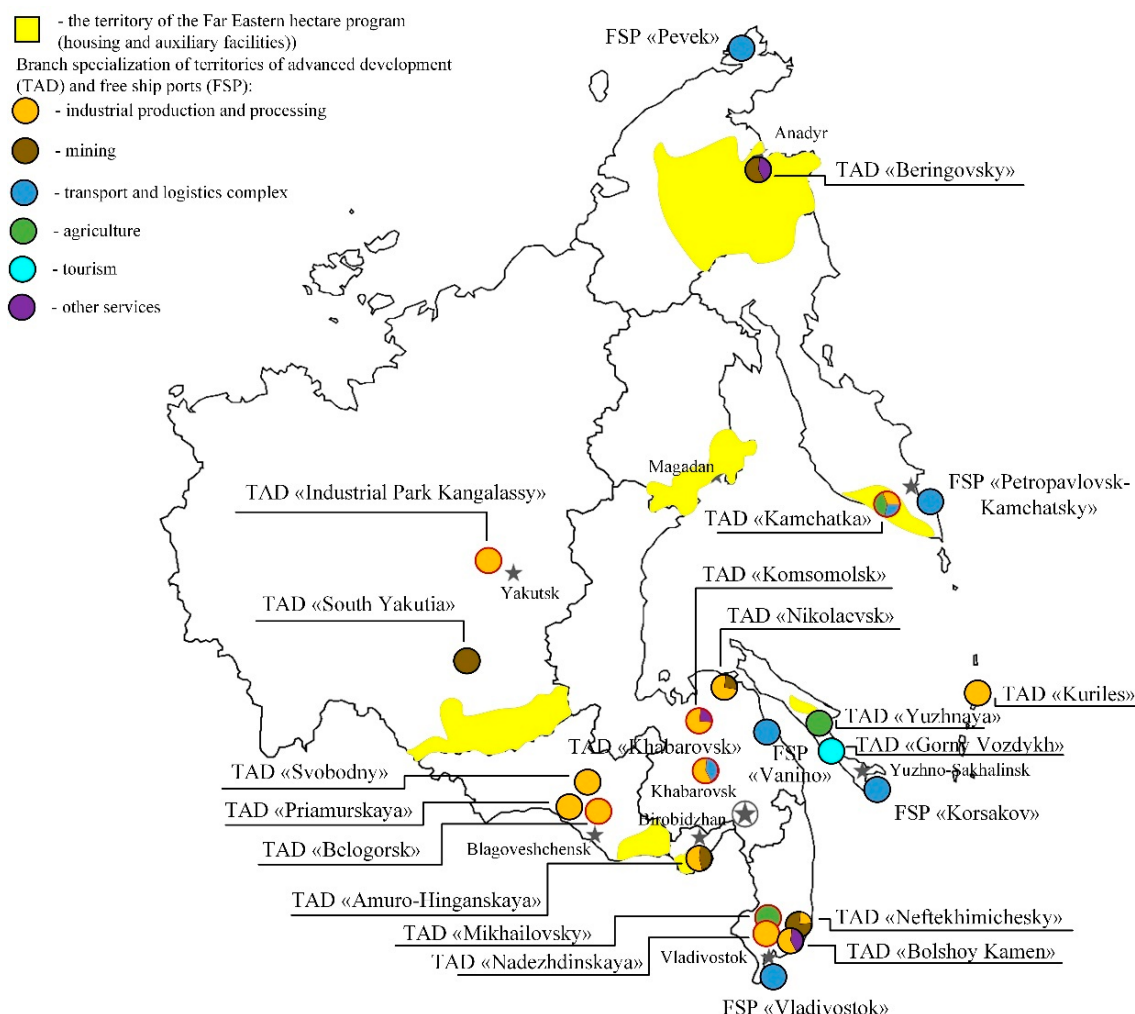


Figure 4. Economic activity and territories of advanced development TAD) in the Federal Far Eastern region.

Table 2. Results of the analysis of the energy security level for the territorial entities of the Far Eastern economic region.

Territorial Formation (region)	The Lower Limit of Electricity Prices, Rubles/kWh	The Upper Limit of Electricity Prices, Rubles/kWh	Electricity Price/Energy Security Level	Electricity Price/The Justified Level of Energy Security
Amur region	3.0	3.4	2.2/–	3.2/1.13
Jewish Autonomous region	3.2	3.6	2.1/–	3.5/1.05
Kamchatka krai	5.7	6.2	4.9/–	5.8/1.14
Magadan region	6.0	6.5	4.0/–	6.5/1.00
Primorsky krai	2.9	3.2	2.7/–	2.9/1.15
Saha Republic	4.4	5.1	6.2/–	5.1/0.67
Sakhalin oblast	3.0	3.3	4.2/–	3.3/0.62
Khabarovsk region	3.6	3.9	2.9/–	3.6/1.17
Chukotsky Autonomous District	7.2	7.8	10.8/–	7.8/0.52
Far Eastern economic region	4.3	4.8	4.5/0.87	4.8/0.96

The lower limit of the electricity prices is determined by the production costs of generating companies. They are quite high in these territorial entities due to high fuel prices associated with climatic conditions, insufficient development of local deposits and the pricing model applied. Furthermore, significant production costs are attributed to the high level of depreciation of generating equipment increasing the percentage of fuel costs in the production cost structure.

Consequently, the upper limit of the electricity prices is determined by the level of social and economic development of the territorial entity that reflects the economic affordability of energy products for the consumers. Currently, the significant economic potential of the Far Eastern region has been poorly executed and implemented. This fact determines the need for the substantial control over the prices of electricity in order to ensure their affordability for the end consumers.

High values of the lower limits for electricity prices at low upper limits lead to rather narrow price corridors that provide energy security of territorial entities without government subsidies for power enterprises and consumers.

Therefore, the prevailing electricity prices for the ultimate consumers of territorial entities go beyond the corridor limits creating a threat to energy security. They are artificially underestimated for most territorial entities of the economic region due to political considerations and the necessity of ensuring conditions for the advance development of industrial zones that leads to unprofitable power generation. In this case, it is necessary to decrease the lower limit value. It would be achieved by optimizing the production structure of power generation and the rules of its operation under market conditions that allow reducing fuel costs, as well as intensifying the development and diversification of local fuel sources that contribute to lower fuel prices. Moreover, electricity prices at several territorial entities of the economic region go beyond the upper limit due to the level of social-and-economic development. This situation is caused by the power generation in the structure of the gross regional product and its essential influence on the formation of the territorial entity budget. In a case such as this one, it is necessary to perform a policy aimed at diversifying the regional production and intensifying its social-and-economic development.

It is evident that in the territorial entities of the Russia's Far Eastern region the existing policy of price equalization to the national average (4 rubles/kWh) (without taking into account conditions and performance of the energy systems of territorial entities, as well as their level of social and economic development), cannot purposefully contribute to increasing the energy security level. Moreover, in some cases it would have a potential for aggravating the existing threats and leading to the potential geopolitical conflicts.

6. Conclusions

Overall, one can conclude that in order to be viable and sustainable, energy security and energy efficiency should be based on solid economic reasoning. Far-going plans of revitalization and development of remote regions should take into account the costs of deployment of the new energy systems, or the reconstruction of the old ones. In addition, the rise of renewables that might seem to be a solution to the above issues, also bears certain threats and is often economically burdensome. We demonstrated these outcomes using the example of energy security issues of Russia's Far Eastern region that represents an important bargaining chip in Russia's relations with its immediate neighbors and in the same time world's leading economies represented by China and Japan.

Furthermore, we developed and tested a method for economic assessment of the energy security level of territorial entities with the integration of energy systems based on the case study of conditions for consumer affordability of energy products and economic profitability of their production. The results of the model demonstrate that implementation of these conditions is associated with efforts to overcome a contradiction in efficiency development criteria for territorial power systems on the part of the state and energy enterprises in the market economy conditions. If the consumer affordability of energy products is the partial criterion for the state, then it is the economic profitability of production for energy enterprises.

In order to harmonize the partial criteria of the state and business, a generalized criterion for the efficiency of the energy system functioning was developed based on relative compensation. The energy production cost for the end user, at which the maximum of a generalized criterion is achieved indicating an economically justified level of energy security, is the subject of this study.

Comparing our results with the similar studies that were mostly mentioned and analyzed in Section 2, one can conclude that energy security is a complex issue that is based on several cornerstones, such as social actors, economic and political concerns as well as effective energy system management (including the crisis management). The creation, integration and managing of energy systems should be made economically stable but also balanced in order to ensure the social justice, effective governance and economic feasibility.

Our research enables us to consider the social-and-economic aspects of ensuring energy security, as well as quantify and justify the necessary level of energy security of territorial entities that provides reliable and efficient operation of the territorial power facilities in the context of ongoing processes of the energy system integration and promulgation of unified regulation rules.

Overall, it becomes obvious that our empirical model for assessing the economically justified level of energy security at the territorial level can also be applied not only for Russia but for the regions and countries around the world with energy systems represented by independent generating companies and the state electric grid complex. This type of energy systems is typical for the countries with liberalized energy markets which is a significant fact that expands the usefulness and the application of the model beyond the scope of just one country.

Our results can be used by the policy-makers and stakeholders seeking ways for enhancing and improving energy security as well as the ameliorating the economic conditions for the energy consumers at various territorial levels.

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. Bassi, A.M. Evaluating the use of an integrated approach to support energy and climate policy formulation and evaluation. *Energies* **2010**, *3*, 1604–1621. [[CrossRef](#)]
2. Cherp, A. Defining energy security takes more than asking around. *Energy Policy* **2012**, *48*, 841–842. [[CrossRef](#)]
3. Cherp, A.; Jewell, J. The concept of energy security: Beyond the four As. *Energy Policy* **2014**, *75*, 415–421. [[CrossRef](#)]
4. Chester, L. Conceptualising energy security and making explicit its polysemic nature. *Energy Policy* **2010**, *38*, 887–895. [[CrossRef](#)]
5. Goldthau, A.; Sovacool, B.K. The uniqueness of the energy security, justice, and governance problem. *Energy Policy* **2012**, *41*, 232–240. [[CrossRef](#)]
6. Kruyt, B.; van Vuuren, D.P.; de Vries, H.J.; Groenenberg, H. Indicators for energy security. *Energy Policy* **2009**, *37*, 2166–2181. [[CrossRef](#)]
7. Sander, M. Conceptual proposals for measuring the impact of international regimes on energy security. *Energy Policy* **2013**, *63*, 449–457. [[CrossRef](#)]
8. Winzer, C. Conceptualizing energy security. *Energy Policy* **2012**, *46*, 36–48. [[CrossRef](#)]
9. Shezan, S.A.; Julai, S.; Kibria, M.A.; Ullah, K.R.; Saidur, R.; Chong, W.T.; Akikur, R.K. Performance analysis of an off-grid wind-PV (photovoltaic)-diesel-battery hybrid energy system feasible for remote areas. *J. Clean. Prod.* **2016**, *125*, 121–132. [[CrossRef](#)]
10. Moghadam, S.T.; Delmastro, C.; Corgnati, S.P.; Lombardi, P. Urban energy planning procedure for sustainable development in the built environment: A review of available spatial approaches. *J. Clean. Prod.* **2017**, *165*, 811–827. [[CrossRef](#)]

11. Chernenko, N. Market power issues in the reformed Russian electricity supply industry. *Energy Econ.* **2015**, *50*, 315–323. [\[CrossRef\]](#)
12. Lisin, E.; Kindra, V.; Horvathova, Z. Sustainable development of regional heat supply systems in the context of the Eurasian economic union energy markets association. *J. Secur. Sustain. Issues* **2017**, *6*, 215–245. [\[CrossRef\]](#)
13. Lisin, E.; Rogalev, A.; Strielkowski, W.; Komarov, I. Sustainable modernization of the Russian power utilities industry. *Sustainability* **2015**, *7*, 11378–11400. [\[CrossRef\]](#)
14. Lisin, E.; Shuvalova, D.; Volkova, I.; Strielkowski, W. Sustainable Development of Regional Power Systems and the Consumption of Electric Energy. *Sustainability* **2018**, *10*, 1111. [\[CrossRef\]](#)
15. Lisin, E.; Sobolev, A.; Strielkowski, W.; Garanin, I. Thermal efficiency of cogeneration units with multi-stage reheating for Russian municipal heating systems. *Energies* **2016**, *9*, 269. [\[CrossRef\]](#)
16. Lisin, E.; Strielkowski, W. Modelling new economic approaches for the wholesale energy markets in Russia and the EU. *Transform. Bus. Econ.* **2014**, *13*, 566–580.
17. Melas, V.; Lisin, E.; Tvaronavičienė, M.; Peresadko, G.; Radwański, R. Energy security and economic development: Renewables and the integration of energy systems. *J. Secur. Sustain. Issues* **2017**, *7*, 133–139. [\[CrossRef\]](#)
18. Mishenin, Y.; Koblianska, I.; Medvid, V.; Maistrenko, Y. Sustainable regional development policy formation: role of industrial ecology and logistics. *Entrepren. Sustain. Issues* **2018**, *6*, 329–341. [\[CrossRef\]](#)
19. Augutis, J.; Martišauskas, L.; Krikštolaitis, R.; Augutienė, E. Impact of the Renewable Energy Sources on the Energy Security. *Energy Procedia* **2014**, *61*, 945–948. [\[CrossRef\]](#)
20. Augutis, J.; Krikštolaitis, R.; Martišauskas, L.; Peciulyte, S. Energy security level assessment technology. *Appl. Energy* **2012**, *97*, 143–149. [\[CrossRef\]](#)
21. Augutis, J.; Krikštolaitis, R.; Martišauskas, L.; Peciulyte, S.; Zutautaitė, I. Integrated energy security assessment. *Energy* **2017**, *138*, 890–901. [\[CrossRef\]](#)
22. Augutis, J.; Krikštolaitis, R.; Peciulyte, S.; Zutautaitė, I. Dynamic model based on Bayesian method for energy security assessment. *Energy Convers. Manag.* **2015**, *101*, 66–72. [\[CrossRef\]](#)
23. Augutis, J.; Martišauskas, L.; Krikštolaitis, R. Energy mix optimization from an energy security perspective. *Energy Convers. Manag.* **2015**, *90*, 300–314. [\[CrossRef\]](#)
24. Ang, B.W.; Choong, W.L.; Ng, T.S. Energy security: Definitions, dimensions and indexes. *Renew. Sustain. Energy Rev.* **2015**, *42*, 1077–1093. [\[CrossRef\]](#)
25. Blum, H.; Legey, F.L. The challenging economics of energy security: Ensuring energy benefits in support to sustainable development. *Energy Econ.* **2012**, *34*, 1982–1989. [\[CrossRef\]](#)
26. Bompard, E.; Carpignano, A.; Erriquez, M.; Grosso, D.; Pession, M.; Profumo, F. National energy security assessment in a geopolitical perspective. *Energy* **2017**, *130*, 144–154. [\[CrossRef\]](#)
27. Borelli, D.; Devia, F.; Lo Cascio, E.; Schenone, C.; Spoladore, A. Combined production and conversion of energy in an urban integrated system. *Energies* **2016**, *9*, 817. [\[CrossRef\]](#)
28. Cherp, A.; Jewell, J.; Vinichenko, V.; Bauer, N.; De Cian, E. Global energy security under different climate policies, GDP growth rates and fossil resource availabilities. *Clim. Chang.* **2016**, *136*, 83–94. [\[CrossRef\]](#)
29. Demski, C.; Poortinga, W.; Pidgeon, N. Exploring public perceptions of energy security risks in the UK. *Energy Policy* **2014**, *66*, 369–378. [\[CrossRef\]](#)
30. Cox, E. Opening the black box of energy security: A study of conceptions of electricity security in the United Kingdom. *Energy Res. Soc. Sci.* **2016**, *21*, 1–11. [\[CrossRef\]](#)
31. Jonsson, D.; Johansson, B.; Månsson, A.; Nilsson, L.; Nilsson, M.; Sonnsjö, H. Energy security matters in the EU Energy Roadmap. *Energy Strateg. Rev.* **2015**, *6*, 48–56. [\[CrossRef\]](#)
32. Martišauskas, L.; Augutis, J.; Krikštolaitis, R. Methodology for energy security assessment considering energy system resilience to disruptions. *Energy Strateg. Rev.* **2018**, *22*, 106–118. [\[CrossRef\]](#)
33. Kalashnikov, V.; Gulidov, R.; Ognev, A. Energy sector of the Russian Far East: Current status and scenarios for the future. *Energy Policy* **2011**, *39*, 6760–6780. [\[CrossRef\]](#)
34. Filipović, S.; Radovanović, M.; Golušin, V. Macroeconomic and political aspects of energy security—Exploratory data analysis. *Renew. Sustain. Energy Rev.* **2018**, *97*, 428–435. [\[CrossRef\]](#)
35. Hughes, L.; Ranjan, A. Event-related stresses in energy systems and their effects on energy security. *Energy* **2013**, *59*, 413–421. [\[CrossRef\]](#)
36. Johansson, B. A broadened typology on energy and security. *Energy* **2013**, *53*, 199–205. [\[CrossRef\]](#)

37. Wang, X.; Nathwani, J.; Wu, C. Visualization of international energy policy research. *Energies* **2016**, *9*, 72. [[CrossRef](#)]
38. Wang, Q.; Zhou, K. A framework for evaluating global national energy security. *Appl. Energy* **2017**, *188*, 19–31. [[CrossRef](#)]
39. Zhang, L.; Yang, Z.; Liang, J.; Cai, Y. Spatial variation and distribution of urban energy consumptions from cities in China. *Energies* **2010**, *4*, 26–38. [[CrossRef](#)]
40. Sovacool, B.K. An international assessment of energy security performance. *Ecol. Econ.* **2013**, *88*, 148–158. [[CrossRef](#)]
41. Sovacool, B.K. Differing cultures of energy security: An international comparison of public perceptions. *Renew. Sustain. Energy Rev.* **2016**, *55*, 811–822. [[CrossRef](#)]
42. Sovacool, B.K. The methodological challenges of creating a comprehensive energy security index. *Energy Policy* **2012**, *48*, 835–840. [[CrossRef](#)]
43. Sovacool, B.K.; Mukherjee, I. Conceptualizing and measuring energy security: A synthesized approach. *Energy* **2011**, *36*, 5343–5355. [[CrossRef](#)]
44. Sovacool, B.K.; Mukherjee, I.; Drupady, I.M.; D’Agostino, A.L. Evaluating energy security performance from 1990 to 2010 for eighteen countries. *Energy* **2011**, *36*, 5846–5853. [[CrossRef](#)]
45. Strielkowski, W.; Lisin, E.; Tvaronavičienė, M. Towards energy security: Sustainable development of electrical energy storage. *J. Secur. Sustain. Issues* **2016**, *6*, 235–244. [[CrossRef](#)]
46. Kiriya, E.; Kajikawa, Y. A multilayered analysis of energy security research and the energy supply process. *Appl. Energy* **2014**, *123*, 415–423. [[CrossRef](#)]
47. Umbach, F. Global energy security and the implications for the EU. *Energy Policy* **2010**, *38*, 1229–1240. [[CrossRef](#)]
48. Månsson, A.; Johansson, B.; Nilsson, L.J. Assessing energy security: An overview of commonly used methodologies. *Energy* **2014**, *73*, 1–14. [[CrossRef](#)]
49. Ren, J.; Sovacool, B.K. Quantifying, measuring, and strategizing energy security: Determining the most meaningful dimensions and metrics. *Energy* **2014**, *76*, 838–849. [[CrossRef](#)]
50. Kisel, E.; Hamburg, A.; Härm, M.; Leppiman, A.; Ots, M. Concept for Energy Security Matrix. *Energy Policy* **2016**, *95*, 1–9. [[CrossRef](#)]
51. Li, Y.; Shi, X.; Yao, L. Evaluating energy security of resource-poor economies: A modified principle component analysis approach. *Energy Econ.* **2016**, *58*, 211–221. [[CrossRef](#)]
52. Löschel, A.; Moslener, U.; Rübhelke, D.T. Indicators of energy security in industrialised countries. *Energy Policy* **2010**, *38*, 1665–1671. [[CrossRef](#)]
53. Marthamadol, J.; Kumar, S. The Aggregated Energy Security Performance Indicator (AESPI) at national and provincial level. *Appl. Energy* **2014**, *127*, 219–238. [[CrossRef](#)]
54. Narula, K.; Reddy, B.S. A SES (sustainable energy security) index for developing countries. *Energy* **2016**, *94*, 326–343. [[CrossRef](#)]
55. Prambudia, Y.; Nakano, M. Integrated simulation model for energy security evaluation. *Energies* **2012**, *5*, 5086–5110. [[CrossRef](#)]
56. Radovanović, M.; Filipović, S.; Pavlović, D. Energy security measurement—A sustainable approach. *Renew. Sustain. Energy Rev.* **2017**, *68*, 1020–1032. [[CrossRef](#)]
57. Proskuryakova, L. Energy technology foresight in emerging economies. *Technol. Forecast. Soc. Chang.* **2017**, *119*, 205–210. [[CrossRef](#)]
58. Jokar, P.; Arianpoo, N.; Leung, V.C. A survey on security issues in smart grids. *Secur. Commun. Netw.* **2016**, *9*, 262–273. [[CrossRef](#)]
59. Kessides, I.N.; Kuznetsov, V. Small modular reactors for enhancing energy security in developing countries. *Sustainability* **2012**, *4*, 1806–1832. [[CrossRef](#)]
60. Shin, J.; Shin, W.; Lee, C. An energy security management model using quality function deployment and system dynamics. *Energy Policy* **2013**, *54*, 72–86. [[CrossRef](#)]
61. Salas-Fumás, V.; Rosell-Martínez, J.; Delgado-Gómez, M. Capacity, investment and market power in the economic value of energy firms. *Energy Econ.* **2016**, *53*, 28–39. [[CrossRef](#)]
62. Ranjan, A.; Hughes, L. Energy security and the diversity of energy flows in an energy system. *Energy* **2014**, *73*, 137–144. [[CrossRef](#)]

63. Strielkowski, W.; Štreimikienė, D.; Bilan, Y. Network charging and residential tariffs: A case of household photovoltaics in the United Kingdom. *Renew. Sustain. Energy Rev.* **2017**, *77*, 461–473. [CrossRef]
64. Rhodes, A.; Skea, J.; Hannon, M. The global surge in energy innovation. *Energies* **2004**, *7*, 5601–5623. [CrossRef]
65. Kyriakopoulos, G.; Arabatzis, G. Electrical energy storage systems in electricity generation: Energy policies, innovative technologies, and regulatory regimes. *Renew. Sustain. Energy Rev.* **2016**, *56*, 1044–1067. [CrossRef]
66. Arabatzis, G.; Kyriakopoulos, G.; Tsialis, P. Typology of regional units based on RES plants: The case of Greece. *Renew. Sustain. Energy Rev.* **2017**, *78*, 1424–1434. [CrossRef]
67. Kyriakopoulos, G.; Arabatzis, G.; Tsialis, P.; Ioannou, K. Electricity consumption and RES plants in Greece: Typologies of regional units. *Renew. Energy* **2018**, *127*, 134–144. [CrossRef]
68. Osorio, S.; van Ackere, A.; Larsen, E.R. Interdependencies in security of electricity supply. *Energy* **2017**, *135*, 598–609. [CrossRef]
69. Piètre-Cambacédès, L.; Bouissou, M. Cross-fertilization between safety and security engineering. *Reliab. Eng. Syst. Saf.* **2013**, *110*, 110–126. [CrossRef]
70. Dincer, I.; Acar, C. Smart energy systems for a sustainable future. *Appl. Energy* **2017**, *194*, 225–235. [CrossRef]
71. Hoffmann, C. Beyond the resource curse and pipeline conspiracies: Energy as a social relation in the middle east. *Energy Res. Soc. Sci.* **2018**, *41*, 39–47. [CrossRef]
72. McPherson, M.; Tahseen, S. Deploying storage assets to facilitate variable renewable energy integration: The impacts of grid flexibility, renewable penetration, and market structure. *Energy* **2018**, *145*, 856–870. [CrossRef]
73. Biresselioglu, M.E.; Yildirim, C.; Demir, M.H.; Tokcaer, S. Establishing an energy security framework for a fast-growing economy: Industry perspectives from Turkey. *Energy Res. Soc. Sci.* **2017**, *27*, 151–162. [CrossRef]
74. Ntanos, S.; Skordoulis, M.; Kyriakopoulos, G.; Arabatzis, G.; Chalikias, M.; Galatsidas, S.; Batzios, A.; Katsarou, A. Renewable energy and economic growth: Evidence from European countries. *Sustainability* **2018**, *10*, 2626. [CrossRef]
75. Boute, A. Off-grid renewable energy in remote Arctic areas: An analysis of the Russian Far East. *Renew. Sustain. Energy Rev.* **2016**, *59*, 1029–1037. [CrossRef]
76. Kuksina, L. Variations of Water Runoff and Suspended Sediment Yield in the Kamchatsky Krai, Russia. *Water* **2018**, *10*, 1451. [CrossRef]
77. Titova, N.Y.; Pervuhin, M.A.; Baturin, G.G. Identification of Regional Clusters in the Russian Far East. *Eur. Res. Stud.* **2017**, *20*, 339–359.
78. Federal State Statistics Service. 2018. Main Statistics. Available online: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics (accessed on 20 September 2018).
79. Ministry for the Development of the Far East. 2016. Far Eastern hectare. Available online: <https://eng.minv.r.ru/activity/razvitie-msp-i-konkurentsii/dalnevostochnyy-gektar> (accessed on 28 September 2018).
80. Reuters. 2016. Russia's Putin Grants Russian Citizenship to U.S. Actor Seagal. Available online: <https://www.reuters.com/article/us-russia-putin-seagull-idUSKBN12Y0W1> (accessed on 21 September 2018).
81. Simshauser, P. Distribution network prices and solar PV: Resolving rate instability and wealth transfers through demand tariffs. *Energy Econ.* **2016**, *54*, 108–122. [CrossRef]
82. Smeets, N. Similar goals, divergent motives. The enabling and constraining factors of Russia's capacity-based renewable energy support scheme. *Energy Policy* **2017**, *101*, 138–149. [CrossRef]
83. Kozlova, M.; Collan, M. Modeling the effects of the new Russian capacity mechanism on renewable energy investments. *Energy Policy* **2016**, *95*, 350–360. [CrossRef]
84. Vasileva, E.; Viljainen, S.; Sulamaa, P.; Kuleshov, D. RES support in Russia: Impact on capacity and electricity market prices. *Renew. Energy* **2015**, *76*, 82–90. [CrossRef]

