HOT WATER SUPPLY AND HEATING OF PREMISES BY SOLAR ENERGY GENERATION USING A SOLAR COLLECTOR

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Abstract. Solar installation is a modern ecological method of obtaining and subsequent use of thermal energy from the sun. In this scientific article, two different solar collectors were selected for room heating and hot water supply. To determine the most efficient solar collector, comparative calculations of several collectors were carried out. Experiments and calculations were carried out to determine at what angle it is better to install the collector on the roof of the house. It was found that the most effective when installing a solar collector is the angle of inclination to the horizon of 35℃. Using this angle, the average monthly coefficient was calculated and a dependency graph was plotted. The total costs and payback periods of solar collectors are determined. It is scientifically proven that the service life of the SCH-20 solar collector is about 15 years, and this collector can justify its price within 3 years. It was estimated that the service life of the ATMOSFERA CBK TWIN POWER collector is 25 years, and this collector can justify its price within 4.5 years. Since 4 people live in the house in question, it is established that 20.47 kW of energy per hour is consumed for daily heating of 40 liters of water. The results and calculations in this article will allow anyone to reliably and easily install a solar collector in their home.

Keywords: alternative energy; structural elements; vacuum solar collector; infrared radiation; boiler; bending angle; payback time; efficiency.

Introduction.

The results of research in this area, on the one hand, are useful for reducing energy costs and are an urgent problem of our time, and on the other hand, they are effectively used in any industry, manufacturing, large stations, universities, substations and companies producing natural electricity. The study of the principle of operation of solar collectors is the basis of modern alternative energy sources and renewable energy sources [1]. Photovoltaics convert light into electric current using a photoelectric effect.

A solar collector is a device designed to store thermal energy from a solar source carried by light and infrared rays. The total consumption of solar collectors and payback time are determined. The service life of the Atmosfera CBK Twin Power collector is 25 years, and the consumption is

1,214,734 tenge, which allows the collector to justify its price in 4.5 years, and according to calculations, the most effective solar collector is Atmosfera CBK Twin Power. In addition, it was found that the bending angle of the horizon when installing the solar collector is better taken as β = 35°C.

Materials

Description of the vacuum solar collector and determination of the solar energy entering the surface of the inclined collector

A solar collector is a device designed to accumulate the thermal energy of a solar source carried by light and infrared radiation [2].

The vacuum solar collector is the most interesting type of equipment. These collectors have two fundamentally different designs: tubular and flat solar collectors.

Due to the insulating properties of the vacuum, the low external temperature and the slight effect of wind on the vacuum are different from flat devices. Systems with solar collectors of this type can operate up to -35°C. In order for the vacuum inside the tubes to remain as long as possible, it is necessary that one end of it be covered with a thick layer of barium [3]. It absorbs gases generated during use and storage of the device. At the same time, barium is a kind of indicator. If it changes color from silver-white to white, there will be no vacuum in the tube, which means that it will need to be replaced with a new one. You don't need to stop the whole system to replace it. In addition, if one of the tubes fails, the collectors will continue to work the same way as before. If necessary, you can add an additional tube to the system or remove the excess.

To maintain a vacuum in a solar water heater, a gas cleaner is used, which is formed in the production environment under the influence of high temperatures, as a result of which the lower end of the vacuum pipe is covered with a clean layer of barium. It absorbs CO, CO_2, N_2, O_2, H_2O, H_2, which exits the tube during storage and use [4] and is a clear visual indicator of the vacuum state in the solar collector tube. When the Vacuum disappears, the silver barium layer turns white. This simplifies the way to determine the integrity of the water heater pipe through the vacuum collector.

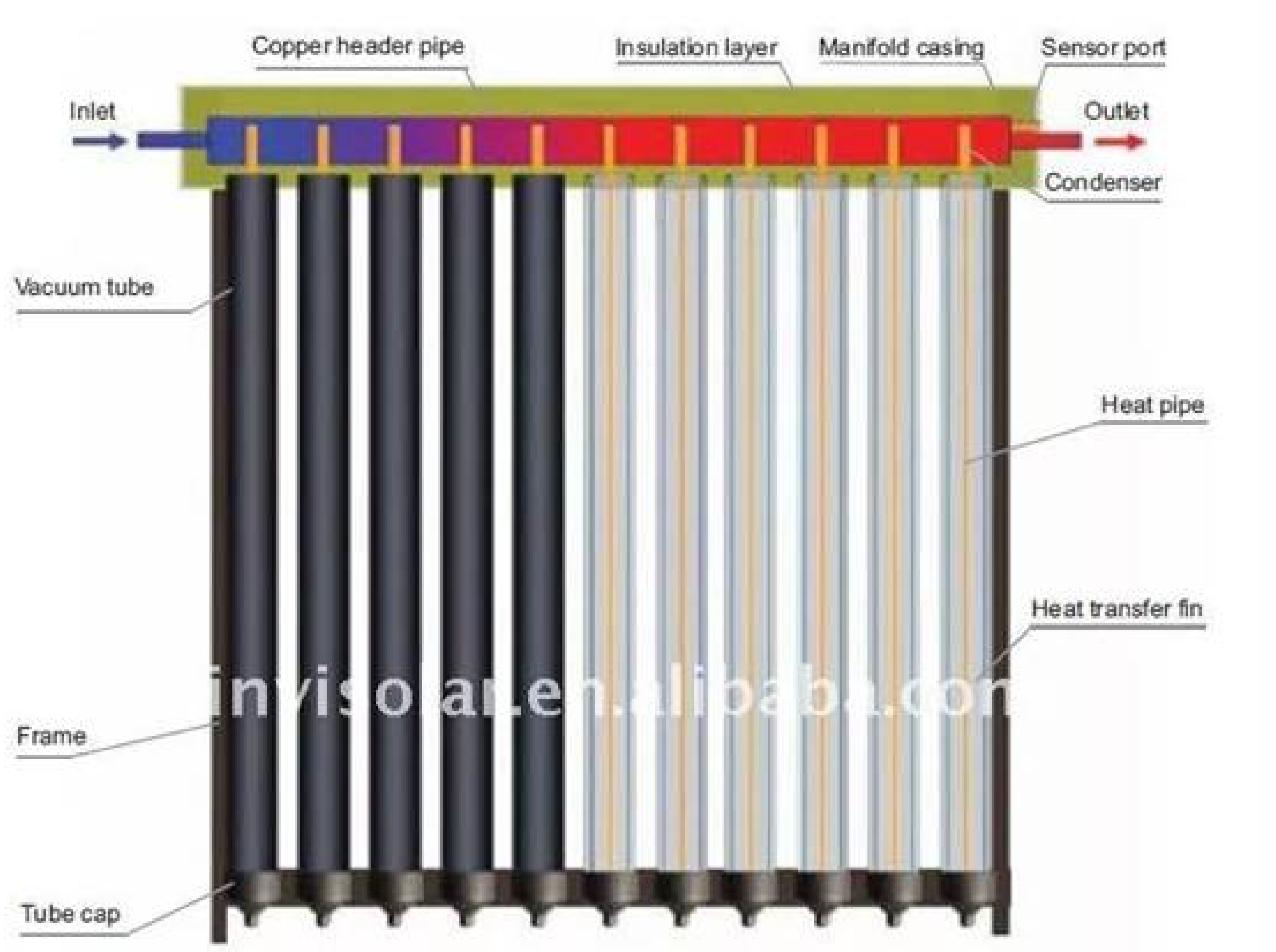

Figure 1. Device of a vacuum solar collector [5]

The main problem of vacuum collectors: maintaining the vacuum at the required level throughout the entire period of operation (in the case of a flat vacuum collector, special pumps are installed). This problem is well solved on tubular type collectors.There is a special non-toxic liquid inside the smaller diameter copper pipe. When heated, it evaporates. Steam rises to the very top of the tube, up to the tip. There it transfers heat to the heat carrier in the heat pipe [6]. Thanks to the vacuum located between the tubes, the non-toxic liquid evaporates from the outside even at a temperature of -30°C. The liquid condenses on the walls of the pipe and drains again. Then the process repeats again. All pipes are arranged in parallel. The angle of inclination will depend on the installation location of the system and the geographical latitude of the object. The panel should be facing south.

An important part of the vacuum collector are: heat pipes. Outside is a list of aluminum glass pipes. Each pipe consists of two tubes of different diameters and has a vacuum between them [7]. Consequently, the coolant inside it is better protected from the effects of ambient temperature.

Advantages of vacuum solar collectors:

- convenient installation;
- maintenance becomes easier;
- less heat loss;
- long service life;
- universal;
- efficiency will be high throughout the year;
- the maximum possible coefficient of operational effect during the maiden season.

Disadvantages:

- low optical (maximum) efficiency;
- inefficient work in areas where temperatures may be below zero (frost formation and snowfall);
- large weight and the same size for the same area as the absorbing element;
- individual tubes must be replaced periodically, due to the loss of vacuum in some tubes, these collectors may work worse than flat solar collectors.
- snow cannot be cleared by itself, and the minimum angle of inclination must be at least $20^{o}C$.

Methods

When installing a solar system in a house, it is necessary to correctly plan the direction of the main cracks relative to their entry into the building. This will help you choose the optimal place for installing solar collectors and develop the maximum amount of power. When installing a solar collector on the roof, special attention should be paid to these several important factors: the angle of inclination, the angle of inclination of the solar collector to the horizon, the absence of windows or the absence of objects that prevent the installation of the solar collector [8]. In addition, it is necessary to take into account the geographical latitude and longitude of the local place where the solar system is installed. At first, there is a need to determine the main angles of incidence of sunlight. If we can choose an effective setting degree for the angle of inclination of the solar collector to the horizon, the collector will be able to absorb a large amount of solar energy and perform more useful work. To find out, calculations were carried out in this work by taking the bending angle of two different horizons. At first, this angle was obtained as $\beta = 35^{o}C$. To find the angle of deflection of the sun, we used this formula:

$$\delta = 23.45 \cdot \sin\left(360\,\frac{284+n}{365}\right)$$

The average monthly coefficient of direct sunlight on a horizontally inclined surface:

$$R_n = \frac{\cos(\phi-\beta)\cdot\cos\delta\cdot\sin\omega_{en} + \frac{\pi}{180}\cdot\omega_{en}\cdot\sin(\phi-\beta)\cdot\sin\delta}{\cos\varphi\cdot\cos\delta\cdot\sin\omega'_{en} + \frac{\pi}{180}\cdot\omega'_{en}\cdot\sin\varphi\cdot\sin\delta}$$

The total monthly average daily amount of solar energy entering the inclined surface:

$$E_c = E\Box R$$

Taking the collector angle to the horizon equal to $40^{o}C$, according to the formulas (1), (2) [11] recalculations were made for the total number of daylight hours falling on the inclined surface of each month.

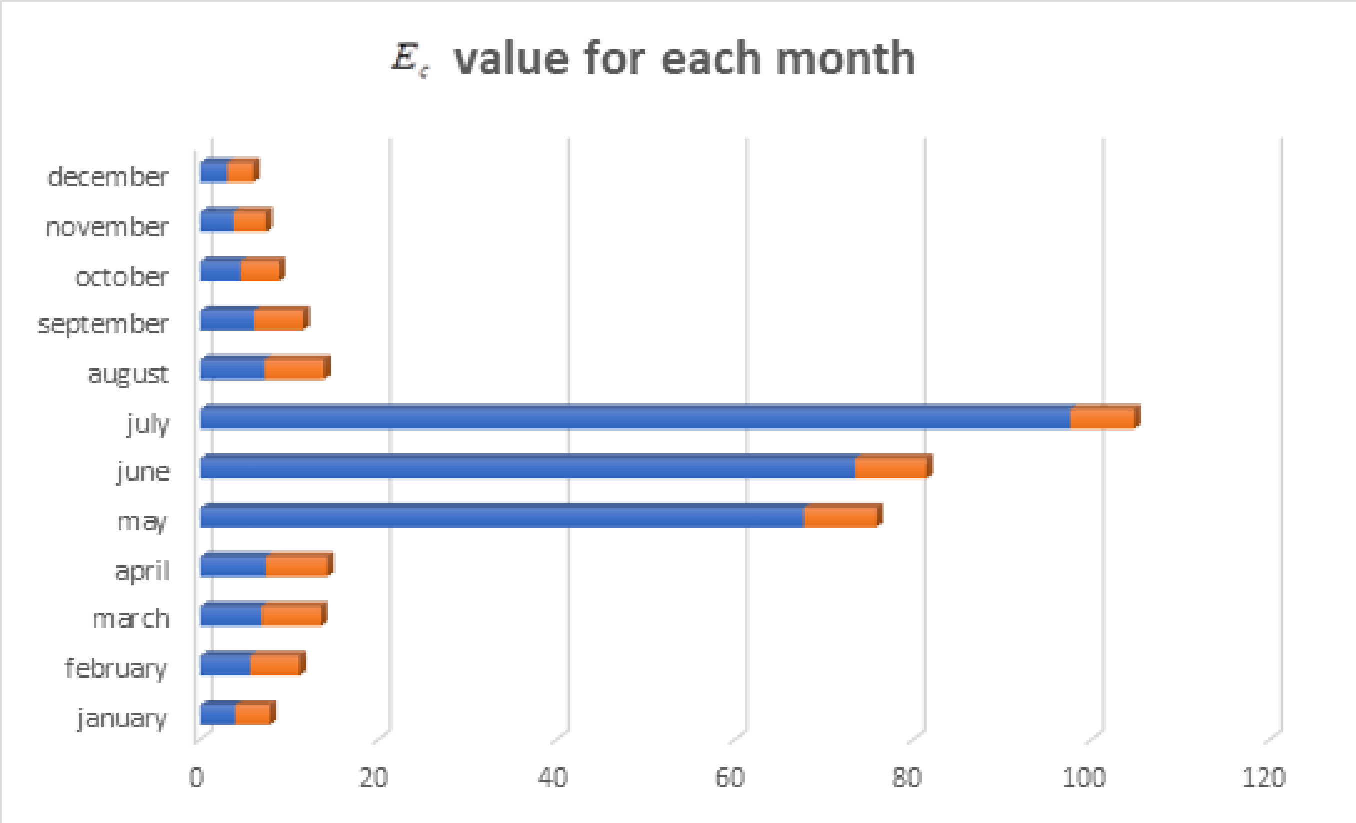

Figure 2. Comparative graph of the total amount of daytime falling on the sloping surface for each month with the angle of inclination of the collector to the horizon β = 35℃ and $\beta = 40^{\circ}C$

Based on the results of the above graphs and calculations, it was found that it is effective to take the angle of inclination to the horizon equal to $\beta = 35^{\circ}C$.

Determination of the boiler volume and calculation of the amount of energy consumed per hour

The volume of the boiler is determined by the formula [9]:

$$V = k_G \cdot I \cdot n = 2 \cdot 4 \cdot 40 = 320 \text{ L}$$

where, (l) is the number of people living in the house, (4 people)

(k_G) is an additional coefficient, $(k_G = 2)$

(N) is the volume of water used per day, (40 L)

To determine the amount of energy, it is first necessary to determine the temperature difference: to convert a kilogram of calories into a kilowatt-hour, we use the expression: 1 kW*H = 859.8 Kcal.

$$\Delta T = T_2 - T_1 = 70 - 15 = 55°C$$

To convert a kilogram of calories into a kilowatt-hour, we use the expression [14]: 1 kW*H=859.8 Kcal.

$$Q = \frac{Q_{kcal}}{859.8} = \frac{17600}{859.8} = 20.4 \text{ kW*H}$$

Thus, it was determined that about 20.47 kW*H of energy is consumed to heat 40 liters of water per hour.

Determination of the operating time of the vacuum collector "ATMOSFERA CBK TWIN POWER"

Table 1

Collector flow rate

Name	Price	Quantity	Aull amount
Collector	316 617	2	633 234
Boiler	481 500	1	481 500
Installation	100 000	1	100 000
			1 214 734 tg.

The tariff for electricity is 19 tenge per 1 kiloWatt-hour. This is according to the tariff "AlmatyEnergoSbyt". Daily electricity consumption for heating hot water with a boiler (boiler power 4 kilowatts, water heating time 6 hours):

$$Q = Q \cdot t = 4 \cdot 10^3 \cdot 6 = 24 \text{ kW*H}$$

And the annual electricity consumption is:

$$Q = Q \cdot 365 = 24 \cdot 10^3 \cdot 365 = 8760 \text{ kW*H}$$

Consequently, 8760 kiloWatts*19 tenge = 166,440 tenge is spent per year.

To determine the payback time of a solar collector compared to an electric heating plant, you must deduct the cost of the boiler from the cost of the solar installation and divide the amount received by the annual electricity bill [10]:

$$\frac{1214734 - 481500}{166440} = 4.5 \text{ year}$$

In conclusion, as a result of calculations, it was found that the total service life of the Atmosfera CBK Twin Power solar collector is 25 years and justifies its price for 4.5 years.

Determination of the payback time of the vacuum collector "SCH-20"

Table 2

Collector flow rate

Name	**Price**	**Quantity**	**Aull amount**
Collector "SCH-20"	179 173	2	358 346
Boiler	481 500	1	481 500
Installation	100 000	1	100 000
			939 846 tg.

The daily and annual cost of electricity, defined above, is taken into account, then the amount of payment for one year is 166,440 tenge. The payback period is defined as:

$$\frac{939846-481500}{166440}=2.758\approx 3$$ year

The service life of the "SCH-20" solar collector is 15 years, and after 3 years the installation can justify its price.

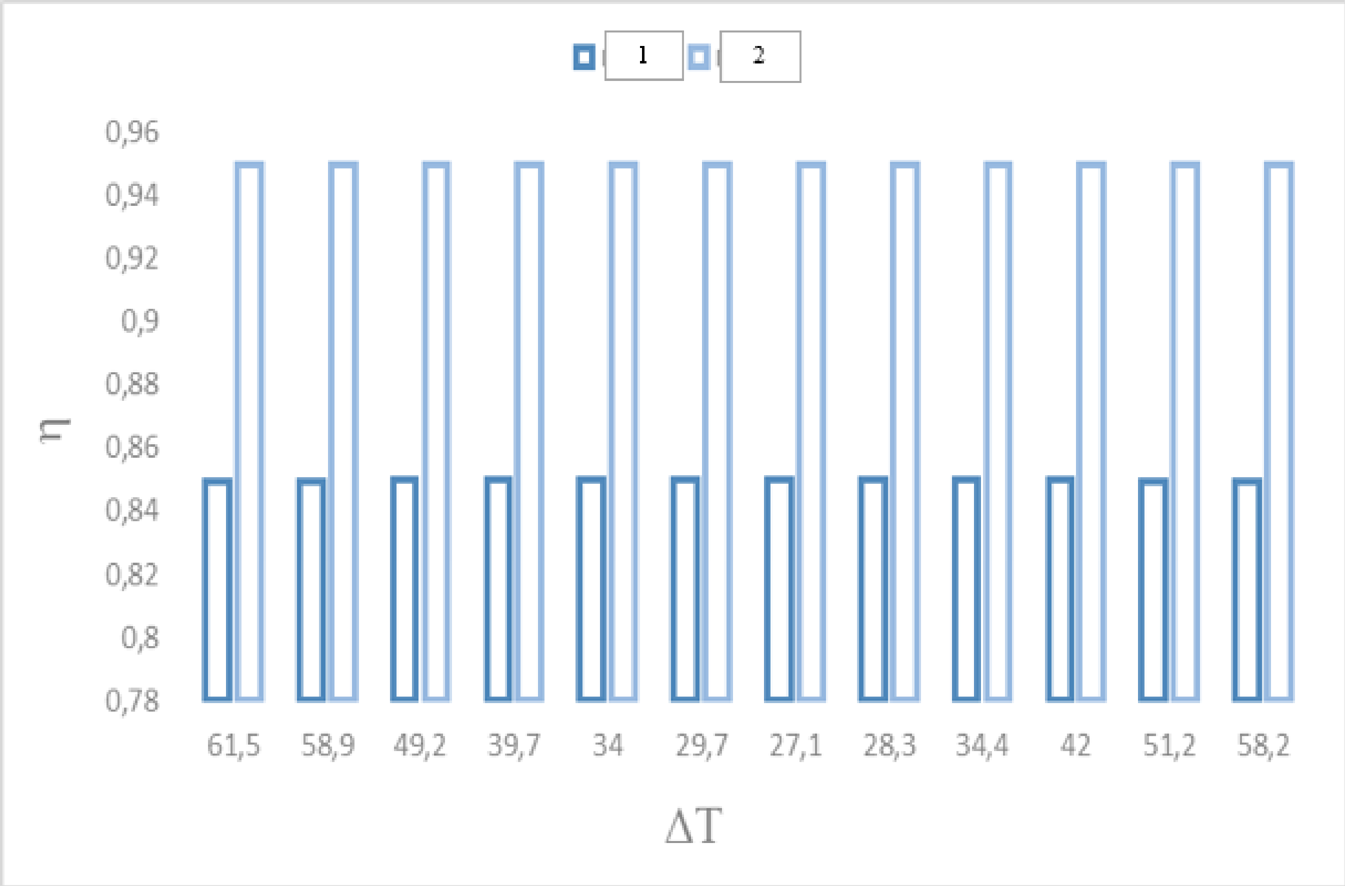

Figure 3. Comparative graph of the dependence of the efficiency coefficients of the vacuum solar collectors "SCH-20" and "ATMOSFERA CBK TWIN POWER" on the temperature difference

Conclusions

Solar energy production-works by converting sunlight into electricity. The vacuum solar collector is the most interesting type of equipment. These collectors have two fundamentally different designs: tubular and flat solar collectors.

1.In this scientific article, a solar collector was selected for heating and hot water supply in the room. To determine the most efficient solar collector, calculations comparing several collectors were carried out.

2. First of all, it is determined at what angle to install the collector on the roof of the house. The angle of inclination of the solar collector to the horizon was obtained as $35^{\circ}C$. Using this angle, the average monthly coefficient for calculating sunlight, the ratio of the daily amount of solar radiation entering the inclined and horizontal surfaces, and the average monthly total amount of scattered sunlight falling on the inclined surface for each month were calculated and a dependence graph was plotted.

3. The total costs and payback time of solar collectors are determined. Since the service life of the solar collector " SCH-20 " is about 15 years, and the consumption is 939,846 tenge, this collector can justify its price within 3 years.

4.The service life of the "ATMOSFERA CBK TWIN POWER" collector is 25 years, and the consumption is 1,214,734 tenge, which allows the collector to justify its price in 4,5 years.

5.It was found that the boiler used in the solar collector system has a volume of 320 liters and a temperature difference of 55°C. It is established that, since 4 people live in the house to be calculated, 20.47 kW of energy per hour is consumed for daily heating of 40 liters of water.

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