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PROSPECTS OF DECENTRALIZED DIRECT CURRENT POWER SUPPLY SYSTEMS WITH DISTRIBUTED SOLAR GENERATION

Mirabbos Khidirov
Karshi State Technical University, Senior Lecturer

Abstract. This study investigates the prospects of decentralized direct current (DC) power supply systems integrating distributed solar generation for autonomous and remote consumers. The research aims to improve power quality, enhance energy security, reduce greenhouse gas emissions, and decrease electricity generation costs through the adoption of DC distribution architectures. Mathematical modeling and simulation were performed using MATLAB/Simulink to analyze the operation of photovoltaic-diesel hybrid power systems under varying load and solar irradiation conditions. A simulation model was developed to determine the optimal technical and economic parameters of the system. The results demonstrate that decentralized DC power supply systems can reduce energy conversion losses, improve the utilization of renewable energy resources, and increase the reliability of autonomous power supply. The proposed approach contributes to the development of sustainable and environmentally friendly energy systems for distributed generation applications.

Keywords: decentralized DC power systems, distributed solar generation, photovoltaic-diesel systems, renewable energy, microgrids, energy efficiency.

Аннотация. В данной работе рассматриваются перспективы децентрализованных систем электроснабжения постоянного тока с интеграцией распределённой солнечной генерации для автономных и удалённых потребителей. Цель исследования заключается в повышении качества электрической энергии, укреплении энергетической безопасности, снижении выбросов парниковых газов и уменьшении стоимости производства электроэнергии за счёт применения систем распределения постоянного тока. Для анализа режимов работы гибридных фотоэлектрическо-дизельных энергосистем использованы методы математического моделирования и компьютерной симуляции в среде MATLAB/Simulink. Разработана имитационная модель, позволяющая определять оптимальные технические и экономические параметры системы при изменяющихся нагрузках и уровнях солнечной радиации. Результаты исследования показывают, что децентрализованные системы электроснабжения постоянного тока способствуют снижению потерь энергии, повышению эффективности использования возобновляемых источников энергии и надёжности автономного электроснабжения.

ISSN 3030-3907

Ключевые слова: децентрализованные системы постоянного тока, распределённая солнечная генерация, фотоэлектрическо-дизельные системы, возобновляемая энергетика, микросети, энергоэффективность.

Annotatsiya. Mazkur maqolada avtonom va uzoq hududlardagi iste'molchilar uchun taqsimlangan quyosh generatsiyasiga ega markazlashmagan o'zgarmas tok elektr ta'minoti tizimlarining istiqbollari o'rganilgan. Tadqiqotning maqsadi o'zgarmas tok taqsimlash tizimlarini qo'llash orqali elektr energiyasi sifatini yaxshilash, energetik xavfsizlikni oshirish, issiqxona gazlari chiqindilarini kamaytirish hamda elektr energiyasi ishlab chiqarish xarajatlarini pasaytirishdan iborat. Fotoelektrik-dizel gibrid energiya tizimlarining ishlash rejimlarini tahlil qilish uchun MATLAB/Simulink muhitida matematik modellashtirish va kompyuter simulyatsiyasi usullaridan foydalanildi. O'zgaruvchan yuklama va quyosh nurlanishi sharoitlarida tizimning optimal texnik-iqtisodiy parametrlarini aniqlash imkonini beruvchi model ishlab chiqildi. Tadqiqot natijalari markazlashmagan o'zgarmas tok elektr ta'minoti tizimlari energiya yo'qotishlarini kamaytirishi, qayta tiklanuvchi energiya manbalaridan foydalanish samaradorligini oshirishi hamda avtonom energiya ta'minoti ishonchliligini yaxshilashini ko'rsatdi.

Kalit so'zlar: markazlashmagan o'zgarmas tok tizimlari, taqsimlangan quyosh generatsiyasi, fotoelektrik-dizel tizimlari, qayta tiklanuvchi energiya manbalari, mikrogridlar, energiya samaradorligi.

INTRODUCTION.

Remote and sparsely populated regions of Russia continue to experience energy instability due to the slow expansion of the power system caused by low economic activity in these areas. Such small energy hubs, formed by rural settlements, have highly complex logistics for the transportation of hydrocarbon fuels. These regions primarily include Siberia, the Far East, and the Far North of the Russian Federation. A distinctive feature of these regions is the low population density across vast territories with limited industrial development.

Due to remoteness, low and uneven population distribution, combined with low household energy consumption (installed capacity ranging from tens to hundreds of kilowatts depending on the number of residents), electricity supply for such settlements is possible only through isolated systems with autonomous energy sources, usually diesel generators requiring expensive diesel fuel reserves. On the other hand, modern microgeneration systems with intelligent control architecture are capable of providing reliable electricity supply to decentralized consumers while reducing both direct and indirect fuel dependence, including fuel transportation, processing, delivery, and storage [1].

Microgeneration systems, under the growing attractiveness of integrating renewable energy sources (RES), have become a justified alternative for the

ISSN 3030-3907

development of decentralized power systems. This allows households, municipalities, and energy stakeholders to make modest initial investments in their energy systems and later modify them according to changing economic conditions and electricity demand. The authors note that such microgrids within Russia's decentralized infrastructure are mainly used for supplying electricity to agricultural, mining, and raw-material enterprises, including reindeer herding, fur farming, livestock breeding, fishing, agriculture, logging, woodworking, ore and precious metal mining, and others.

Electricity supply for such consumers based on renewable energy sources has already been implemented in the Russian Federation, as confirmed by recent studies [2–4]. The construction and commissioning of photovoltaic power plants (PVPPs) and wind power plants (WPPs) are no longer considered unusual. The authors prepared a table summarizing the installed capacities of the Unified Energy System of the Russian Federation (UES of Russia) [5].

Table 1.

Installed capacity structure of the United Energy System of Russia Installed Capacity and Share in UES (2015–2018)

№	2015 Capacity (MW)	2015 Share (%)	2016 Capacity (MW)	2016 Share (%)	2017 Capacity (MW)	2017 Share (%)	2018 Capacity (MW)	2018 Share (%)
1	160,233	68.1	160,242	67.8	162,779	67.9	164,586	67.7
2	47,855	20.3	48,085	20.3	48,449	20.2	48,506	19.9
3	27,146	11.5	27,929	11.8	27,914	11.6	29,132	12.0
4	60.2	0.03	75.2	0.03	534.2	0.22	834.2	0.4
5	10.9	0.01	10.9	0.01	134.4	0.06	183.9	0.08

As shown in Table 1, where 1 represents thermal power plants (TPPs) based on coal, natural gas, fuel oil, etc., 2 – hydropower plants (HPPs), 3 – nuclear power plants (NPPs), and 4 and 5 – photovoltaic (PV) and wind power plants (WPP), the share of renewable energy sources in the Unified Energy System (UES) of the Russian Federation remains relatively small, although their growth dynamics are clearly increasing.

The development of renewable energy generation should primarily be justified by socio-economic indicators in sparsely populated regions, including energy security, environmental decarbonization, power quality, reliability of electricity supply, and quality of life. These indicators should be supported not only by legal frameworks but also by improving the architecture of autonomous power supply systems (APSS).

ISSN 3030-3907

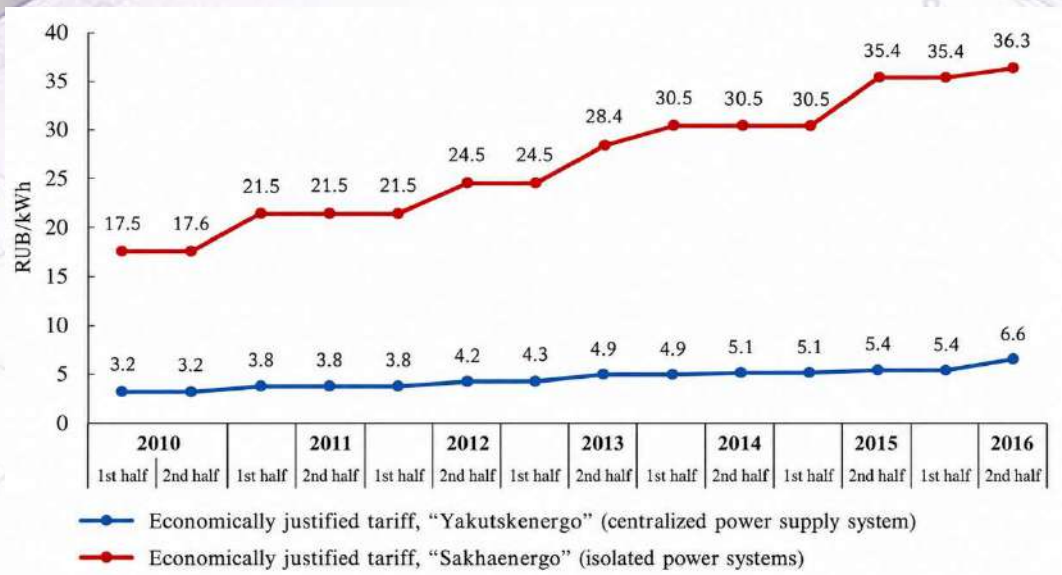


Fig. 1. Economically sound tariff in centralized and decentralized systems as exemplified by the Republic of Sakha (Yakutia) [10]

This study presents research results on photo-diesel autonomous power supply systems operating in AC and DC configurations. It focuses on a comparative analysis of decentralized photo-diesel power plants (PDPPs) based on AC and DC systems, considering energy security, capacity utilization factor, power quality, environmental impact, and economic efficiency.

Recent studies [6–8] identify three main approaches to electrifying decentralized consumers: expansion of centralized grids (over 2.7 million km in Russia), development of microgrids, and construction or improvement of autonomous power systems.

Decentralized electrification problems are not unique to Russia. According to the International Energy Agency (IEA), out of 588 million people living in Sub-Saharan Africa, only 30% can be economically efficiently electrified through centralized grid expansion. The remaining 70% are more effectively served by microgrids (52.5%) and autonomous power supply systems (17.5%) [9].

Comparing global experience with Russia, only 14% of the population lives in 67% of the country's decentralized territory. This makes centralized electrification economically inefficient due to high transmission losses and mismatch between grid voltage levels and power demand caused by long distances and low load density [11].

Diesel power plants (DPPs) are the most common solution for micro-systems in remote areas. Their modular structure allows phased implementation and flexible adaptation to demand. However, electricity from DPPs remains very expensive due to fuel transportation costs. As shown in Fig. 1, in Yakutia prices range from 17.6 to 36.3 RUB/kWh, compared to 3.2 to 6.6 RUB/kWh in centralized systems.

ISSN 3030-3907

To reduce fuel dependency, hybrid renewable systems such as solar-diesel plants are being developed. In addition, diesel fuel prices continue to rise in Russia due to both market factors and pricing policies of major oil companies such as Rosneft, Lukoil, and Gazprom Neft, which also contribute to regional price disparities [12, 13].

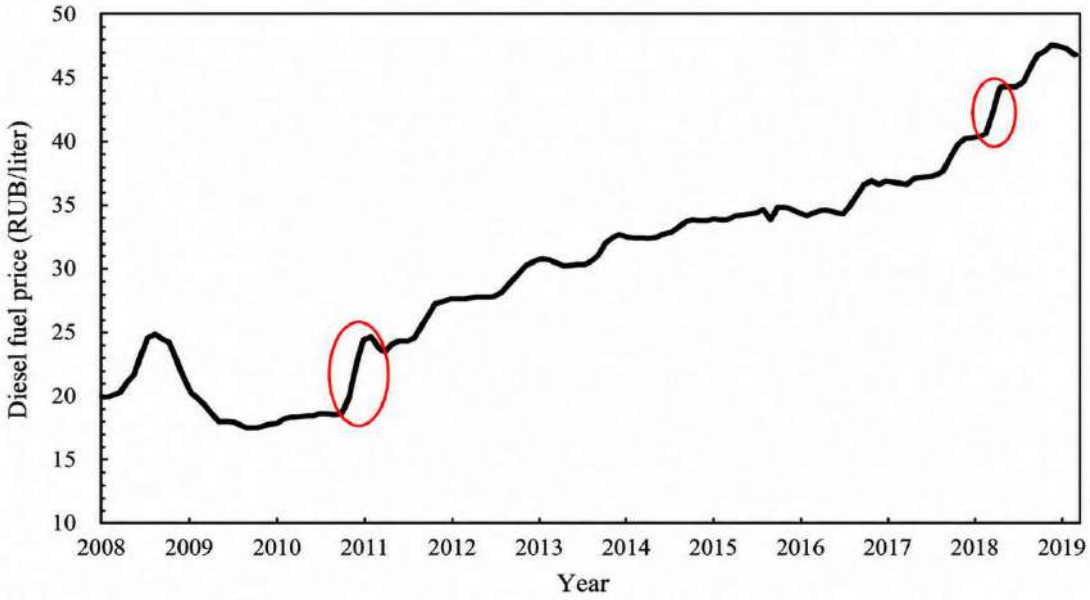


Fig. 2. Dynamics of diesel fuel prices in Russia from 2008 to 2019 [12, 13]

The recent increase in diesel fuel prices, which began in 2018, was caused by changes in the value-added tax (VAT), ranging from 0.6% to 1.7% depending on the fuel supplier. The composition and nature of local energy resources, the aggregate power demand, the configuration of the energy system, the cost of energy equipment, and the flexibility of microgeneration systems can provide viable solutions for the electrification of decentralized regions.

In particular, the declining costs of solar panels and other renewable energy technologies, which are comparable to the rate of increase in diesel fuel prices, create an important challenge in comparing alternative power supply options based on generating sources of different physical nature. According to estimates presented in [9], by 2030, approximately 400 TW of installed microgeneration capacity (including electric vehicles) will be deployed, accounting for about 40% of new energy sources required to achieve universal electrification.

Analysis of DC Microgrids.

The residential and community sector requires electricity primarily to power small household appliances such as lighting devices, smartphone chargers, small television sets, stereo systems, personal computers, and other similar equipment. As shown in Fig. 3, most general-purpose household appliances utilize electricity in either direct current (DC), alternating current (AC), or a combination of both forms. According to [14], up to 76% of the energy demands of the residential sector

ISSN 3030-3907

can be supplied through DC networks, where the majority of electricity consumption is associated with lighting systems and devices operating at nominal voltages of 12 V and 24 V, which are particularly attractive from an electrical safety perspective.

Therefore, it is reasonable to anticipate the development of decentralized DC microgrids based on local renewable energy sources, particularly photovoltaic power plants, which generate and store electrical energy in the form of direct current.

Microgrids are locally confined and independently controlled electrical networks in which a distributed architecture enables the supply of uneven electrical loads from distributed energy resources [15]. Compared with other electrification options, microgrids offer numerous advantages that make them attractive to investors. Unlike centralized power systems, they require lower installation costs, have shorter deployment periods (even under pessimistic scenarios, the installation of photovoltaic systems typically does not exceed one year), and can be designed to match local energy requirements. Furthermore, their capacity can be expanded in response to increasing demand or technological advancements.

In addition to supplying electricity to households and small businesses, microgrids have many other potential applications, as summarized in Table 2.

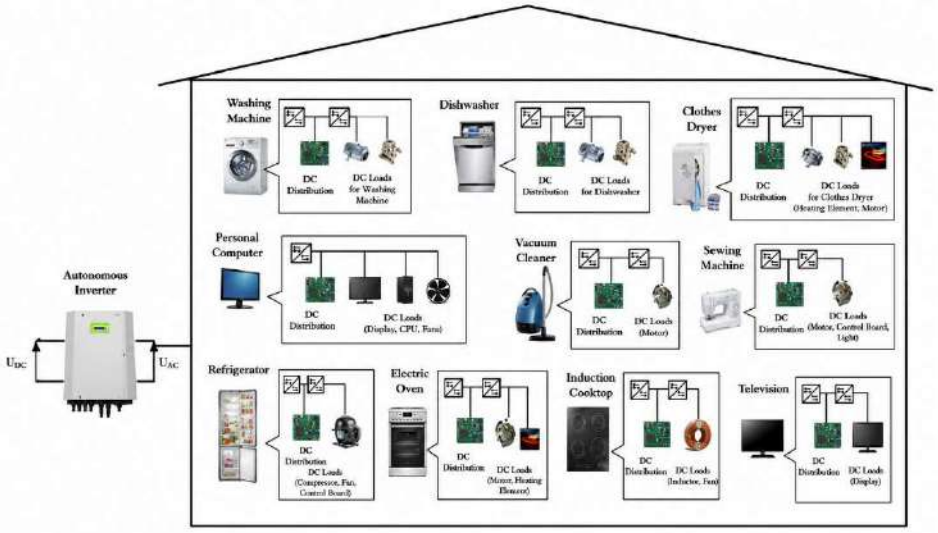


Fig. 3. Composition of the electrical loads in a residential house [7]

According to the data presented in [9, 15] and the information summarized in Table 2, microgrids can be classified into two main categories: microgrids with capacities below 10 kW and those ranging from 10 kW to 10 MW. Regardless of their installed capacity, every microgrid consists of an electricity generation system and a power distribution system.

The electricity generation system, in turn, comprises generation and energy storage subsystems. Power distribution systems with capacities up to 100 kW

ISSN 3030-3907

generally include distribution and consumption subsystems. The generation subsystem incorporates energy generators, voltage stabilization and conversion equipment, and power management technologies. Distribution subsystems consist of networks that deliver electricity to end users through cable lines (CLs) or overhead transmission lines (OHLs). Consumption subsystems include all equipment located on the consumer side of the point of common coupling, such as metering devices, electrical wiring, grounding systems, and electrical loads.

Microgrids can be implemented using direct current (DC), alternating current (AC), or hybrid AC/DC architectures. Importantly, DC networks eliminate many of the energy conversion stages required in AC systems, thereby improving overall techno-economic efficiency. Traditionally, AC systems have provided efficient voltage transformation and high-voltage power transmission over long distances. However, recent technological advances have led to the development of highly efficient AC/DC and DC/AC power converters, enabling efficient power transmission not only through AC systems but also through DC networks [15, 16].

Therefore, according to the authors, DC power distribution networks offer several significant advantages:

• Higher energy efficiency due to reduced conversion losses. According to [16], nearly 30% of AC power is processed through power electronic converters (inverters), with energy losses ranging from 10% to 25%.

• DC systems are inherently modular and scalable compared to AC systems. This characteristic results from the simpler control of DC converters, providing greater flexibility in system design and expansion and enabling more efficient investment management.

• DC systems offer higher transmission capacity than conventional AC systems, primarily because reactive power is absent in DC networks. Furthermore, DC system components are generally more compact than their AC counterparts due to the absence of frequency-dependent constraints.

• Easier integration of intermittent energy resources without the need for mutual synchronization. This feature enhances system resilience and operational reliability under both internal and external disturbances.

• Most distributed renewable energy sources and electrical energy storage devices inherently generate or store electricity in DC form, making DC-based architectures a natural and efficient solution that minimizes additional conversion stages.

• The majority of modern electrical loads require DC power supplies, further supporting the adoption of DC microgrids.

• Growing interest from the energy market in DC microgrids. DC microgrids integrated with distributed photovoltaic power plants can provide substantial

ISSN 3030-3907

economic benefits, including reduced investment and operating costs, lower power losses, improved power quality, fuel savings, decreased greenhouse gas emissions, and a reduction in the levelized cost of electricity (LCOE).

RESEARCH RESULTS.

In this section, the authors compare the identified DC and AC microgrid configurations through simulation modeling. The developed simulation model enables the analysis of operating modes of autonomous AC and DC power supply systems within a predefined time scale, where one day of real operation corresponds to 10 seconds of simulation time.

The economic feasibility assessment of the project is based on the maximum service life of the power generation equipment, particularly photovoltaic (PV) modules, which is assumed to be 20 years. The service life of the diesel power plant (DPP) is determined by the total operating hours of the diesel generators. Considering the availability of reserve generators within the DPP, actual operating conditions, optimal loading levels, scheduled maintenance, and repair activities, the operational lifetime of the diesel power plant is assumed to be comparable to that of the photovoltaic system.

Based on these assumptions and the data presented in Table 3, the main techno-economic parameters of the power supply systems were calculated using the MS Excel software package. The obtained results are summarized in Table 4.

Table 4.

Simulation results of the technical and economic indicators of the options of the photo-diesel plant configuration

Number	Investments, ths. rub.	Mitigation of atmospheric pollutants, t/year	Decreasing of tariff, %	NPV, ths. rub.	ICUF, %
1	12 000	1,1	9,3	8 000	17,7
2	21 000	5,5	17	10 200	22

CONCLUSION.

This study compares photovoltaic–diesel power supply systems based on direct current (DC) and alternating current (AC) architectures for the electrification of remote rural areas in terms of cost, efficiency, and energy security.

The results demonstrate that power losses in distribution networks and energy conversion losses constitute a significant share of the operational costs of microgrid systems. By transitioning from an AC-based network to a DC-based

ISSN 3030-3907

network, power losses in the distribution system of the investigated case were reduced by 6.8%, while voltage drop was decreased by 3%.

Due to the reduction in the number of energy conversion stages and the absence of reactive power in DC networks, photovoltaic–diesel systems based on DC architecture represent an economically promising solution for the electrification of remote regions. The economic performance of the diesel power plant is enhanced through optimal loading achieved by intelligent control of generation units and battery energy storage systems (BESS). This control strategy reduced the cost of electricity generation from 40.7 RUB/kWh in the AC configuration to 37.3 RUB/kWh in the DC configuration, resulting in an efficiency improvement of 8.4%.

Optimization of the diesel power plant operating mode also contributed to a reduction in harmful atmospheric emissions, including carbon dioxide (CO_2), nitrogen dioxide (NO_2), and hydrocarbon compounds. The higher level of energy security offered by DC systems, together with their architectural flexibility and improved techno-economic performance, makes them an attractive option for owners of diesel power plants in municipalities and for other potential investors.

The findings further highlight the fundamental differences in maintaining the stability of electricity supply in AC and DC systems. The AC network configuration is directly dependent on the operational status of a reference power source through a grid-connected inverter. Consequently, this dependency represents a significant vulnerability of AC systems employing grid-tied inverters. Considering the conclusions presented in [29], concerns regarding energy security may shift consumer preferences toward DC-based systems, particularly among users seeking greater reliability and security of electricity supply.

Finally, the authors identify potential directions for the further development and improvement of DC power systems, including the application of inverter-based diesel power plants with variable rotational speed and the integration of hybrid energy storage systems for peak power compensation.

REFERENCES

1. Лукутин Б.В. Интеллектуальные системы электроснабжения с ветровыми и солнечными электростанциями. – Томск: Изд-во Томского политехнического университета, 2019. – 115 с.
2. Драчѐв В. Три солнечные электростанции общей мощностью 45 МВт запустили в Бурятии // ТАСС. 2019. URL: https://tass.ru/ekonomika/7056227 (дата обращения 14.12.2019).
3. Шамуков Р. Две солнечные электростанции запустили в Чите // ТАСС. 2019. URL: https://tass.ru/ekonomika/7065192 (дата обращения 14.12.2019).

ISSN 3030-3907

4. Интернет-портал общества ТЭК. В арктическом поселке Тикси смонтировали первую ветроустановку // EnergyLand.info. 2018. URL: http://energyland.info/news-showtek-alternate-175862 (дата обращения 14.12.2019).
5. Марцинкевич Б. Развитие ВИЭ энергетики в России // Геоэнергетика.ru. 2019. URL: http://geoenergetics.ru/2019/09/27/ razvitie-vie-energetiki-v-rossii/ (дата обращения 14.12.2019).
6. Opiyo N.N. A comparison of DC- versus AC-based minigrids for cost-effective electrification of rural developing communities // Energy Reports Journal. – 2019. – V. 5. – P. 398–408. DOI: https://doi.org/10.1016/j.egyr.2019.04.001.
7. AC and DC technology in microgrids: a review / E. Planas, J. Andreu, J.I. Gárate, I.M. Alegría, E. Ibarra // Renewable and Sustainable Energy Reviews Journal. – 2015. – V. 43. – P. 726–449. DOI: https://doi.org/10.1016/j.rser.2014.11.067.
8. Суржикова О.А. Проблемы и основные направления развития электроснабжения удаленных и малонаселенных потребителей России // Вестник науки Сибири. – 2012. – № 3 (4). – С. 103–108. URL: http://earchive.tpu.ru/handle/11683/16065 (дата обращения 14.12.2019).
9. World Energy Outlook // IEA. 2018. URL: https://www.iea.org/ reports/world-energy-outlook-2018 (дата обращения 14.12.2019).
10. Энергоснабжение изолированных территорий в России и мире / В. Гимади, А. Курдин, Д. Нестер, А. Амирагян, О. Колобов, С. Пих, И. Поминова, А. Мартынюк, А. Кутузова // Аналитический центр при Правительстве Российской Федерации. Энергетический бюллетень. – 2017. – № 51. – С. 14–18.
11. Пятков П.Ю. Потери мощности и электроэнергии в электрических сетях. – Екатеринбург: Изд-во: УрГУПС, 2009. – 36 с.
12. Цены на солярку: полный абсурд и наглость // Авто Mail.ru. 2011. URL: https://auto.mail.ru/article/34055-ceny_na_solyarku_ polnyi_absurd_i_naglost/ (дата обращения 14.12.2019).
13. Мордюшенко О. Дизель разогревает цены // Газета КОММЕРСАНТЪ. 2017. URL: https://www.kommersant.ru/doc/3408522 (дата обращения 14.12.2019).
14. Fairley P. DC versus AC: the second war of currents has already begun [in my view] // IEEE Power and Energy Magazine. – 2012. – V. 10 (6). – P. 102–104.
15. Opiyo N.N. Droop control methods for PV-based minigrids with different line resistances and impedances // Sustainable Energy Grids Netw. – 2018. – V. 9 (6). – P. 101–112.

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