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Automated system of smart-windows using solar cells

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The smart window management system uses the Arduino controller to automate the device working on renewable energy sources. Possibility of using the obtained solutions for the design of wall-mounted power plants using solar energy is presented. Solar panels can be used not only for their direct purpose (generation of electricity), but also as a household appliance with a set of various consumer functions. Mounting of such device on the facade of residential and office buildings modernizes the architectural view and contributes to the improvement of the cities environment. Using the Arduino controller and its accompanying circuit boards will help to solve the problem of digitalization of the building windows and connect solar cell based devices to the Internet via a standard Wi-Fi router. Such actions will ensure the broad demand for such devices among residents of cities, which will result in a high degree of commercialization of the resulted work.

Key words: renewable energy sources, arduino, automation, solar cells, sustainable development/
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1 Introduction

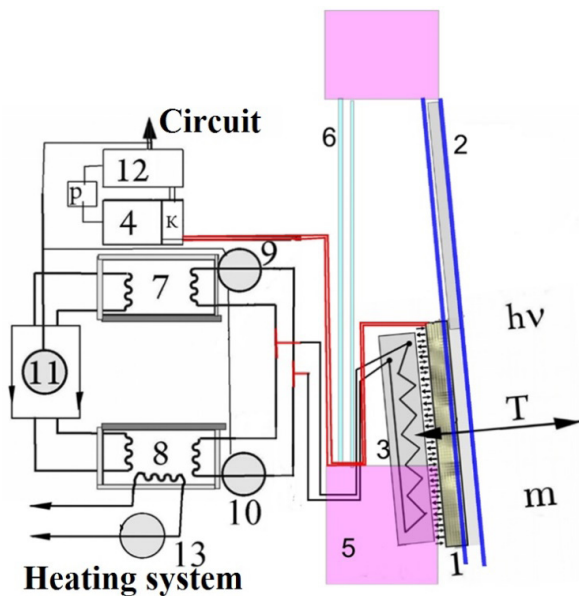
The two most important obstacles to the development of renewable energy in Kazakhstan are low profitability of renewable energy sources (RES) and developed traditional energy with redundant provision with natural resources. Perhaps, the only stimulus to develop renewable energy is a large-scale environmental problem, which is still perceived only at the national and international level and is not perceived by the average person. At the same time, due to of automobile emissions, traditional power plant emissions and dust threatening the health of residents, so the ecological situation in cities, in particular Almaty, is getting worse. [1-4] This determines the needs to carry out the active cleaning of the air and thereby improving the comfort and quality of life. Part of this time-consuming work can take on the elements and components of renewable energy sources. With regard to the first thing, the government introduced several important measures to reduce the operating costs of renewable energy producers, including favorable access to the grid, priority in providing land and customs privileges for the supply of materials and equipment [5-10]. Among the renewable energy sources of Kazakhstan, solar power plants occupy a special place, since most areas like in Iran or Chine, have a large solar exposition

[11-16]. However, the low profitability of solar panels, high cost of mounting and related equipment, in addition to the need to delve into the physics and technological nuances of operating solar panels, reduce their appeal to consumers. One way to make solar cells more cost-effective is to use their non-target properties with the ability to perform additional consumer functions like an air conditioner, a dust collector or a heater, with mandatory automation of the management of these functions To automate the device on renewable energy sources, one can actively use ARDUINO units [17-20].

2 Results and Discussion

The most acceptable way to automate the device as an element of a smart window is to use the Arduino controller and its associated framing applications. In addition to the automation of processes, the capabilities of this device allow to connect an automated design to the Internet via a standard Wi-Fi router or application on the mobile phone. Relevance of the work is increasing, if we take into account that production of solar batteries from local raw materials is started in Kazakhstan and in the next five years there will be a problem of cost-effective use of the products of factories located in Astana, Ushtobe and Ust-Kamenogorsk. Manufacturing of construction,

the general scheme of which is presented in Figure 1, will mainly be of an assembling – like and can be carried out at a variety of enterprises and workshops in Kazakhstan with available power tools.



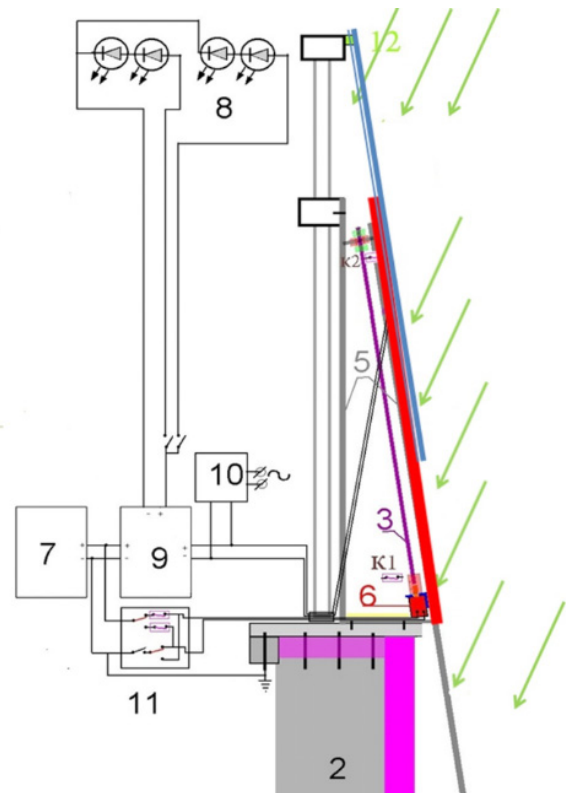
- 1 – solar cell; 2 – frame with a film; 3 – heat exchanger;
- 4 – electric accumulator; 5 – window sill; 6 – window;
- 7 – cold accumulator – radiator; 8 – heat accumulator-radiator; 9 – circulating pump of the cold coolant circuit;
- 10 – circulation pump of the hot coolant circuit;
- 11 – compressor of the heat pump; 12 – inverter and power supply of lighting devices.

Figure 1 – Functional diagram of an automated smart window system with solar cells

Winter air conditioner variant allows combining thermal energy from solar radiation and atmosphere and heat the room. In other words, we can combine central heating with air conditioning system of the room and the accumulation of heat and cold. The solar panel will play a role of additional outdoor radiator of heat exchange with atmosphere for a heating and cooling system (room air conditioner). The variant of the summer air conditioner allows accumulating the cold at night and cooling the room in the afternoon.

In situations where it is not necessary to perform the listed functions, the device allows accumulating electricity, heat and cold for emergencies in the room. Such accumulated electricity could be used for evening lighting of other rooms, thereby smoothing peak overloads in the city network.

Figure 2 shows a functional diagram of such type of the device. When the sun illuminates the solar panel 1, it generates electricity, which is stored in the battery 7.



- 1 – solar panel with reflective film; 2 – wall of the house;
- 3 – moveable pin; 4 – plate with a protective film;
- 5 – corners; 6 – motor-reducer; 7 – battery; 8 – LED emitters; 9 – battery charge controller; 10 – battery charger;
- 11 – commutator power supply of the motor-reducer; 12 – heat insulating and soundproofing layers

Figure 2 – Functional diagram of an automated smart-window system in the mode of room lighting regulation and sound insulation

Two-folded window is equipped with two panels. The panels are mounted moveable to the corners, which are screwed to the wall, the windowsill and the window frame. All installation is carried out from the room, which makes the device usable and easy to use. The solar stream penetrating into the room through the window can be adjusted or overlapped with the solar panel [2].

The radiation flux and sound waves $h\nu$, dust m , atmospheric heat and cold flows T are periodically present in the external environment in front of the window. With these elements, the home appliance can operate to perform programmed consumer functions. If solar radiation flux $h\nu$, is presented, the device can accumulate photovoltaic energy directly in the accumulator 4 and we can use this energy at any time to power electric appliances, preferably with illumination. However, if the radiation flux into the room needs to be reduced, it can be covered with an improvised curtain, the role of which is performed by

the solar panel 1, which is opaque to radiation and absorbs it. Reversible motor reducer raise or lower the solar panel by using a 1.5-meter pin with metric thread M10. The motor reducer connects to the electric battery and consumes its energy. At night, the consumer may want to reduce the radiation flow $h\nu$ from illumination of the street, in which case the solar panel should cover the maximum window area. If, the film frame with the film itself is extended at the same time with a screening sound, then the level of sound waves penetrating into the room from the street will decrease significantly. This helps to improve the insulation and sound insulation of the room with windows, but also it increases the insulation of the room. Electrically charged dielectric film could help to forcibly remove dust and fumes m from the atmosphere of the ambient air of the street and therefore dust and fumes m don't penetrates into the room. Periodically, the film is washed from the dust by moving towards the stationary moistened sweeper. Dust can be collected in the dust collector.

Arduino is used to create electronic devices with the ability to receive signals from various digital and analog sensors that can be connected to the plate, and used to control various actuators as well. The environment of the developed program with all sceneries is available for download and free of charge [3]. Controller, sensors, actuators, expansion plates, programs for all kinds of combinations are very cheap and available anywhere in the world. Thus, almost any smart system can be assembled as a Lego children's designer from ready-made and accessible blocks.

There are also recoverable fuses that used to protect the USB port of the computer from short circuits and overloads in the Arduino plate, which alas, occur not so rarely as desired. Despite the fact that most computers have their own protection (the so-called UPS), such fuses provide an additional level of protection for the microprocessor. If a current of more than 500 mA is consumed from the USB port,

this fuse will automatically break the connection until the cause of the short circuit or overload is eliminated.

For this reason, a cheap and affordable Arduino controller is selected for automatic control of solar panels that hung out of the window and perform many non-core consumer functions. The logic of controlling the smart device, which can be located on the window or outside the window, including the movable front panels is very complicated. The obtained results will have a significant impact on the development of science and technology in the field of solar energy and ecology in Kazakhstan, so the results of many scientific works in this and related fields will be applied. Application of the results into production will ensure the sales market of the plants in Kazakhstan and create new jobs.

3 Conclusion

The solar panels mounted on the facades of buildings makes it possible to use the consumer functions that is non-core for them, which increase the profitability of renewable energy devices. The mounting the devices with solar cell on the facades of buildings will improve the esthetic view of buildings and contribute to the improvement of the ecological situation in the city. Automation management and usage of several consumer demands in the simultaneously smart and simple designed household appliance will increase the demand for it in a broad consumer market and could be sold to individuals at retail as a household device. Combination of several consumer properties in a photoelectric generator of energy for urban conditions is justified.

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