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STUDY THE CHARACTERISTICS OF HEAT ENERGY IN THE AUTONOMIC SOLAR SYSTEM

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Khuzhakulov Saydulla Mirzaevich [1], Khamraev Sardor Ilkhomovich [2] ,Mamedova Dilora Nusurovna [3] , Kamolov Behzodjon Ilkhomovich [4]: Study The Characteristics Of Heat Energy In The Autonomic Solar System-- Palarch's Journal Of Archaeology Of Egypt/Egyptology 17(6),. ISSN 1567-214x

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ABSTRACT:

This article highlights the issues connected with the use of solar energy in heating rural houses, and economizes the energy supply on the account of autonomizing solar renewable energy. Furthermore, according to the potential of solar energy, data of the heat load on the issues of the heating houses and hot water supply were found. Besides, autonomizing heat system was recommended to one storey houses in rural areas and its characteristics were conducted widely.

INTRODUCTION

In Uzbekistan, a large-scale work is being carried out in the economic and social spheres to increase energy efficiency and the use of renewable energy sources. In particular, the President of the Republic of Uzbekistan on May 26, 2017 "On the program of measures for further development of renewable energy, energy efficiency in the economy and

social spheres for 2017-2021" No. PP-3012, November 8, 2017 "On rational use of energy resources Resolution No. PP-3379 "On measures to ensure energy security" and the "Action Strategy for the five priority areas of development of the Republic of Uzbekistan in 2017-2021" to reduce energy and resource consumption in the economy, the widespread introduction of energy-saving technologies in production, renewable energy sources Expansion of use, improvement of energy efficiency in various sectors of the economy have been identified as priorities [1, 2].

In European countries, including Russia, heat consumption for the heating season in multi-storey houses, on average - 350 - 600 kWh / (m^2□year), and in single-storey houses - 600 - 800 kWh / (m^2□year), per capita water consumption through the plumbing network is 250 - 500 l, including for houses connected to the central heating system - 150 - 200 l. Research on the creation of autonomous heat supply systems shows that the use of autonomous system equipment instead of a central heating system can save up to 70% of energy [3, 4, 5, 6].

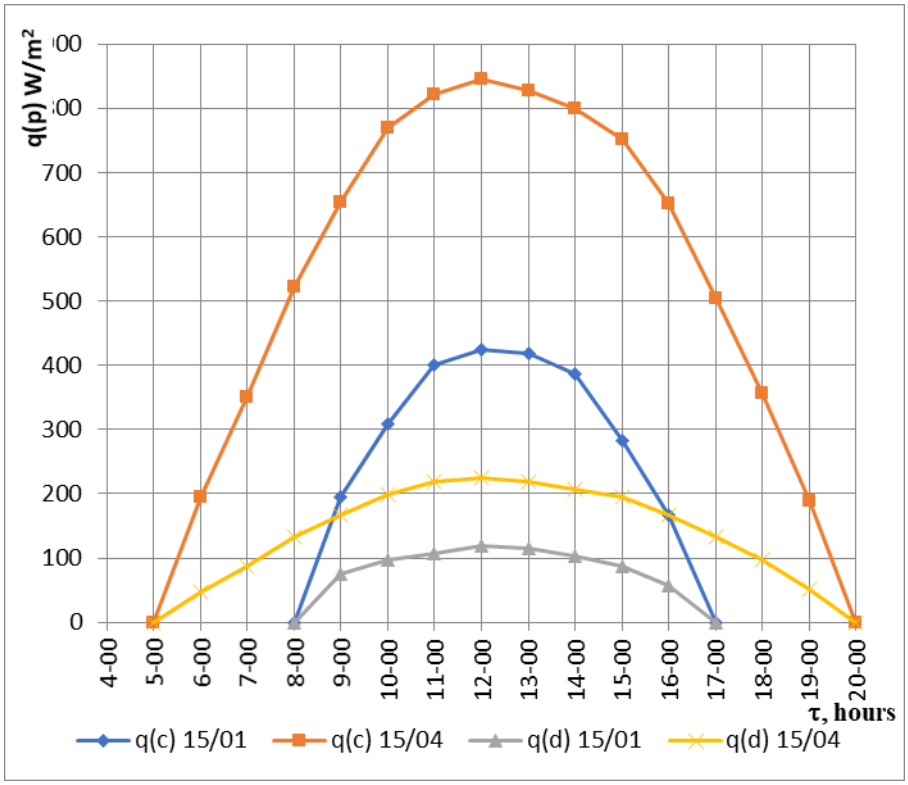
About 40% of the energy produced in Uzbekistan is used for heating and lighting. According to industry experts, an average of 400 kWh of energy is used to heat 1 m^2 in Uzbekistan, and 170 kWh in temperate climates in developed countries. In order to create a gross domestic product of one thousand dollars in our country, 2-3 times more energy is used than in developed countries. Therefore, the task is to reduce energy consumption by 2-2.5 times in the coming years. Electricity consumption in our country is growing from year to year. In 2000, the monthly consumption of a family was 114 kWh, but now it is 175 kWh [7].

In the context of Uzbekistan, the introduction of energy and resource-saving technologies in residential buildings, increasing energy efficiency in public utilities and the economy, as well as the use of renewable energy sources are relevant [8, 9, 10, 11, 12, 13, 14, 15].

METHODS AND MATERIALS

In order to develop autonomous energy systems based on the use of energy and resource-saving, renewable energy sources, especially solar, in rural areas, especially in settlements far from traditional energy sources, the heat load of a one-story model house was determined, heat-energy parameters were analyzed and heat the heating scheme of the supply system was developed.

In order to assess the potential of solar energy, the daily changes in the intensity of solar radiation based on the geographical location of Kashkadarya region were studied (as of January 15 and April 15, 2020). Based on the measurements and research results, a daily graph of solar radiation intensity was developed (Fig. 1).



q (c) is the total (straight and scattered) solar radiation flux density;
q (d) is the scattering radiation flux density (W/m^2).

Figure. 1. 15.01.2020 y. and 15.04.2020 y. Schedule of daily changes in the intensity of solar radiation for the days (in the conditions of Karshi district):

The calculation of the heat load for residential buildings is carried out taking into account the climatic conditions, the indicator of the specific thermal characteristics of the building surface. To do this, knowing the surface area or size of the area occupied by the building allows to determine the total heat load of the building [16, 17,18,20]:

$$Q = q \cdot V_{build} \cdot (t_{i.t} - t_{c.t.o}). \quad (1)$$

where V_b is the total volume of the residential building, m^3; q - specific heat characteristic of surface areas, W / m^2, q = 0.78 W / m^2 for modern buildings; $t_{i.t}$ - required indoor air temperature of the house, ° C; $t_{c.t.o}$- is the calculated temperature of the outside air (selected for the coldest day), ° C.

A one-storey model house with a total area of 144 m^2, a hotel with a surface area of 31.9 m^2 and a dormitory with an area of 31 m^2, a kitchen and a children's room with an area of 18 m^2, as well as a corridor with a surface area of 22.4 m^2 and a bathroom with a surface area of 6.4 m^2. The total heat load of the house shown in Fig. 2 is given by formula (1) as follows:

$$Q = 8{,}1 \quad \text{kW}.$$

Typically, in engineering calculations, the capacity of the water heating boiler is selected with a reserve factor of 1.1 to 1.25 per heat load

index. When choosing a water heating boiler for the heating of a house with an area of 144 m^2, it was considered expedient to choose a boiler with a heat capacity of 8-9 kW.

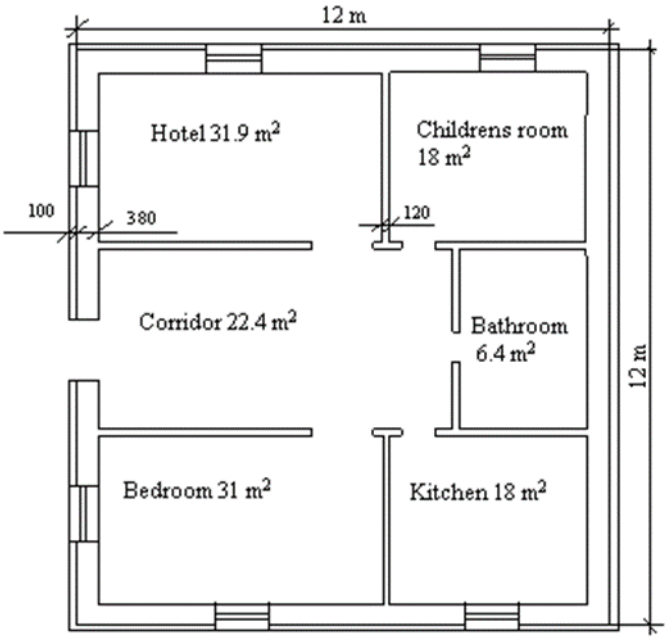


Figure. 2. Scheme of layout (model design) of single-storey standard house rooms with a total surface area of 144 m^2.

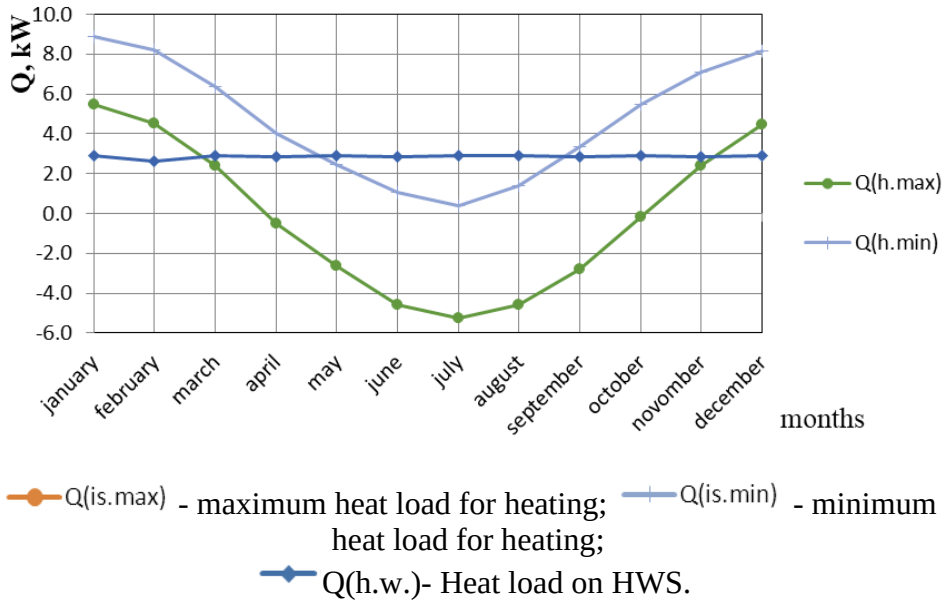
For the conditions of Karshi district of Kashkadarya region, the calculation of the total heat load (HL) for heating and hot water supply (HWS) of a one-storey house with a total surface area of 144 m^2 is given in Table 1.

1-Table

Calculations of the average monthly heat load of a sample house with a surface area of 144 m^2

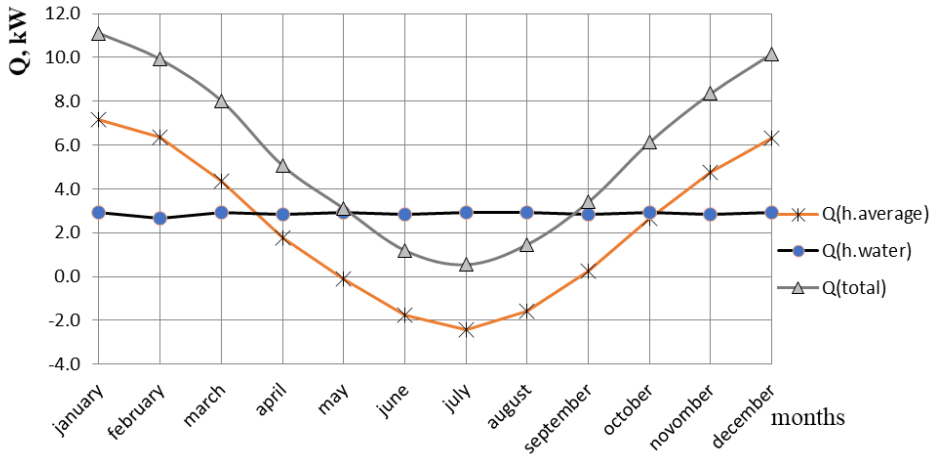
Months	Maximum average monthly temperature, t_{max}, °C	Minimum average monthly temperature, t_{min},, °C	Average temperature indicator $t_{cp.}$, °C	Maximum heat load, $Q_{is.min}$, kW	Minimum heat load $Q_{is.max}$, kW	Average heat load $Q_{heat.av}$, kW	HL on HWS, $Q_{heat.water}$, kW	General Heat Load, $Q_{g.av}$, kW
January	7,3	-2,0	2,7	5,4	8,9	7,2	2,9	10,1
February	9,8	-0,2	4,8	4,5	8,2	6,4	2,6	9,0
March	15,6	4,8	10,2	2,4	6,4	4,4	2,9	7,3
April	23,3	11,1	17,2		4,0	1,8	2,8	4,6
May	29,1	15,4	22,3		2,4		2,9	2,8
June	34,3	19,1	26,7		1,1		2,8	1,1
July	36,2	20,9	28,6		0,4		2,9	0,5
August	34,3	18,3	26,3		1,4		2,9	1,3
September	29,6	13,0	21,3		3,3	0,3	2,8	3,1
October	22,4	7,3	14,9		5,4	2,7	2,9	5,6
November	15,5	2,8	9,2	2,4	7,1	4,8	2,8	7,6
December	9,9	0,0	5,0	4,5	8,2	6,3	2,9	9,2

The graph of heat loads for maximum, minimum and hot water supply is shown in Fig. 3, and the graph of average and total indicators of heat load is shown in Fig. 4.



Q(is.max) - maximum heat load for heating; Q(is.min) - minimum heat load for heating;
Q(h.w.)- Heat load on HWS.

Figure. 3. Annual heat load schedule for maximum, minimum and hot water supply of a one-storey country house (in Karshi district conditions).



Q(h.average) - average heat load for heating; Q(h.w.)- heat load for hot water supply;
Q(total)- heat load (heating + HWS) for the general heat supply of the country house.

Figure. 4. Schedule of total and average annual heat load of a one-storey country house (in the conditions of Karshi district).

The calculated graph of the heat load for a rural home heating system based on the use of solar energy is shown in Fig. 5.

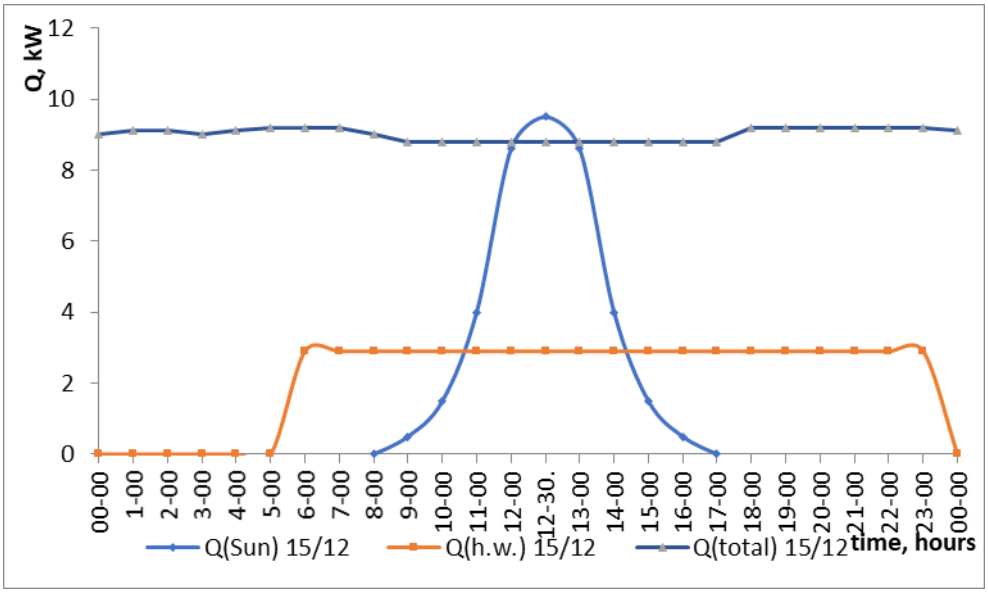
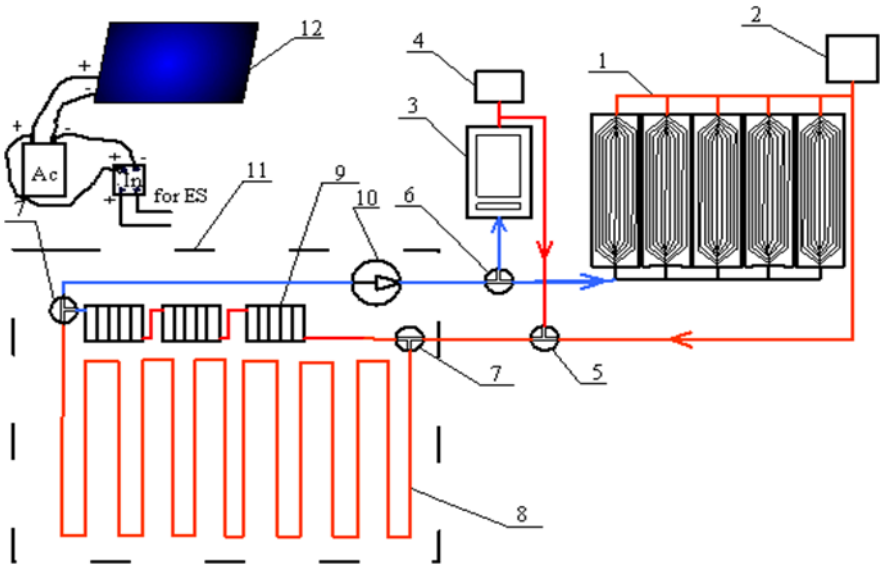


Figure. 5. Calculated schedule of heat load for a solar-powered heat supply system (as of December 15, 2019).

Calculation of heat load shows that the total heat load of the house under study in the climatic conditions of Karshi district is about 6-8 kW during the heating season, the hot water supply system – 2,8 kW, which is 46-35% of the total heat load. On a sunny day (December) from 10-00 to 15-00 in the afternoon 50-60% of the hot water supply load can be covered by solar energy.

INSTALLATION DESCRIPTION

A heating scheme of a solar house with an autonomous heat supply system was developed (Fig. 6).



1-solar collector; 2,4-expander; 3-water heating boiler; 5,6,7 - shut-off valve; 8-water heated floor; 9-heating batteries; 10-pump; 11-heated house; 12-solar panels (SP); Accumulator; In-inverter-converter; ES-electrical system.

Figure 6. Scheme of solar house with autonomous heat supply system.

The proposed system is designed to fully cover the heat and electricity needs of rural homes using solar energy. No electricity is received from an external source for the system to operate. In a country house, 11 heat supply systems can be implemented using solar collectors 1 and a photoelectric panel 12. In this case, the solar collector heats the water needed for heating to 55-60 ºC. On cloudy days and cold days of the year it will be possible to use 3 water heaters to heat the water. Due to the autonomous nature of the scheme, it should be noted that the boiler is designed to run on agricultural waste and firewood. The heating system in the interior of the house combines two different styles. Firstly, the heating floor 8 is installed, which serves to distribute the heat evenly throughout the heating area of the room, and secondly, traditionally the heating coils 9 are installed, which improves the convective heat exchange for volumetric heating of the room. The water returning from the heating system is sucked out by pump 10 and pumped to the heating source. Separation valves are used to carry out water circulation through the floor or heating coil, to change the flow of water coming through the solar collector or water heater 5, 6, 7. The power supply of the pump is carried out from the solar photovoltaic panel 12 from the accumulator to the energy converter inverter Ac.

The main element in the proposed heat supply system is the solar collector. The principle of operation of solar collectors is based on the collection of solar radiation energy and the use of this energy to heat the water circulating inside the piping system. The more energy is supplied to the heat carrier, the higher the efficiency of the device. The cold water in the collector reservoir flows towards the bottom of the collector and at this time the heated water flows out into the reservoir. Cold water enters instead of the empty medium in the collector pipe, where it is heated. In practice, the water collected in the reservoir is stored in a boiling state, and on sunny winter days the water temperature can reach 55-60 ° C.

A flat solar collector was developed for the autonomous heat supply system (Fig. 7).



Figure 7. An overview of the experimental solar collector.

To calculate the thermal efficiency of a solar collector, it is necessary to determine the area of the light-receiving surface, the amount of insulation for the installation area, and the collector's efficiency (18,19,20,21,22,23].

CALCULATION METHOD

The heat flux through the solar collector is calculated from the following formula:

$$Q = G_m \cdot c_p (t_2 - t_1), \quad (2)$$

where G_m is the mass consumption of the heated medium, kg / sec; c_p - isobaric heat capacity of the medium, kJ / kg □°C; t_1 and t_2 - temperature at the inlet and outlet of the solar collector, °C.

The calculated surface area of the solar collector is determined as follows:

$$F = \frac{\mathrm{Q}}{\alpha \Delta \mathrm{t}}, \quad (3)$$

where $\Delta \mathrm{t} = \mathrm{t_{ст}} - \mathrm{t_{air}}$ – the difference between the light-receiving surface and the average air temperature,; $°\mathrm{C}$; α – heat transfer coefficient, $\mathrm{W/(m^2 \cdot °C)}$.

The useful heat energy obtained from a solar collector is determined from the Wheeler-Hottel-Bliss equation, which is convenient for calculating flat collectors [12]:

$$Q_{useful} = \mathrm{k_r} \cdot F\left[q_c^{\Sigma}(\tau \cdot a) - u_T(t_1 - t_{e.t})\right], \quad (4)$$

where, $\mathrm{k_r}$ – is the coefficient of heat extraction from the collector; q_c^{Σ} - the current density of total solar radiation on the flat surface of the collector, $\mathrm{W/m^2}$; τ – transmittance of the transparent coating to sunlight; a – absorption properties of the collector plate in relation to sunlight; u_T – total coefficient of heat loss in the collector, $\mathrm{W/(m^2 \cdot °C)}$; $t_{e.t}$ - environmental temperature, °C.

To test a solar collector, the flux density of solar radiation incident on the collector surface, the outside air temperature, the ambient consumption and temperatures at the inlet and outlet of the collector are measured. In this case, the useful energy of the collector is determined by the following expression:

$$Q_{useful} = G_v \cdot \rho_в \cdot \mathrm{c_p} \cdot (t_{out2} - t_{ent1}), \quad (5)$$

where, G_v – volumetric consumption of the heat carrier, m^3/c; t_{out2} – ambient temperature at the outlet of the collector, $°C$.

The volumetric consumption of the heat carrier through the solar collector G_v, m^3/c, is determined as follows:

$$G_v = w \cdot F_o, \quad (6)$$

where F_0 – is the cross section of the collector, m^2.

Specific heat capacity of the collector, W/m^2:

$$q_{\text{sp}} = \frac{Q_{EE}}{F}. \quad (7)$$

Based on the conducted experimental studies, the efficiency of the solar collector is determined by the following formula:

$$\eta = \frac{\text{Q}_{\text{EE}}}{q_p^{\Sigma} \cdot F}. \quad (8)$$

If we consider the heat balance equation:

$$\text{G}_{\text{v}} \cdot \rho_{ent} \cdot c_p \cdot \Delta t = \alpha \cdot F \cdot \Delta t_{cp}, \quad (9)$$

in that case,

$$\eta = \frac{\alpha \cdot \Delta t_{cp}}{q_p^{\Sigma}}. \quad (9)$$

Based on the above method, computational and experimental studies were conducted to determine the thermal efficiency of the solar collector - heat efficiency and efficiency [24,25,26].

According to experiments and calculations, the temperature of hot water at the outlet of the solar collector reaches 55-60.

According to the results of the experiment, the insulation value for the southern regions of the Republic is 800 W/m^2, taking the efficiency of the solar collector as 0.6, we determine the useful power obtained from the surface of 1 m^2 of solar collector:

$$\text{Q}_{\text{useful}} = F \cdot q_p^{\Sigma} \cdot \eta = 1 \cdot 800 \cdot 0{,}6 = 480\, W = 0{,}48\, \kappa W$$

If the power per 1 m^2 of collector surface is 0,48 kW, assuming that the maximum heat load of a model house in winter is 8.1 kW, for a house with a surface of 144 m^2, the installation of a collector with a common surface is required:

$$\text{F}_{\text{col}} = Q / Q_{useful} = 8{,}1 / 0{,}48 \approx 17 \quad m^2.$$

This means that a solar collector with a surface area of 17.0 m^2 is required to provide a full heat load (8.1 kW) using a solar collector. However, in winter, the sunny period of the day is extremely short and there are many cloudy days, causing other types of problems in the heating system. To solve these problems, it is necessary to keep the water heater running. In this case, the hydraulic resistance of the heating system increases and a rapid failure of the pump is observed.

As a result of the experiments, graphs of solar radiation on the surface of the flat solar water heating collector applied to the hot water supply system in summer mode (July 15, 2020), changes in water temperature, collector performance and efficiency during sunny days were constructed (8-11-Fig) [21,22,23].

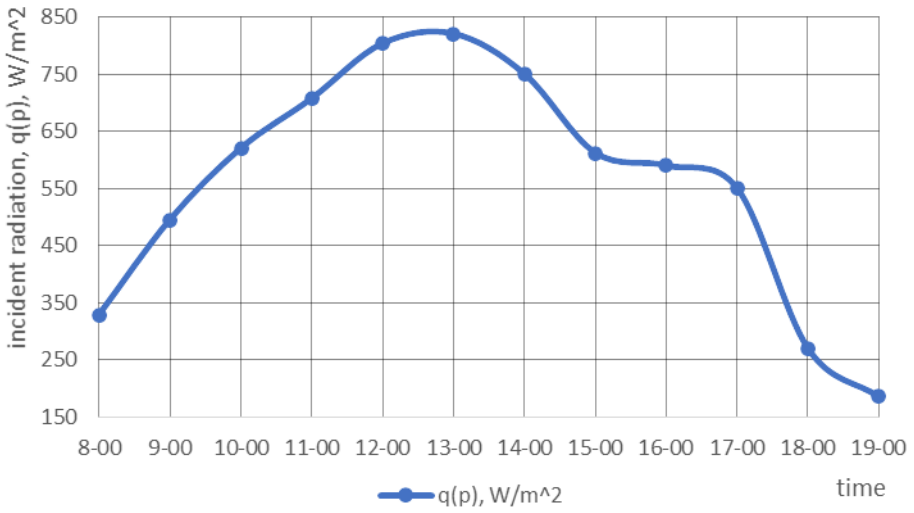


Figure 8. Graph of change of solar radiation incident on the surface of the Solar Collector.

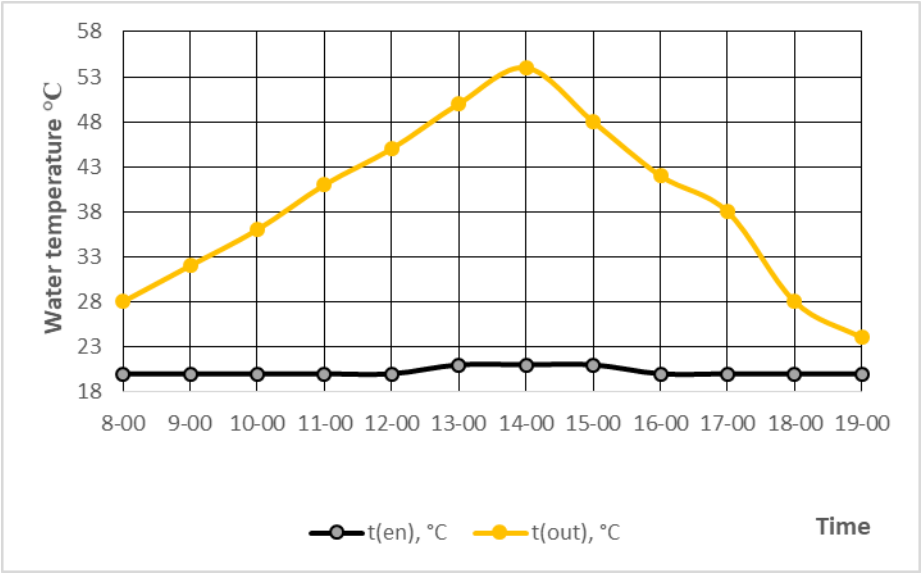


Figure 9. Graph of water temperature change at SC inlet and outlet for HWS system.

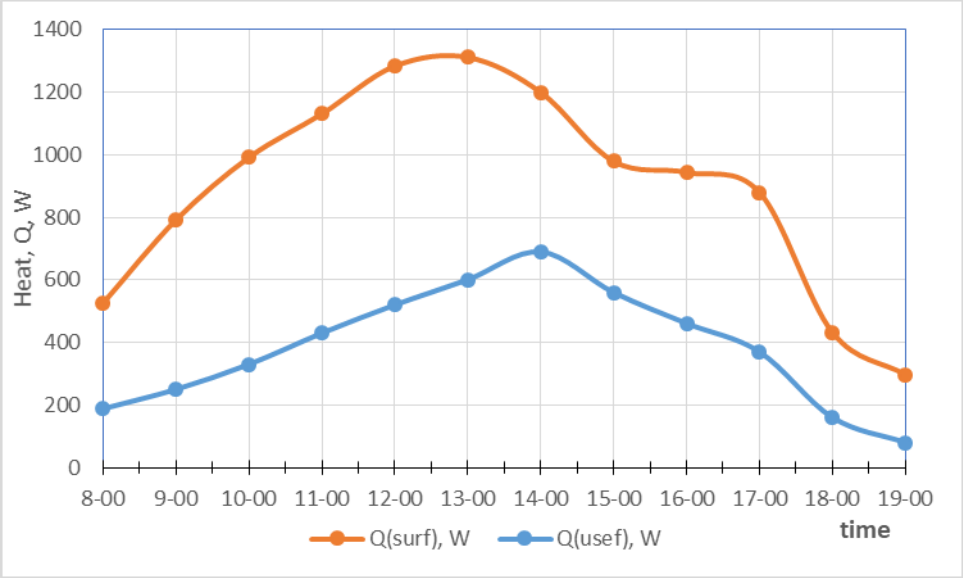


Figure 10. Solar Water Heater Heat Productivity Graph.

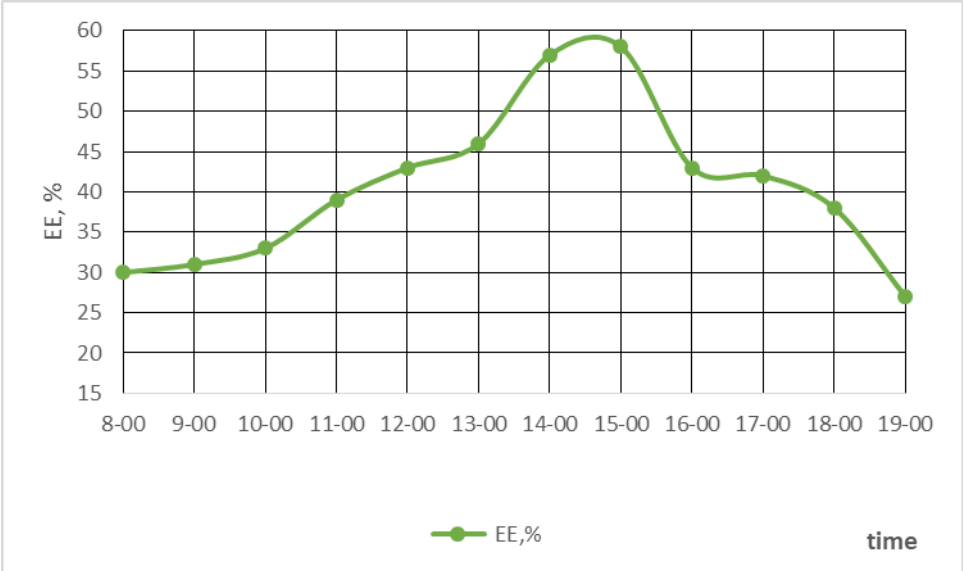


Figure 11. Graph of change of efficiency of flat solar water collector.

CONCLUSION

Heating houses in the rural areas by solar energy and characteristics of those were extensively conducted in the south of Uzbekistan. According to the analysis of the data, the heat load of one storey house was 6-8 kW, consisting of 19008-25344 kW per hour (132-176 kW per hour/m^2) in winter. Additionally, the result indicated that heat load in the hot water system was 50-60% in winter, but heat load from solar energy consisted of 100% in summer.

According to the data analysis collected from the experiments carried out with the issues on flat collector in the heat system, the indication of the temperature of hot water flowing from collector 50-60 degrees in summer, this showed 50-60 % EE of collector. Heater water pan indicated 70% in the night and cloudy days, heat load (54 kg/per day), solar heating collector consisted of 30%. As a result, we economized coal, 23 kg per day

(0.75$). During heating season (132 days) , we found that 3036 kg or 112$ (1kg of Angren coal which cost 0.15$ according to the statistics in 17.06.2020.)

REFERENCES

Resolution of the President of the Republic of Uzbekistan dated May 26, 2017 No PP-3012 "On the program of measures for further development of renewable energy, energy efficiency in the economy and social spheres for 2017-2021."

Resolution of the President of the Republic of Uzbekistan dated November 8, 2017 No PP-3379 "On measures to ensure the rational use of energy resources."

Podolyan L.A., Energy efficient residential buildings of a new generation. Abstract of dissertation of candidate of technical sciences.

S.V. Onishenko Self-contained energy efficient residential buildings of the manor type. Abstract of dissertation of candidate of technical sciences.

Ivanov G.S., Podolyan L.A. Energy saving in buildings .// "News of heat supply". 2001. No. 7. S.8-13.

Onishchenko S.V. Self-contained energy efficient manor buildings. // Housing construction. 2008. No. 7. P.7-8.

https://nuz.uz/ekonomika-i-finansy/35155.

Zakhidov R.A., Kiseleva E.I., Orlova N.I., Tadzhiev U.A. Combined use of solar, wind and watercourse energy is the basis for creating reliable energy supply systems in Uzbekistan. // Fundamental and applied questions of physics. Proceedings of the conference dedicated to the 60th anniversary of ANRU and FTI, Tashkent, 2003. p. 103.

Uzakov G.N. Khuzhakulov S.M. Investigation of temperature regimes of a helium-air heating installation for systems of thermal regeneration of adsorbents. // Solar technology. - No. 1. 2017.40-43 p.

Khujakulov S.M., Uzakov G.N. Research of thermo moisten mode in underground vegetable storehouses in the conditions of hot –arid climate. //European science review. – Premier publishing s.r.o., Austria, 2017. – №11-12. pp. 164-166.

Khujakulov S.M., Uzakov G.N., Vardiyashvili A.B. Effectiveness of solar heating systems for the regeneration of adsorbents in recessed fruit and vegetable storages. //Applied Solar Energy. – USA. 2013. – vol.49, № 4. – pp. 257-260.

Uzakov G. N., Aliyarova L. A., Davlonov Kh. A., Toshmamatov B. M., Khusenov A. A. “The use of Solar Energy in Systems of Heat-Moisture Treatment of Air of Heliogreenhouse”. International Journal of Mechanical and Production// Engineering Research and Development (IJMPERD)// ISSN (P): 2249-6890; ISSN(E): 2249-8001// Vol. 10, Issue 3, Jun 2020, pp.3813-3820.

Uzakov G.N. Technical and economic calculation of combined heating and cooling systems vegetable store-solar greenhouse// Applied Solar Energy. – Allerton Press, USA, 2012. –vol.48, №1. –PP. 60-61.

Uzakov G.N., Aliyarova L.A., Toshmamatov B.M. Solar heating system for heat and humidity treatment of air in solar greenhouses. “The development of science and technology”. №4 / 2019. 87-92 pp.

Avezov R.R., Orlov A.Yu. Solar heating and hot water systems. - Tashkent, Fan. -1988. -288 p.

Kamenev P.N., Skanavi A.N., Bogoslovsky V.N. Heating and ventilation. Textbook for universities. M., Stroyizdat, 1975.483 p.

https://books.google.co.uz/books?id=cjdOCQAAQBAJ&pg=PA21&lpg=PA21&dq.

Savelyev A.A. House heating. Calculation and installation of systems. Adelant Publishing House LLC, 2009, 120 pages

Duffy W.J. Thermal processes using solar energy. - M .: Mir, 1977 .- 413 p.

Uzakov G.N., Toshmamatov B.M., Kodirov I.N., Shomuratova S.M. On the efficiency of using solar energy for the thermal processing of municipal solid waste.// *Journal of critical reviews*. ISSN- 2394-5125 VOL 7, ISSUE 05, 2020: Pp 1887-1892.

Toshmamatov B.M., Uzakov G. N, Kodirov I. N& Khatamov I. A. Calculation of the heat balance of the solar installation for the thermal processing of municipal solid waste.// *International Journal of Applied Engineering Research and Development* (IJAERD) ISSN (P): 2250–1584; ISSN (E): 2278–9383 Vol. 10, Issue 1, Jun 2020, India. PP. 21–30.

A.Sychov, V.Kharchenko, P.Vasant, G.Uzakov. "Application of various computer tools for the optimization of the heat pump heating systems with extraction of low-grade heat from surface watercourses".//International Conference on Intelligent Computing & Optimization. 10.4. (2018) Springer, Cham: 310-319.

G.N. Uzakov. "Calculation of the heat engineering characteristics of a combined system of a vegetable storage facility and solar greenhouse". // Applied Solar Energy 47.3 (2011): 248-251.

V.V. Kharchenko, A.O. Sychov, G.N. Uzakov. "Innovative Instruments for Extraction of Low-Grade Heat from Surface Watercourses for Heating Systems with Heat Pump". // Innovative Computing Trends and Applications (2019): 59-68.

G.N. Uzakov. "Efficiency of the use to energy of the biomass for autonomous power supply fruit-vegetable-vault". Europaische Fachhochschule ORT Publishing (2015): 92-94.

G.N. Uzakov, A.B. Vardiyashvili. "Intensity influence of solar radiation on shrinkage of goods in fruit and vegetable stores". Applied Solar Energy 47.1 (2011): 27-30.