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Production and implementation of solar-powered water heaters for consumers

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Abstract: The production and implementation of solar-powered water heaters represent a significant step toward sustainable energy solutions, particularly for rural communities in Uzbekistan. This paper discusses the development of an innovative solar-powered water heating device, its technological features, and its benefits in enhancing living conditions while reducing environmental impact. The depletion of fossil fuels and the associated global energy crisis necessitate a transition to renewable energy sources (RES), such as solar energy, which is abundant and sustainable. In line with Uzbekistan's energy strategy, the government has been promoting alternative energy sources (AES) to decrease reliance on traditional fuels and increase energy efficiency. The proposed solar-powered water heating system leverages modern technological advancements to maximize energy absorption and storage, ensuring a reliable supply of hot water. This development aligns with the nation's broader energy policy, which emphasizes renewable energy integration to address economic and environmental challenges. By implementing these systems, Uzbekistan aims to contribute to global efforts in reducing carbon emissions and promoting sustainable energy solutions. The study also highlights international best practices in renewable energy adoption, offering insights into future strategies for enhancing energy sustainability in the

region.

Keywords: Renewable energy sources, alternative energy sources, solar-powered water heaters, energy efficiency, sustainability.

Introduction:

The depletion of fossil organic fuel reserves will inevitably lead to a global energy crisis because the amount of traditional energy sources cannot be considered unlimited. Solar, wind, and rivers – renewable energy sources (RES) – are considered limitless. Such alternative energy sources (AES) reduce the risk of dependence on traditional fuels. In Uzbekistan's conditions, the transition to AES in all possible situations will lead to fuel savings.

From the early years of Uzbekistan's independence, the state leadership's energy policy has been aimed at ensuring the country's energy security and using national energy capabilities to solve the social and economic problems of society. In the context of the formation of a market-based economy, the state has provided significant assistance to the main sectors of the industry, in particular, to the enterprises of the fuel and energy complex [1]. State policy in this area has defined the main directions and goals of the energy strategy. In this regard, new thermal power plants (TPP) and units were built, and thousands of kilometers of high-voltage power transmission lines were constructed.

Modern Uzbekistan has a developed energy system. Our country ranks among the top ten largest gas-producing countries in the world in terms of natural gas production volume. 50% of the power generating capacities of the Central Asian countries' energy systems are located in Uzbekistan [2].

Currently, the strategic tasks that the President of the Republic of Uzbekistan has set for the employees of our country's energy sector are to identify ways to effectively use the energy resources of nature, which is the wealth of our people. The modern world economy depends on oil, natural gas, coal, and other mineral resources that have been accumulated since ancient times. Every action, event, and occurrence in our lives: from the birth of a person, the services provided to them, the preparation of daily meals, to the production of goods in industrial enterprises – all these processes are related to burning this heritage - wealth. The main problem is that this resource - valuable wealth - is non-renewable. Sooner or later, humankind will completely extract this wealth from the depths of the Earth and burn it away. In such a situation, what energy sources will the lives of future generations (and perhaps some of us) be based on? We must also not forget the negative ecological impact of the fuel combustion process on nature. The increase in greenhouse gases in the atmosphere leads to an increase in the average temperature on our planet. The products formed during the combustion of fuel lead to air pollution [3].

In recent years, large-scale measures have been implemented in the economic and social sectors of the Republic to ensure the conservation of electricity, including the development of renewable energy sources. The government's key decisions on increasing energy efficiency in the Republic have approved the targeted parameters for further development of renewable energy sources. Accordingly, while in 2018, 90% of the generated electricity came from traditional energy and 10% from renewable energy sources (10% hydro), according to experts, by 2025, the share of alternative energy sources in Uzbekistan should reach 12.7 to 19.7 percent. Within the structure of alternative energy, the share of solar energy will reach 2.3 percent, and the share of wind energy will reach 1.6 percent. Also, energy savings of 9.79 million tons of standard fuel per year are expected from the energy used for production. By 2030, there are plans to increase the share of alternative energy in the country's energy sector to 30% [4]. A significant amount of experience has been accumulated in this area in a number of developed countries. For example, in Germany, 20 percent of the energy consumed is generated from alternative sources, and by 2050, this figure is planned to reach 50 percent. In Switzerland, even more - a 60 percent result is targeted [5].

MATERIALS AND METHODS

Today, the widespread introduction of energy-saving technologies and alternative energy sources into the economy, the social sphere, and the construction industry is a key priority of our Republic. Since 2017, a joint project "Supporting the Development of Energy Efficient Rural Housing Construction in Uzbekistan" has been implemented in cooperation with the Ministry of Construction of the Republic of Uzbekistan and with the support of a grant from the Global Environment Facility. Based on the above tasks, we have developed a water heating device that provides the rural population of Uzbekistan with improved and comfortable living conditions, while being environmentally friendly. This device utilizes inexpensive materials made from local raw materials for rural areas [6,7].

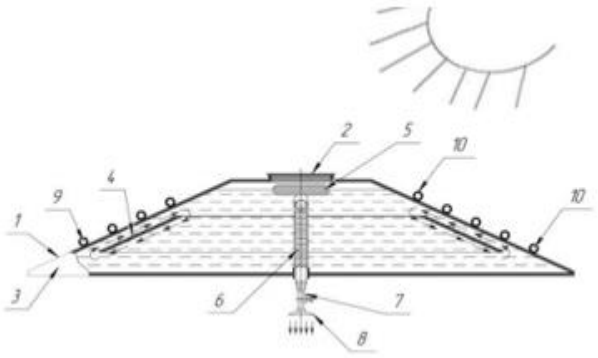

Fig. 1. The device elements

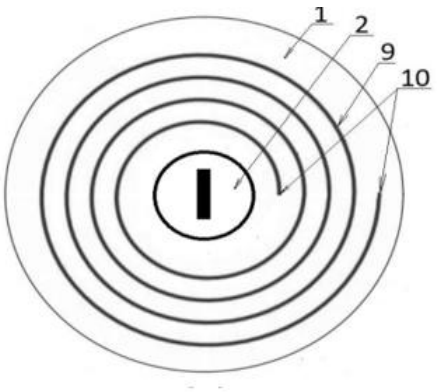

Fig. 2. The device elements

The device being claimed consists of the following elements (Fig.1 , Fig. 2,):

1. Solar energy collector in the form of a storage tank filled with a liquid heat carrier – water.
2. Transparent removable cap.
3. The angle of inclination of the truncated cone, not more than 0.9ϕ, where ϕ is the latitude of the location.
4. Deflectors installed inside the tank.
5. Float, to ensure the withdrawal of water from the upper layer.
6. Flexible tube, for supplying hot water.
7. External pipe, which has a valve at the other end.
8. Shower.
9. Spiral-shaped copper tubular deflector.
10. Inlet/outlet of the copper tubular deflector.

Research Results: The claimed device (Fig.1, 2) operates as follows:

The collector is constructed in the shape of a truncated cone with an angle of inclination of no more than 0.9ϕ (3, Fig. 1), where ϕ is the latitude of the location. This design effectively allows the stationary collector surface of the water heater to track the sun, as the conical surface is consistently oriented toward the sun.

The addition of an external spiral-shaped copper tubular deflector, attached to the conical surface of the water heater, significantly increases the overall circulation speed of the heated water under solar exposure. This is because the thermal conductivity of the copper tube (390 W/(m·K)) is 7 to 8 times greater than the thermal conductivity of galvanized steel (50-60 W/(m·K)), which improves heat exchange between the heating area of the collector and the water.[8]

Solar rays cover the entire active surface of the collector, including the copper tube deflector. This initiates the heating of the collector. The thermal energy from the collector is then transferred through contact to the water inside the collector and inside the copper tube. Due to its high heat capacity, the copper tube heats up actively. The tube's thermal energy is simultaneously transferred to the water and the wall of the collector, enabling faster accumulation of solar thermal energy in both the collector and the water. The water inside the tube heats up more quickly than the water inside the collector. The resulting temperature difference between the beginning and end of the copper tube initiates water circulation through the copper tube. Furthermore, the deflector located inside the collector also initiates natural water circulation. Thus, the overall circulation of the water is accelerated by the additional circulation created by the external spiral-shaped copper

tube deflector (9, Fig. 2).

The proposed deflector design ensures continuous water circulation from bottom to top when the water level is above the end of the copper tube. When the water level drops below the end of the copper tube, the latter stops functioning as a deflector (9, Fig. 2) but continues to convert solar rays into thermal energy, and does so more effectively than the steel part of the collector, thanks to the high heat capacity of the copper tube. This increases heat exchange between the collector wall and the water, thereby increasing the heat transfer of the entire collector and achieving the objective of the invention. The technical result achieved with the claimed device is that the external copper tube deflector, attached by soldering to the water heater body, heats up faster (7-8 times) than the metal body of the heater. Consequently, the water also heats up faster, thus accelerating the water heating process and improving the overall thermal performance of the household solar water heater.The device uses the property of a black surface, close to an absolute "black body," to fully absorb light from the sun and convert it into heat. The obtained heat energy is directed to the production of hot water, which can be used in domestic conditions. It also serves for heating rooms. The temperature of the water in the device's water chamber reaches 80 °C in summer and 50-60 °C in winter. In addition, in case of malfunctions, it is easy to replace individual parts of the collector without having to replace the whole collector (Figure 1).

The main tasks and assignments for preparing the device are:

- To meet the hot water needs of domestic consumers;
- To abandon traditional methods used for producing hot water;
- To reduce the use of old technologies and energy equipment that pollute the environment;
- To produce inexpensive devices for export from local raw materials;
- To establish production and create jobs;
- To supply the primary domestic market with such inexpensive devices and stop the import of expensive foreign equipment;
- To organize the production of solar water heaters based on local materials, which will ensure:
- The device will create additional comfort in people's social lives;
- It will bring economic benefits due to energy savings;
- It will be simple in structure and convenient for introduction into production; and the materials used are fully composed of local raw materials or recycled materials.

The main global principles for introducing a specific production, using the latest technologies and scientific and technological progress, are based on adaptability, the ability to calculate and monitor changes in world prices for a specific product, and striving for quality improvement and growth. The constant search for alternatives, the achievement and application of simple technological solutions, makes it possible to produce and deliver local, affordable, and convenient devices without losing quality parameters. Another aspect is the ecological requirement. A strict, but also beneficial for the manufacturer, legislative framework is designed not only to "provide," but also to introduce privileges, and sometimes to provide advantages and benefits. At the legislative level, in particular in the European Union, the growing environmental concerns and benefits have increased interest in ecologically clean energy devices, particularly solar devices. The implementation of the principles of the 2015 Paris Protocol necessitates special attention to the comparative effectiveness in terms of CO2 emissions.

CONCLUSION

The market for solar water heaters in our country is one of the fastest-growing segments of secondary energy production based on renewable energy sources. The adoption of solar-powered water heating systems presents a promising opportunity to address energy challenges and promote sustainability in Uzbekistan. By leveraging renewable energy resources, the country can reduce its dependency on fossil fuels, decrease greenhouse gas emissions, and enhance energy security. The successful implementation of these technologies will not only benefit rural communities by improving their quality of life but also contribute to national economic development. Continued research, investment, and policy support are essential to further integrate solar energy solutions into the country’s energy infrastructure. As Uzbekistan moves toward a more sustainable energy future, the lessons learned from this initiative can serve as a model for other regions aiming to transition to renewable energy sources.

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