AUTONOMOUS HYBRID POWER PLANTS BASED ON RENEWABLE ENERGY AND TRADITIONAL SOURCES OF ELECTRICITY

YENİLENEBİLİR ENERJİ VE GELENEKSEL ELEKTRİK KAYNAKLARINA DAYALI OTONOM HİBRİT ENERJİ SANTRALLERİ

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Abstract
The purpose of this study is to consider a passive balancing system for battery storage. In the future, it is necessary to study a new method of searching for methods that will increase their reliability, reduce repair costs, maintain their operational condition and increase their service life, as well as to find suitable methods for harmony, stabilizing the supplied electric energy, which is the main criterion. For this purpose, various theoretical methods of scientific research (analysis, concretization, comparison, generalization) were applied. In order to improve the performance of batteries using the considered method, the passive balancing system, the main issues were considered in this article. The example of a typical structural diagram of a hybrid power plant of the Autonomous Republic presented here is to obtain efficient solutions and battery longevity by increasing the efficiency of pre-project work on the development of a highly efficient design and scheme. The quasi-opposition method seeks to find a harmonic balance for hybrid power plants based on renewable and traditional energy sources. Their design and operational features will allow stabilizing the load frequency. Students studying renewable energy in higher education institutions, as well as their teachers, to familiarize themselves with the problems posed to consumers during the transition between energy sources. Energy-related people play a major role in finding hybrid plants and their solutions.
Keywords: Power plant, renewable resources, batteries, charging frequency, balancing system.

Öz
Bu çalışmanın amacı, batarya depolaması için pasif bir dengeleme sisteminin ele alınmasıdır. Gelecekte, bataryaların güvenilirliğini artıracak, onarım maliyetlerini azaltacak, işletim durumlarını koruyacak ve hizmet ömürlerini uzatacak yöntemlerin araştırılması ile birlikte, sağlanan elektrik enerjisinin dengelenmesi ve uyumunun sağlanması gibi temel kriterlere uygun yöntemlerin bulunması gerekmektedir. Bu amaçla, çeşitli teorik bilimsel araştırma yöntemleri (analiz, somutlaştırma, karşılaştırma, genelleme) kullanılmıştır. Bu makalede, incelenen yöntem olan pasif dengeleme sistemini kullanarak batarya performansını artırmaya yönelik temel konular ele alınmıştır. Burada sunulan Özerk Cumhuriyet'e ait tipik bir hibrit enerji santralinin yapısal şeması örneği, yüksek verimli bir tasarım ve şema geliştirilmesine yönelik ön proje çalışmalarının etkinliğini artırarak verimli çözümler elde etmeyi ve batarya ömrünü uzatmayı amaçlamaktadır. Yarı-zıtlık yöntemi, yenilenebilir ve geleneksel enerji kaynaklarına dayalı hibrit enerji santralleri için uyumlu bir denge bulmayı hedeflemektedir. Bu santrallerin tasarım ve işletim özellikleri, yük frekansının dengelenmesini mümkün kılacaktır. Yenilenebilir enerji üzerine yükseköğretim kurumlarında eğitim alan öğrenciler ve öğretmenleri, enerji kaynakları arasındaki geçiş sürecinde tüketicilerin karşılaştığı sorunlarla tanışmalıdır. Enerjiyle ilgili kişiler, hibrit santrallerin ve bu santrallere yönelik çözümlerin bulunmasında önemli bir rol oynamaktadır.
Anahtar Kelimeler: Elektrik santrali, yenilenebilir kaynaklar, bataryalar, şarj sıklığı, dengeleme sistemi.

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Introduction

Currently, combined (hybrid) power supply systems using renewable and traditional energy sources are widely used in the world. The article considers a typical structural diagram of a combined power supply system. The design and operational features of three types of structural and circuit solutions for combined power supply systems are disclosed, as well as their main advantages and disadvantages. The features of selecting and calculating the parameters of the main functional elements of the combined system are considered. The main characteristics of solar cells are disclosed and analytical expressions for calculating their main parameters are given (Chetoshnikova, 2010). The main characteristics of batteries and the features of calculating the capacity of batteries operating in autonomous systems are presented. The features of selecting voltage converters are disclosed, it is shown that in addition to the nominal input and output voltage, it is necessary to take into account their other characteristics that affect the operation of an autonomous power supply system. It is shown when it is advisable to use electromechanical generators to provide electricity to autonomous consumers. The types of structural solutions and features of selecting the main functional elements of combined power supply systems considered in the article will increase the efficiency of their design.

In the research work, neralization was used to analyze, evaluate, specify and process the geo-researched data. The combination of various theoretical and practical methods contributes to the qualitative study of the problems of autonomous hybrid power plants and suggests ways to solve them. The main aspects of the operation of autonomous hybrid power plants, as well as the potential of consumed electric energy, are involved and analyzed. The characteristics, differences, advantages and disadvantages of alternative stations of hybrid power plants on traditional and renewable energy sources, their interconnected stations were determined. In addition, the feasibility of autonomous hybrid power plants in the current situation in the world and their use in Azerbaijan were the main basis for the creation of the study. Potential resources in the field of alternative energy were obtained and analyzed (Jalilov, 2009; Germanovich & Turilin, 2014). Thus, the calculation and development of renewable energy were carried out. Abstract study of the geography, climate and policy of Azerbaijan, analysis of its geographical position, the study of hydropower, assessment of energy potential, solar energy and biomass energy, generalization and processing of information about them were considered.

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The study of autonomous hybrid power plants based on alternative energy sources was carried out. The installation of electric power supply in Azerbaijan, and in addition, the analysis and filtering of literature on various methods of alternative energy production were carried out. The problem of energy intensity loss, as well as the problem of frequent surges in chargers that reduce the life of batteries, was assessed and analyzed. Power plants based on alternative or renewable energy sources are the main difference between the stability of the supply of electric power to consumers and the stability of the supply of electric power. The passive balancing system was discussed. The proposed system is also built in conjunction with a power system with an increased number of batteries. In order to increase the efficiency of the quasi-opposition method to achieve harmony, a speed controller was built and evaluated to stabilize the frequency of the consumer when switching from alternative sources to an autonomous hybrid single diesel piston generator. Currently, a well-developed harmonic search is used in power plants used in power plants. For a simpler and more qualitative understanding of the data, the collected data was analyzed and systematized.

A systematic analysis of the methods used in the production of electricity using iterative energy resources was carried out. The resources were developed with the aim of identifying the best autonomous hybrid power plants for the analytical energy of renewable energy. The article examines the design features of autonomous hybrid power plants based on renewable and traditional sources of electricity and their operation in various operating modes, and a typical structural diagram of such a power plant is given. It is shown that the system's operation algorithm in the autumn-winter period should be adjusted based on monthly monitoring data, and when the batteries are more deeply discharged, the generator of the backup autonomous source can be turned on. It is known that the most expensive and at the same time the weakest link in solar photovoltaic plants are accumulator batteries. In addition, the more of them there are in the system, the more difficult it is to fulfill all the conditions for proper operation. It is proposed to extend the service life of batteries using a passive balancing system, which increases the reliability of their operation and reduces their cost (Udell, 1980). It is shown that a real opportunity to improve the technical and economic performance of autonomous hybrid power plants is to implement them on the basis of solar photovoltaic plants. The features of the construction and operation of hybrid power plants discussed in the article will increase the efficiency of pre-

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project work on the development of highly efficient structural and circuit solutions for plants.

In 2019, solar energy grew faster than wind energy. According to the results of last year, the total installed capacity of solar power plants exceeded 650 GW, leaving wind generation behind by 645 GW. According to Bloomberg NEF experts, the gap between solar and wind energy will increase. According to their forecasts, 130-170 GW of solar power capacity will be built annually, compared to 50-60 GW of wind generation. However, wind power is still the winner – it produces twice as much electricity due to a higher efficiency of installed capacity.

Experts also note that wind and solar power accounted for more than 60% of all generation capacity built in the world in 2019. It is noted that solar power is in 4th place in terms of installed capacity (650 GW), after coal (2100 GW), gas generation (1810 GW) and hydroelectric power plants (1160 GW). However, it may rise to first or second place by 2030. In 2019, photovoltaics provided almost 3% of the world's electricity, while 15 years ago it was less than one tenth of a percent. In total, at the end of 2019, the installed capacity of green energy (including hydropower) amounted to about 2.5 TW.

Conventional frequency converters cannot provide the desired performance due to uncertainties related to generation and load in an autonomous hybrid power plant (Jalilov, 2008). Optimization methods are used to effectively solve problems related to the operation and management of an autonomous hybrid power plant. Researchers are constantly working to improve existing optimization algorithms and at the same time, they are looking for new optimization algorithms to solve complex engineering constraints efficiently and quickly. Harmony search algorithm (HSA) is one of the latest additions in this field. HSA is a metaheuristic algorithm inspired by music, and its basic working principle is the ability of a musician to find the best harmony. Simply put, HSA allows for the most efficient field of decision vectors quickly, and thus has been adopted by researchers to solve many reference engineering/non-engineering problems. However, many empirical studies show that the basic HSA does not provide the best optimization results (Losyuk & Kuz'mich, 2005).

As a result, several new versions of HSA have been developed in recent years. Through an accelerated exploration of the possibilities of quasi-oppositional learning (QOBL), Tarke-shwar and Mukherjee (2015) proposed the quasi-oppositional harmony

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search algorithm (QOH-SA). QOBL and population initialization based on generation jumps have become additional options. Roughly speaking, QOHSA is a rapidly evolving QOBL concept incorporated into standard HSA, which makes it a special and potentially successful optimization algorithm. TLBOA is a newly developed, powerful nature-inspired, parameterless metaheuristic optimization algorithm that mathematically simulates the teaching-learning process. The process between teachers and students in the classroom. Teachers and students are the two important pillars of this algorithm. Teachers, as the embodiment of knowledge, inspire students to improve their overall performance (Shankar and Mukherjee 2016). However, it can be noted that the concept of work compared to QOHSA has a number of differences, but not disadvantages, which makes them ±equal in the field of work.

Discussion

According to researchers, the problem of environmental sustainability has become increasingly urgent in recent years, and energy systems using renewable energy sources are becoming increasingly popular among energy companies (Quasching, 2007). This is especially noticeable in rapidly developing countries, in Europe, America and Asia. However, the operation of such systems can be limited by the instability of renewable sources. One of the solutions to this problem is autonomous hybrid power plants based on renewable and traditional energy sources. Such plants can provide electricity to remote regions, islands or other areas where other energy systems are unavailable or economically inefficient (Shaimurunov et al. 2023). They can significantly reduce the cost of fuel transportation and reduce toxic emissions into the environment. When choosing a technology for the operation of autonomous hybrid power plants, solar and wind energy are taken into account. Because they have low operating costs and practically do not emit any toxic substances into the environment (Ismayil-Zada 2022; Chernets et al. 2008). In addition, traditional sources of electricity, such as gas or diesel fuel, can be used as a backup source of energy when renewable energy sources cannot provide sufficient energy. However, it should be noted that hybrid power plants are more difficult to operate and require professional knowledge and experience for maintenance and management. In addition, the construction cost of hybrid power plants can be higher than that of conventional power plants (Kaltschmitt & Hartmann, 2001).

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This article reviews autonomous hybrid power plants, their operation, battery problems, and load frequency stabilization. Compared with the studies of Sadykov et al. (2018), it was found that the battery problem is currently critical. There are ways to improve their operation and increase the life and capacity of batteries through a passive balance system; however, such a system is quite expensive, and its installation in existing hybrid power systems without public funds can be problematic and sometimes obsolete. This method of improving performance to some extent eliminates one of the advantages of autonomous hybrid power plants - their low cost. In the case of installing such a system in a new power plant, the batteries initially receive load stabilization and regulation of battery charging and discharging, which will help extend their service life from the moment of commissioning. However, when a passive balancing system is installed on batteries that have not been in operation for some time, their service life will be extended to a relatively short period, which still forces them to be replaced in the near future (Chernets, et al. 2008).

Solving the problem of installing a passive battery A balancing system in an already operational power system can replace some of the most "obsolete" batteries. Some batteries can be more damaged during use due to overcharging and overdischarging. It is recommended to replace the two batteries with the worst capacity out of the four batteries and then install a passive balancing system. Thus, the remaining pair of batteries will increase their service life by about one and a half times, and new energy storage devices will be immediately controlled by the system. However, thanks to the same system, the number of battery replacements due to wear is reduced, which completes another advantage of hybrid power plants. A real opportunity to improve the technical and economic performance of autonomous power plants is to use inexhaustible energy sources. In particular, solar energy, photovoltaic plants and autonomous hybrid power plants have been developed based on them.

Potential renewable sources are solar energy, wind energy, energy from small rivers and mountain streams, and biomass energy (Shevchenko, 2016). However, it currently does not even reach 1% in the country's energy balance. This is due to various reasons, primarily to weak incentives for clean energy by the government. Due to the favorable geographical location and favorable climatic conditions of Azerbaijan, the country's territory produces an average of 4.64 billion MW per year or 1 sq.m. and the average

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annual duration of sunlight reaches 2100 to 2900 hours, depending on the region. Experts say that solar energy has great potential for real use in the energy industry. The expediency of developing RES in Azerbaijan is due to the following reasons: increasing depletion of traditional fuel and energy resources, increasing electricity prices.

It follows that the issue of studying and systematizing the potential of renewable energy, improving equipment selection methods, and optimizing the autonomy of power plants based on renewable energy sources is currently relevant (Environmental Energy, 2011)

Today it is known that autonomous hybrid power plants based on various types of electrical energy sources give a significant economic effect. The best option for autonomous-mouse hybrid power plants is a system that includes several sources of electrical energy generation, two of which are alternative solar and wind power plants and one is a traditional gas piston or diesel electric generator. The block diagram of autonomous hybrid power plants is shown in Figure 1. The system works according to the following principle: all the electrical energy converted by solar panels is fed through the grid converter I1 to the power supply with a nominal voltage of 220 V. system. The main tasks of the hybrid converter I2 (which can direct energy flows in both directions) are to charge the batteries of a traditional generator and to create an electric city for the load converted from the batteries in case of voltage or shortage from alternative sources. . In situations where the energy received from solar and wind panels exceeds the energy spent on powering the loads, its excess goes to charge the batteries, and when the batteries are fully charged, they can power additional loads. Between the two daily power options available in the battery, a 50% discharge of the battery in cloudy and calm weather (actually three days with a deep discharge) and a daily discharge option, but 30%, something in between is usually chosen (discharging the battery more than 25% daily - unacceptable). The performance and service life of batteries depend not only on Figure 1.

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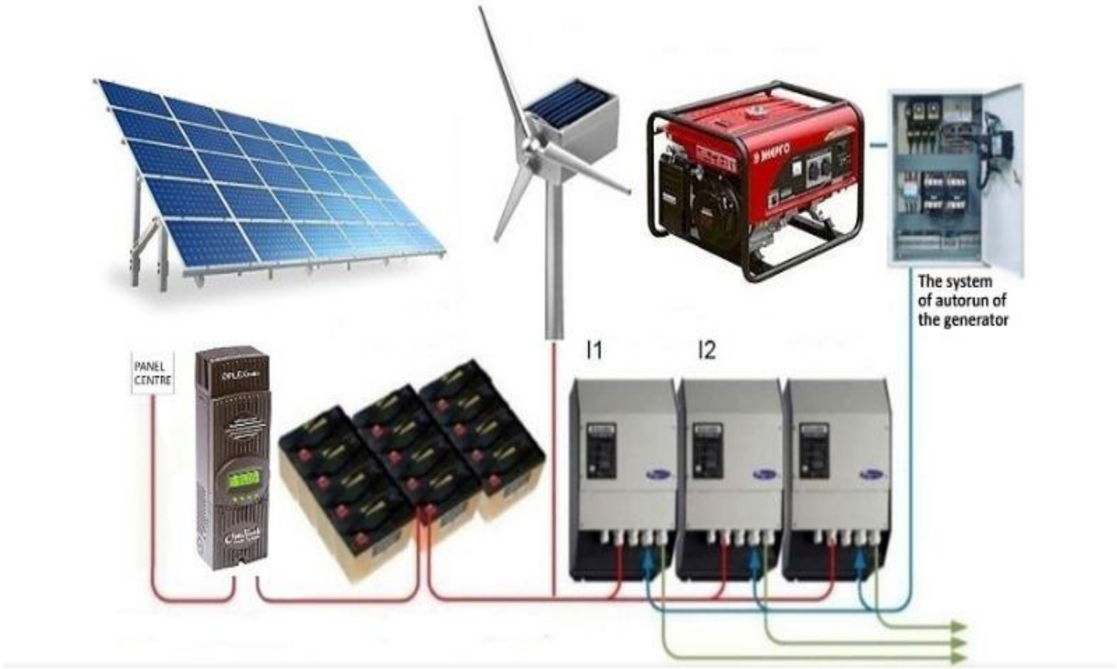

Figure 1. Typical block diagram of off-grid hybrid power plants

From the very beginning of charging the batteries, the voltage of the individual batteries in the system is constantly equalized. The system takes into account the voltage on each battery, calculates the average value, and includes an additional (ballast) load on high-voltage batteries. With its help, it is possible to significantly reduce the power released on the ballast load. Each module of the balancing system has its own number, which can be compared with the number of a specific battery (PBX, 2024). This allows for constant monitoring, which allows you to visually assess the condition and performance of each individual battery both during charging and during discharge. It is possible to turn off the load when the voltage of at least one battery drops below 10.5V (the lower limit of the operating voltage of a 12-volt lead battery). It is possible to maintain balance as a result of galvanic distribution on the control bus. several battery groups.The modular design principle allows you to add battery groups to an already working system, not from one manufacturer. The balancing system is selected depending on the battery capacity and charging current. If the power system has the possibility of forced charging for two to four hours (for example, from a solar battery or wind generator), it is likely that the balancing system will not have time to discharge excess voltage in certain batteries.

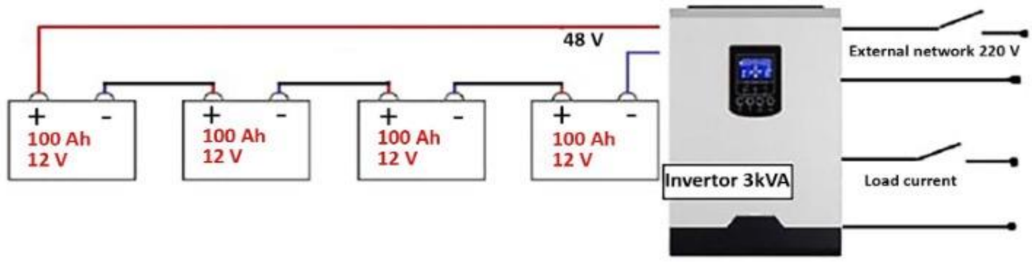

Figure 1.1 Balancing elements.

Balancing elements should have increased power compared to the standard charging mode. A separate feature of the passive balancing system is that it can be installed on batteries that have been operating for several years. The effect is due to the fact that it allows an unbalanced system (old batteries) to operate for a longer period of time before replacement. Modern energy systems are becoming more complex every year. Therefore, it is necessary to use intelligent optimization methods for the optimal use and management of energy systems. In recent years, researchers have begun to apply optimization methods to find Figure 1. 1. Battery system for an autonomous hybrid power plant with an increased number of energy storage devices, designed for 3 kWRys (UNFCCC, 1998).

Conclusion

This article examines hybrid power plants using the example of Azerbaijan, which does not have such a large territory and coastline bordering the ocean; however, Azerbaijan has great potential for renewable energy. This is especially due to its mountainous terrain, rivers, mountain streams, winds, and relatively stable year-round solar radiation distributed over the territory of the republic, which makes it an excellent place for alternative energy. Azerbaijan has great potential for off-grid hybrid power plants, solar and wind energy, as highlighted by Suyudukov and Sadykov (2020) in their work. In addition, taking into account the mountainous terrain of the country, its agricultural type, and the location of most farms and villages far from large settlements, it can be concluded that autonomous hybrid power plants are the best solution to solve the problem of energy supply. Remote regions are supplied with electricity. The development of hybrid power plants based on various energy sources will contribute to the relatively cheap and rapid development of Azerbaijan's infrastructure and economy.

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The quasi-opposition matching system based on the development of a frequency controller will increase the stability of a hybrid power system with several power sources. Alternative energy sources, a backup power source based on traditional sources (diesel or gas piston generator) and a multi-battery system (Havrysh et al. 2019). Currently, the issue of creating a load frequency stabilization system is increasingly being raised among people studying or working with hybrid power plants. In recent years, more and more systems have appeared, including a harmony search system. In the scientific work of Shankar and Mukherjee (2016), methods such as QOBL (quasi-oppositional learning method), HSA (metaheuristic algorithm for quickly finding the effective area of decision vectors), TLBOA (learning-based harmony search method), as well as QOHSA are studied. The method discussed in the present article based on the QOBL and HSA methods is studied (biz.nv.ua, 2024). These methods help stabilize the load frequency in a hybrid power system during the transition between alternative energy sources and the generator (when solar panels and wind turbines do not produce enough energy). In summary, it can be noted that autonomous hybrid power plants based on traditional and renewable energy sources are an excellent solution for providing electricity to remote regions of Azerbaijan, and its renewable energy potential makes it easy to implement this idea. However, autonomous hybrid power plants have critical problems such as batteries and their wear, as well as less critical, but still problematic, stabilization of the load frequency.

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