INCREASING THE EFFICIENCY OF A HYBRID SOLAR-WIND POWER PLANT

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Abstract

This paper describes the process of transformation of solar energy into electricity and all related processes. It was found that some part of the energy is not used when the battery is fully charged. The hypothesis was presented that if we do not stop operation of the plant after the full charge of batteries with excess natural energy and direct it to permanently included power consumers that are available at each average enterprise it is possible to significantly increase the efficiency of using natural energy in the solar power plant.

In view of the above, the aim of the research work is to develop and construct a load control relay to improve the efficiency of the use of mini-power plants of renewable energy. In order to achieve the goal of the research work the following tasks were set: to study the principles of operation of modern low-power units; to formulate the main changes in the algorithms of power plant operation control; to develop a structural scheme of power plant increased efficiency; to construct the device, to write a program for it.

Based on the data obtained and the prototype constructed, the results and given conclusions about the efficiency.

Keywords: hybrid solar-wind power plant, renewable energy, relay load control, solar power plant

Összefoglalás

Cikkünk a napenergia villamosenergiává történő átalakításával és az ehhez kapcsolódó folyamatokkal foglalkozik. Amennyiben az akkumulátor feltöltött állapotba kerül, a megújuló forrásból termelt energia további része már nem hasznosul. Hipotézisünk alapján, amennyiben a megújuló energiaforrásokhoz kapcsolt akkumulátorok feltöltődését követően be tudunk kapcsolni a rendszerbe olyan fogyasztót, ami képes felvenni az előállított villamosenergiát, a megújuló alapú termelés hatásfoka jelentősen javul.

A kutatás célja a fentiek alapján egy energiamenedzsment eszköz elméleti kifejlesztése, ami nem más, mint egy töltésvezérlő relé, ami beépítésével a megújuló alapú villamos energiatermelés kiserőművek esetén hatékonyabbá tehető. A szerzők először elemezték a modern magas teljesítményű napenergia alapú energiatermelő egységeket, majd ezek vezérlését, hogy a hatékonyságnöveléshez szükséges változtatásokat véghez tudják vinni. Ezt követte az energiamenedzsment berendezés struktúrájának, majd programozásának megváltoztatása.

Az eszköz prototípusa is megvalósult Kazahsztánban, ami lehetőséget biztosított a hatékonyságnövekedést bizonyító mérések elvégzésére.

Kulcsszavak: hibrid nap-szél erőmű, megújuló energia, töltésvezérlő relé, naperőmű

Introduction

Green energy is the energy that comes from renewable sources. Renewable energy resources are obtained from natural sources - wind, sunlight, tides, rain and geothermal energy. These sources are renewable because they are naturally replenished (Evseev 2012). To this trend, innovation (e.g. technology, product, process or service innovation) has also contributed a lot (Birkner et al, 2017). The global development of the renewable energy industry creates opportunities for the transformation of the national economy, the comprehensive production and market reforms, the production of marketable goods, job creation and job restructuring (Németh, et al, 2018).

In recent years, Kazakhstan has been actively developing "green" industrial energy - today about 50 solar, wind and mini-hydro power plants produce about 300 megawatts of electricity. In Pavlodar, hybrid solar wind power plants (SWPP) are also installed on the territory of Innovational Eurasian University and Pavlodar State university. Such a source of energy is safe for the environment and can provide large and medium scale electricity to the enterprise (Kashkarov, 2017).

Algorithms in SWPP and their problems

Algorithms of their operation management, which are currently used in the commercially available controllers of solar batteries and wind turbines of the SWPP, are mainly suitable for enterprises that are located in a remote place from the city, for example, in the steppe or desert - where there is no centralized power supply.

Such algorithms are not suitable for stations in settlements where there is an urban power grid and a great number of electric consumers to which energy can be directed. Most controllers only allow natural energy to be used until the battery is fully charged. But when the energy flow is too high (due to the optimal angle of sunlight or clear sky; strong wind) and the battery is charged to its limit, the station stops operating and the controller disconnects the solar battery current from the battery. Formally, this is logical - this way the battery will not recharge, the battery will not boil. But if we evaluate it from the point of view of common sense, it is absolutely illogical, because there is a paradox, when there is a lot of free energy, automatics turns off power generation (Yalanskiy, 2012)!

Main aim and objectives of the research

The novelty of the project is that the work is aimed at increasing the efficiency of the existing system by directing surplus energy to the needs of permanently included consumers of electric current, which are at any medium-sized enterprise.

The study will be useful, as it offers a way to improve the existing principles of SWPP operation to improve its energy efficiency.

The aim of the work is to increase the efficiency of the SWPP operation through a more complete use of natural renewable energy sources.

The objectives of the research include the following points:

- to study the operation of modern low-power installations;

- to formulate the main changes in the algorithms of power plant operation control,
- to develop a structural scheme of the power plant of increased efficiency;
- design the device, write a program for it;
- to simulate a hybrid power plant and demonstrate its operating principle (Krivchenko et al, 2010).

The hypothesis can be formulated as follows: If we will not stop operation of the plant after a full charge of batteries with excess natural energy, and direct it to permanently included power consumers, which are available at each average, and even more so at a large enterprise, it is possible to significantly increase the degree of use of natural energy and energy efficiency of the solar power plant.

A solar-wind power plant was chosen as the object of research**.**

Material and methods

The research methods are:

- Literature review on this topic. Analysis and synthesis of the information about the work processes of the SWPP.
- General monitoring of the operation of the combined heat and power plant on the basis of SWPP.
- Construct the device for loads control.

We offer to send this excess energy to the power supply of the permanently connected consumers with a large amount of electricity produced by a wind turbine and solar panels. This method is relevant for any medium sized companies, which, unlike urban apartments or motorhomes, always have such consumers, and there is always a need for energy.

Literature review of the problem with SWPP.

We can talk for a long time about the fact that we do not need electricity to illuminate the room during the day, heating the house and heating the water, because now all this is centralized. But thinking in this way and ignoring the gift of natural energy, we will constantly overpay for electricity to the grids.

Another reason why we built our load control relays was the impossibility of changing the factory settings of the inverter. When the battery discharged, the inverter automatically turns off the load, but if the battery is charged at least a little, the inverter turns the load back on. This principle is suitable for wheeled houses or steppe SWPPs, where the electrical loads can be switched on and off manually), but when using this inverter in enterprises with permanently switched on loads and at high currents consumed by them (e.g. 50-100 A on the battery side), there is a noticeable voltage drop at the internal resistance of the battery (Vinnikov et al. 2015).

As a result, the battery output voltage is lower than the shutdown threshold set in the inverter automation software. Naturally, it is switched off and the mentioned voltage drop becomes zero, and the battery voltage increases after the loads are switched off. The inverter automation, by measuring the battery voltage at this point, considers the battery to be already charged and turns on the loads. The inverter is switched on again, i.e. the power wrench, which switches on the load, is constantly shimmering. And, as a result, his failure. That is, the inverter does not work properly under our operating conditions.

Therefore, it is necessary to change the strategy of work. Naturally, the difference between switching on and off the payload voltage must be increased. Hysteresis (Greek for "lag") must be entered into the automatics. Therefore, in addition to the existing inverter automation system, it is necessary to introduce one of its own, since the manufacturer cannot foresee the magnitude of the voltage drop to be adjusted at the customer's premises. Ideally, the automation should respond to the battery charge level. It should measure the current, find the product of the current for the time being and get the value of the current AB charge. But the fact is that measuring current in hundreds of amperes requires the installation of several shunt or DC semiconductor sensors separately for solar panels and wind turbines. This requires a great deal of effort to install and install all this equipment (Chivenkov, 2013).

For this reason, it is possible to limit the installation of a controller that reacts to the AB (accumulator battery) voltage at first and to introduce an adjustable load hysteresis. For adjustment from deterioration of AB parameters at its ageing the load should be switched on at a voltage level of 90-95% of the maximum allowable. The switch-off threshold depends on the type of battery used (lead acid, lead gel, or lithium-iron-polymer). If we want to use the energy obtained as long as possible, it is worth choosing a lower voltage threshold corresponding to the minimum permissible voltage of the AB manufacturer. And if we want to prolong the life of AB and save its resource, then do not allow its discharge below 30-70%.

Constructing the load relay control device. The factory automation of the inverter is not enough to ensure the optimal functioning of the solar power plant, and you need to build your own load management controller. In this project we have implemented such a controller in a simplified form as a load control relay depending on the magnitude of the voltage (rather than the degree of charge) of AB.

Back to the first problem, when the power is high, the battery is charged and there's nowhere to go. Our solution is as follows: shortly before reaching the maximum charge of the AB, to direct this excess energy to the additional controller for the needs of the loads. Excess energy will need to be measured indirectly by the battery voltage, having previously removed the charge and discharge curves - namely, the dependence of the battery voltage on the accumulated (or remaining) charge in it. The more excess energy, the more loads can be switched on. Specifically, switch from city power to inverter power.

Choose of microcontrollers. In order to start manufacturing our automatic load control device, first it was necessary to choose the element base for it. If in the last century automatic machines were based not only on electric, but also on pneumatic and hydraulic principles, with the invention of microcontrollers for building automatic devices they were beyond competition.

To write the program code we used a high level programming environment - BASCOM AVR.

All modern MCs (microcontrollers) are capable of performing mathematical calculations and logical operations and input/output of information signals with low energy consumption and ergonomic use of memory (Gurevich, 2017).

After the analysis of possibilities of families MC for construction of our relay of management of loadings we have chosen microcontrollers of firm Atmel. In calculation speed, volume of program and operative memory, power consumption, quantity of ports of an input-output, and also presence of the built in ADC were accepted first of all.

AVR microcontrollers have a good resistance to the negative effects of electromagnetic waves causing interference, this controller is quite common among developers and radio amateurs, there is a lot of literature and discussion on the forums. Also an important factor in favor of its use was the presence of built-in ADC (Shahnovich, 2006).

Results and Discussion

Our research result is the developed load relay control (fig. 1):

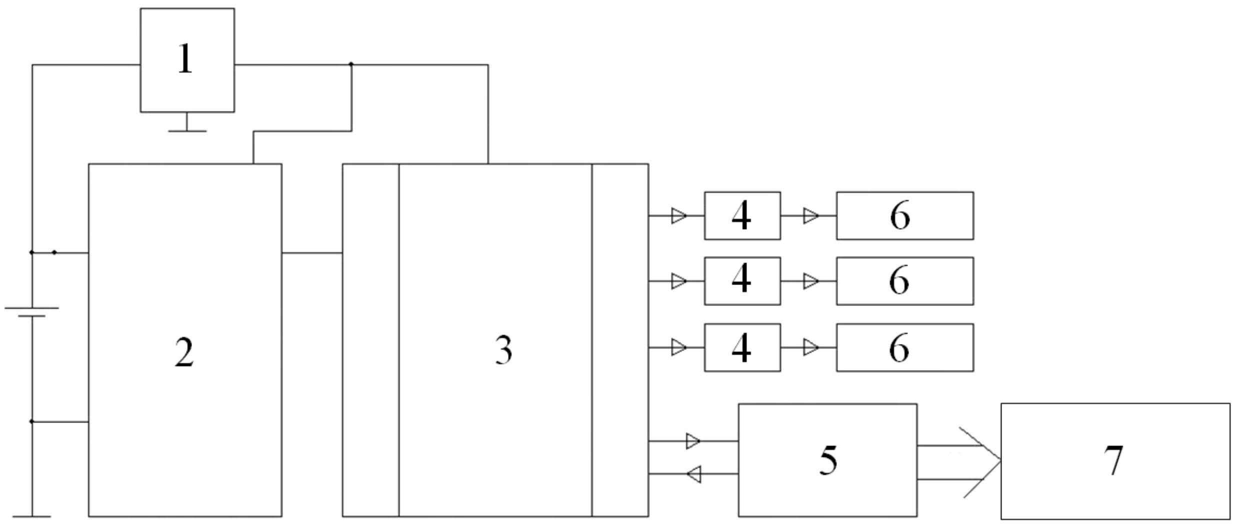

Figure 1. Structural scheme of the load control relay

Abbreviations:

1 - voltage regulator

2 - analogue digital converter

3 - microcontroller

4 - controlled current stabilizer

5 - The indication control device

6 – loads;

7 – screen (LED)

Principle of operation:

Our relay should be used for the battery, which is charged with solar and wind energy. In order for the relay to switch between loads and know exactly what to do at the moment, the ADC will continuously measure the voltage on the battery. The data that will be received by the ADC will have to be processed by the microcontroller itself. One of the microcontroller ports will act as an analog input for the rest of the microcontroller and control the loads.

The most important role will be played by the microcontroller, which will be embedded in the program itself, it will control loads not directly, but through the current amplifiers.

But constructed relay can’t work with the high voltages and should be improved using by the resistors and capacitors with the higher values that used in this project.

Conclusion

First of all, we learned that the modern method of constructing a SW power plant is economically inefficient, it does not fully use energy and is mainly intended only for small enterprises. During a hot or windy day after the battery is fully charged, the UPS stops operating. I mean, there's a lot of energy, and we don't use it. In order to solve this problem you need to build your own relay with four load levels.

Secondly, in order to prevent the inverter from slamming permanently, which is due to too small a difference between the on and off voltage. Hysteresis should be entered into the system.

Third, we were able to transfer our two ideas into a load management relay, which is a smaller copy of the device that can be used on a larger scale in medium-sized enterprises.

Fourth, we have understood the general algorithms of the SWPP operation, which are currently used. Also familiarized with the terminology related to microcontrollers. We chose the one that best fits our goals.

Fifth, the result of our work is a working device, which is mounted on the model of the educational institution and were able to present in the form of boards with diodes themselves useful loads. These diodes serve as indicators that show the current power supply method.

Our study can play a key role in the development of Kazakhstan's green electricity industry, as it explores methods to improve the SWPP algorithm at medium and large enterprises. It touches on methods to increase the economic efficiency, make the most of the energy, and solve the problems with the inverter clapping, which was caused by the lack of hysteresis. The results of this project may also be used by other researchers who wish to deepen their understanding of the topic.

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