Photovoltaic panel and wind turbine as an electric energy source for water evaporation and desalination

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Abstract. The purpose of the article is to study the process of heating and desalination of seawater due to electricity from wind turbines and solar panels. This electric current is collected and transmitted through wires to be used to power electrical devices. The advantages of using solar panels as an alternative energy source include environmental cleanliness, long service life, no noise, low cost of operation and no emissions of harmful substances. Boiling water using wind turbine energy is a great way to use renewable wind energy to support daily activities. By placing a wind turbine in an area with a steady wind, the turbine can collect kinetic energy from the air and convert it into mechanical energy that can be used to rotate the generator. This generator can then convert mechanical energy into electrical energy, which can be used to power an electric boiler. The boiler can then use electrical energy to heat the water, producing steam to boil the water.

1 Introduction

Solar panels are devices that use the energy of the Sun to produce electricity. They can be used as an alternative energy source instead of traditional sources such as gas, coal and oil. The principle of operation of solar panels is based on the photoelectric effect that occurs when light hits the surface of the panel. When photons of light hit a silicon crystal, which is commonly used to make solar panels, they cause the release of electrons, which then create an electric current.

Wind turbines capture the kinetic energy of the wind and convert it into electricity, which can then be used to power homes and businesses. Wind energy has many advantages, ranging from its ability to generate a constant and reliable source of energy, ending with low environmental impact and low maintenance costs.

Wind turbines are also modular, which means they can be installed in specific locations and can be adapted to the energy needs of each individual location. In this case, with the help of a wind turbine, it is possible to carry out the process of boiling water, eliminating the need to use combustible fuel and connect to city power grids [1, 2].

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This article describes the process of boiling water due to energy from a wind turbine. The scheme in question includes four main elements: a wind turbine, an electric generator, a storage device and a water heater. In addition, the methods of automating the described process are reviewed. The article also presents the advantages of using air flow energy as an alternative to the main sources [3, 4].

This article describes the process of boiling water due to energy from a solar panel. The scheme under consideration includes three main elements: a solar panel, a storage device and a water heating unit (device), in addition, calculation formulas are reviewed. The article also presents the advantages of using solar energy as an alternative to the main sources.

2 Materials and methods

Boiling and desalination water due to electricity from a solar panel is feasible using the "solar panel – battery – water heater" scheme. A tubular electric heater (TEH) will be used primarily as a water heater. The heating element is a metal tube filled inside with an electrical insulator, which, when connected to the network, heats up and boils water [5, 6].

The scope of application of heating elements is extremely extensive. It includes industrial electric boilers for heating water and evaporation plants for concentrating solutions. Speaking of household use, it is worth mentioning electric kettles, boilers, irons and so on. In addition, electric heaters are often used as equipment in baths and saunas.

The principle of operation of the selected scheme is associated with obtaining electricity from solar panels and wind turbines powering sectional batteries. Storage devices, in turn, power heating elements, boilers and other household appliances. Thus, consumer devices are connected not to a shared network, but directly to the drive. The battery ensures uninterrupted operation of the boiling devices at night or in the absence of sunlight, because in this case it is not possible to power the installation directly from solar panels. This is the need to include it in the scheme.

Calculation of the amount of heat required for heating and evaporation of water:

\[ Q = c \cdot m \cdot \Delta t + m \cdot r = m \cdot (c \cdot \Delta t + r) \]  

We take for both the radiated solar flux and the flux falling on the plate, respectively, then

\[ E_z = E_i \cdot (1 - A - R), \]  

where \( A \) - absorption coefficient, \( R \) - reflection coefficient.

Further, taking into account the loss of heat and electricity, we can write the following equation:

\[ E_i \cdot (1 - A - R) = Q \cdot \eta_i \cdot \eta_e \]  

In addition to the basic elements of the scheme, additional equipment can be used to automate the process. Controllers that monitor the electrical load on solar panels can act as this. They allow you to make sure that there is enough power to power the devices. In the case of using a boiler, it is necessary to install temperature sensors to regulate the operating mode of the device. The controller monitors the degree of water heating, then adjusts the system accordingly to achieve the desired temperature. Then it turns on or off the boiler when the temperature or water level in the tank falls below the set.

Finally, the automated boiling process can be controlled remotely, which allows the consumer to adjust the boiler settings from a distance. This ensures that the water is always heated to the desired temperature, and that the boiler is used only when necessary.
The principle of operation of the scheme is that the air flows cause the windmill shaft connected to the generator rotor to rotate. Thus, the mechanical work on the rotation of the blades of the installation, performed by the wind, is removed from the shaft and converted into electrical energy according to the law of electromagnetic induction. Further, electricity accumulates in the accumulating device. The battery ensures the uninterrupted operation of the heaters in the absence of wind, because in this case it is not possible to power the installation directly from the windmill. This is the need to include it in the scheme. The closing element of the circuit is, in fact, a water heater that heats the water until it reaches the boiling point. Mainly a tubular electric heater (TEH) will be used as it. The heating element is a metal tube filled inside with an electrical insulator, which, when connected to the network, heats up and boils water [7, 8].

Tubular electric heaters are widely used in production. They are found in almost all manufacturing industries, agriculture and horticulture, food processing and other commercial environments. They can also be used to heat water and other liquids. It is worth noting that heating elements are ubiquitous as the main element of many household appliances (electric kettles, irons, boilers). In addition, electric heaters are often used as equipment in baths and saunas [9, 10].

3 Results. Practical significance

Considering the factors described above, we can say that the scope of application of the process of boiling water due to energy from wind turbines is extremely extensive and has great potential both in industrial conditions and in domestic use. In addition to boiling, wind turbines can be included in the seawater desalination scheme. Wind turbines do not produce any emissions, which makes them an attractive option for the environment. In addition, wind turbines do not create sound pollution, which makes it an excellent way to use energy responsibly [11, 12].

We offer a scheme for heating and desalination of seawater according to Figure 1. The scheme is characterized by the novelty of using renewable energy sources in combination with a thermal desalinator.

Figure 1 shows a scheme for desalination of seawater based on a heat pump, including an evaporator 2, a compressor 4, a condenser 5 and a throttle valve 6. In a heat pump, the heat source is water or air 1. Heated water 7 is directed to a thermal evaporator 8. Evaporation is achieved through the use of an electric heater 9. Electricity comes from a photovoltaic panel 3 and a wind turbine 11. The salt-saturated water 10 is drained, and the pure steam 12 is sent further to the cooler.

The desalination scheme developed by the authors is considered in the energy complex with renewable energy sources. The photovoltaic panel works during the daytime and sends electricity first to the battery, then to the inverter. The wind turbine works depending on the wind speed in the region, it can work both in the daytime and at night. When the wind turbine stops, the battery is switched on, and for some time the heating element in the desalination plant starts to work from it.

In this regard, the scheme is reliable if the desalination plant is used in regions with high solar radiation intensity, in coastal areas where the wind practically does not stop. The energy complex receives fresh water from sea water, so fresh water can be used both by the population and not to be used for the needs of agriculture.
4 Discussion

The efficiency of the boiling process depends on various factors, including weather conditions, the size of the solar panel and wind turbine, wind speed and water temperature. The larger the solar panel and the speed of the wind turbine, the more efficiently they convert the energy of sunlight and wind into useful electricity and, in turn, the more efficiently the installation boils water. In addition, the higher the water temperature, the less energy is required to heat it to the boiling point, given that the process of desalination of water is directly related to its pre-boiling and evaporation [13, 14].

After desalination of water, it can be used for various purposes, such as drinking water, industrial processes, cleaning and even powering engines. The amount of energy spent on boiling water is significantly less than it would take to power a traditional internal combustion engine [15, 16].

Also, the efficiency of the scheme under consideration can be improved by observing the alignment of the windmill shaft and the rotor of the electric generator. That is, instead of a vertical wind turbine, you can use a device with a horizontal axis of rotation of the shaft. This will eliminate the need to transfer torque to a horizontally positioned generator rotor through a bevel gear, thereby reducing mechanical losses.

So, in addition to the basic elements of the scheme, additional equipment can be used to automate the process. Controllers that monitor the electrical load on the wind turbine and the photovoltaic panel can act as this. They allow you to make sure that there is enough power to power the devices. In the case of using a boiler, it is necessary to install temperature sensors to regulate the operating mode of the device. The controller monitors the degree of water heating, then adjusts the system accordingly to achieve the desired temperature. Then it turns on or off the boiler when the temperature or water level in the tank falls below the set. Finally, the automated boiling process can be controlled remotely, which allows the consumer to adjust the boiler settings from a distance. This ensures that the water is always heated to the desired temperature, and that the boiler is used only when necessary.
5 Conclusion

In conclusion, it should be noted that solar energy is becoming an increasingly popular source of renewable energy, which is used in a wide variety of applications. This industry is developing rapidly, and the installation of solar panels and other solar energy systems can provide people with jobs. Solar energy is renewable and clean and can help reduce electricity bills by reducing dependence on other energy sources. In addition, the sale of excess energy generated by solar systems can provide additional income to both households and businesses.

Boiling and desalination of water using a wind turbine is a relatively simple process that requires little energy to achieve the desired end result. It also has many advantages, including providing clean and affordable energy for various industrial processes and providing people with a sustainable source of electricity. With the increasing popularity of renewable energy sources, it is likely that the process of desalination of water using wind turbines and photovoltaic panels will become commonplace in the near future.

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References

1. A. Shcherbakov, O. Shcherbakova, D. Savvateev, E. Khusnutdinova, Solar panels as an alternative energy source (Russia, 2019).