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EFFICIENCY OF USING SOLAR COLLECTORS IN ENERGY SAVING AND SAVING ENERGY RESOURCES

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Abstract: *Most manufacturers, suppliers and installers make only a rough calculation of solar collectors. The article goes step-by-step calculation, solar systems for heating, in order to fully provide the house with warmth in winter. Calculation of the real power of the solar collector. Calculation of the efficiency of the solar collector in the direction. Calculation of solar collector performance by installation angle. Features of flat panels. The performance of the vacuum manifold. How many solar collectors do you need to heat your home? Hot water connection*.

Keywords*: solar collectors, flat panels, vacuum manifold, vacuum collector, solar panel, and insolation.*

INTRODUCTION. “The development and well-being of the city, the success of the nation, and the progress of the entire human race is determined by the available energy. We should not be satisfied with simply improving steam engines or inventing new batteries. We have something better to work for, a greater challenge. We must develop methods of obtaining energy from sources that are inexhaustible, improve methods that do not require the consumption and expenditure of any materials "Nikola Tesla" Mission of Science ", 1900. [1].

Energy production from the processing of hydrocarbon fuels causes serious damage to the nature and health of all living beings inhabiting our planet, the Earth. In addition, hydrocarbon fuels are not unlimited. Such a disappointing forecast makes countries that produce hydrocarbon fuels think about switching their activities to more environmentally friendly, technologically advanced industries that do not require hydrocarbon fuels. It is time to think about switching to cleaner forms of energy [2]. The solar heat that we have in abundance (300 days a year), and its proper use, is not only a benefit in monetary terms, but also a benefit for humanity, which is slowly but surely destroying nature with harmful emissions into the environment ... So, how to use this priceless gift to your advantage [3].

The use of solar collectors for the heating system is a way to significantly save on home heating. Solar radiation is free and available to everyone, and the cost of solar systems is constantly decreasing. The correct calculation of the solar collector for home heating will allow you to avoid unnecessary equipment costs and organize an efficient building heating system.

Manufacturers indicate the maximum capacity of the solar collector in full light, when facing south and oriented perpendicular to the sun at noon. But it is not always possible to direct the panels in this way, especially if they are installed on the roof of the house.

MATERIAL AND METHODS. Below are formulas that are universal and can be used both to calculate the number of collectors and to calculate the total area in square meters. It is possible to calculate the base heat output of a solar flat plate or vacuum collector using the following formula:

$$P_v = \sin A \cdot P_{max} \cdot S \qquad (1)$$

-P_v – solar collector power;

-A – deviation angle of the solar collector plane from the direction to the south;

-P_{max} is the average level of insolation in the region during the cold season.

Even if the sun is not obscured by clouds, during the day the level of insolation changes, which affects the performance of the collector flat plate solar collector has a small heat loss through the back wall, which averages 5 W per square meter. Therefore, from the previously obtained value of the real power P, it is necessary to subtract 5 W per square meter of area.

The level of absorption of solar radiation by a flat solar collector is below 100%. This must be taken into account when calculating its thermal power. If the panel absorbs only 95%, then its real power:

$$P = P_m \cdot 0.95 \cdot S \qquad (2)$$

Designations:

-P_m is the collector power from the formula above;

-P – real collector productivity;

-S – collector area.

Manufacturers of vacuum collectors may specify the capacity of the collector without taking into account the distance between the tubes. To determine what is the actual surface area of the tubes and the performance of the vacuum collector, we use the formula:

$$P = P_m\, D/L \qquad (3)$$

Designations:

-P is the actual performance of the solar collector;

-P_m – collector power calculated earlier;

-D – diameter of vacuum tubes;

-L is the distance between the tubes.

With this type of collectors, everything is much more complicated. Now they are not very common, manufacturers are experimenting with materials and selective coatings. Different models differ in the level of absorption and heat loss.

By dividing the obtained data by the value of P, calculated according to the last formula, you can find out how many solar collectors or square meters of collectors are needed to provide heating for the house in winter.

The main problem in winter is to clean the collectors from the cold.

In addition to heating, hot water can be connected to the collector solar system. To do this, we calculate how much heat energy needs to be spent every day:

$$P_w = 1{,}163 \cdot V \cdot (T - t)/24 \quad (4)$$

Designations:

-P_w is the amount of heat required to heat water;

-V – average volume of consumed hot water per day;

-T – temperature to which it is necessary to heat the water;

-t is the temperature at which water enters the system.

To calculate the required number of additional DHW collectors, divide this value by the solar collector capacity P, obtained by the last formula. Flat solar collectors are more efficient in the warm season, while vacuum solar collectors are more efficient in winter. Depending on the model and manufacturer, the difference can be up to 50%. In case of an unforeseen situation, it is worth having alternative sources of thermal energy convectors, a gas or solid fuel boiler, a heat pump. Collectors are usually supplied with separate storage tanks. It will be more profitable to purchase separately flat or vacuum panels and one or two large tanks with good thermal insulation. The smaller the volume of the tank, the faster it cools down.

Table 1

Solar insolation in Tashkent

	January	February	March	April	May	June	July	August	September	October	November	December
Average daily solar radiationk Wh/m^2	2,91	3,98	4,67	5,42	6,23	6,92	7,83	8,08	7,01	5,05	3,68	2,45

To organize efficient heating, it is worth having a large storage tank in which collectors will heat water during daylight hours, and at night it will be used to heat the building. The presence of a high-quality controller in the heating system will allow you to maintain the desired temperature, regulate circulation, set the temperature regime, set the on timer. For autonomous heating of a house with solar collectors, it is necessary to purchase a large amount of equipment, pay for its installation and connection. If you cannot afford it, you can use solar collectors as an auxiliary heating system.

Good savings can be achieved if solar collectors are used in tandem with a heat pump. They will heat the water, and the heat pump will heat it up to the required temperature. If the building is poorly insulated, it is more efficient to use solar collectors with underfloor heating. It gives maximum heat to the room, and not to the walls, like heating radiators. Solar insolation is the irradiation of surfaces with sunlight, the flow of solar radiation to the surface; irradiation of a surface or space by a parallel beam of rays coming from the direction in which the center of the solar disk is currently visible.

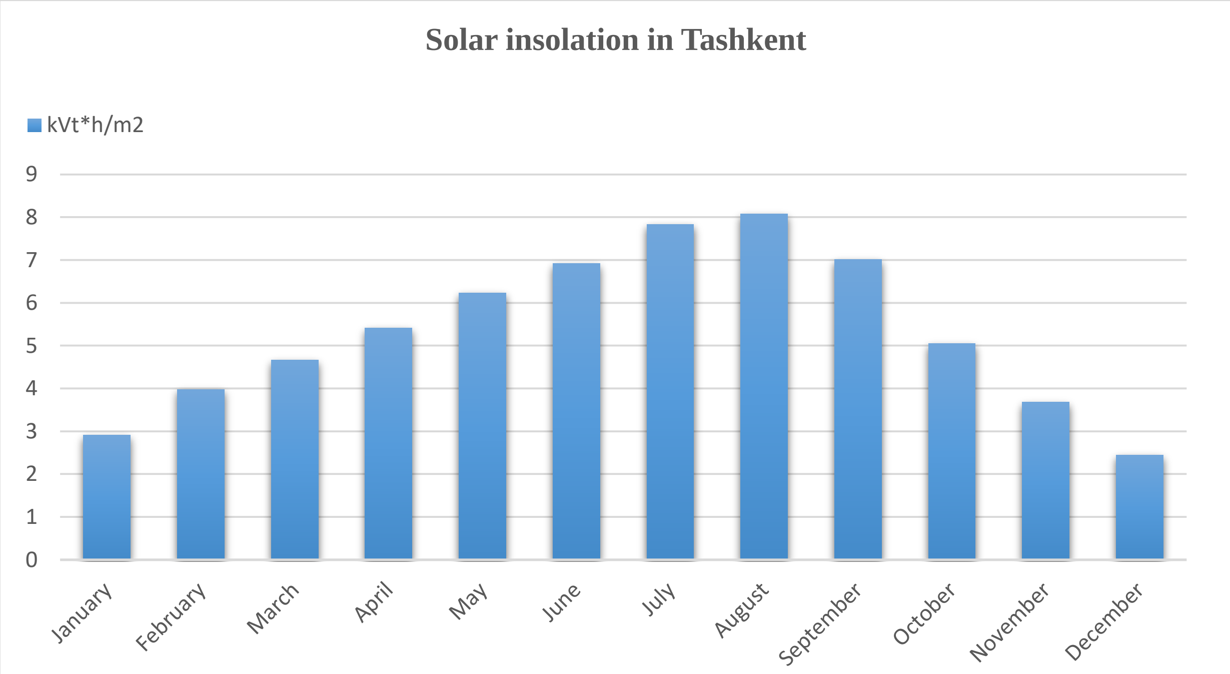

Fig. 1. Solar insolation in Tashkent [5]

Solar collector. For example, consider flat solar panels Vaillant VFK 135/2 VD (Germany). The area (absorber) of one collector is 2.33 m^2. How much heat can we get from one collector? To do this, we need to know the efficiency of the panel and solar insolation in a given period of time. This table shows the average solar insolation per day per 1 m^2 of surface area broken down by months. We take December the lowest indicator of insolation in the year is 2.45 kWh/day. The efficiency coefficient of one Vaillant VFK 135/2 VD panel is 78.5%. Therefore, one panel in the month of December (on average)

$$2{,}45 \cdot 2{,}33 \cdot 0{,}78 = 4{,}45 \text{ kWh/day} \quad (5)$$

(2.45 insolation in December, 2.33 solar panel absorber area, 0.78 solar panel efficiency). Now let's take an example in the month of July.

$$6{,}92 \cdot 2{,}33 \cdot 0{,}78 = 12.58 \text{ kWh/day} \quad (6)$$

In July, the duration of a sunny day is 15 hours, 12.58/15 = 0.83 kW/h. For example, this power is enough to heat two boilers of 100 liters each at an input temperature of 22 degrees to 65 degrees in 16 hours, thereby providing DHW (hot water supply) to a family of 3-4 people.

Payback of solar collectors. The higher the contribution of the installation to the consumption of thermal power by the consumer, the shorter its payback period. These are mainly cottages, hotels, sanatoriums, boarding houses and other objects where there is a large consumption of thermal energy for heating water, heating the pool, and supporting the existing heating system. For example, let's take a hotel with 15 rooms with a water consumption (50 degrees) of 2500 l/day. 50 people for 50 liters of hot water.

RESULTS AND DISCUSSION. Let's calculate the amount of heat (Q) for heating water from the current temperature (tт) to the set temperature (tз).

$$Q = G \cdot R_o \cdot C \cdot (t_т — t_з) = 2{,}5 \cdot 1000 \cdot 1 \cdot (50\text{-}22) = 70\ 000 \text{ kcal} \quad (7)$$

(2.5 m^3 of water, 1000 kg/m^3 water density, 1 water specific heat capacity, 50 heated water temperature, 22 initial water temperature). Convert kcal to kWh

$$(1000 \text{ ккал} = 1{,}16 \text{ kWh}).\ 70 \cdot 1{,}16 = 81{,}2 \text{ kWh} \quad (8)$$

To heat 2500 liters of water from 22 to 50 degrees, 81.2 kWh will be required. Based on the objects where solar panels with such water consumption are used, we calculate their payback. 10 panels of 2.33 m^2 of absorber area, we get a total area of 23.3 m^2. We consider the amount of heat in seasonal time (April-September). We give the maximum value (conditions for total consumption of 2500 liters of hot water per day).

23,3·0,78·5,42 = 98,50 kWh (April)
23,3·0,78·6,23 = 113,22 kWh (May)
23,3·0,78·6,92 = 125.76 kWh (June)
23,3·0,78·7,83 = 142.30 kWh (July)
23,3·0,78·8,08 = 146.84 kWh (August)
23,3·0,78·7,01 = 127.39 kWh (September).

The diagram shows that 10 panels are able to provide peak load during the summer season, April and September are unlikely to need peak loads for hot water preparation, and if necessary, there is an alternative source of heat, for example, an electric boiler. In total, for 6 months, in total, heating 2,500 liters of water from 15 to 50 degrees every day, a solar installation of ten flat panels is able to generate up to 17,300 kW of thermal energy during the holiday season.

Let's calculate on the example of heating water with electricity, 1 kW, take for example the cost of electricity for legal entities 450 soums. Total for the season spent/saved 17300·450=7785000 soums. To calculate the payback, you need to take the cost of the installation as a whole, including materials for installation, the cost of work. Each manufacturer of solar solar collectors has its own nuances, and its own cost. Next, it is worth dividing the amount of installation investment by 7785000 and get the number of years for which it will fully pay off. The amount of investments is 109 812 250 soums, payback = 14 years.

The initial temperature of the water entering the house from the water supply is 10 ° C, and the use of this water for needs (washing, showering, heating, cleaning, etc.) requires its heating. Of course, to warm it up to at least 40 degrees, you will need to spend energy gas, firewood, electricity, in a word, pay for its heating. In winter, the solar collector will be able to heat water from 40 to 70°C, and in summer up to 100°C. Let's try to figure out how effective the use of solar heating will be.

On a sunny day, for every square meter of the surface, which is installed perpendicular to the sun's rays, from 610 to 1963 watts of solar thermal energy falls within one hour [1]. Depending on the atmospheric condition. For example, let's take the average value, i.e. 1000 W/m2.

It takes approximately 1.16 watts to heat 1 kg (l) of water by 1 degree. Now imagine a solar collector whose area is 1 m2. The heat absorption of the side that faces the sun is almost 100%. From this it follows that a collector with an area of $1m^2$ will be able to heat the water by one degree:

$$1000 \text{ vt}/1{,}16 \text{ vt} = 862{,}07 \text{ kg water} \tag{9}$$

For convenience, we assume that

$$К=862 \text{ kg}\cdot\text{OC}\cdot\text{м}^2\cdot\text{hour} \tag{10}$$

This ratio shows how much water can be heated by how many degrees in 1 hour in a solar collector with an area of 1 m2. For example, a solar collector in a set consisting of 15 vacuum tubes with an area of 3m2. The most optimal volume of a thermos for the liquid of this collector is 150 liters. The duration of heating this amount of water to 45°C in the cold season is: *(*150 l·(45°C – 10°C))/(3 m^2·862 kg·°C·$м^2$· hour) = 5250/2586=2,03 hour.

To ensure the heating of 150 liters of water to a temperature of up to 45 ° C, a solar installation can take 2 hours. If we take into account the heat loss of the collector and the fact that the atmosphere is not always clean and transparent, and the solar collector is not perfectly clean, then the heating time in winter increases to 4 hours. Let's carry out a calculation for heating a given volume of water with electricity.

$$t = (m \cdot c \cdot \Delta\vartheta)/ (P \cdot \eta) \tag{11}$$

where, t is the heating time in hours=1h.c.=1,163 (Watt/h)/(kg·K), m - amount of water 150 kg, P - power in W, η efficiency = 0.98, $\Delta\vartheta$ - temperature difference in K (ϑ_2 - ϑ_1) = 35°C ϑ_1 - cold water temperature at 10 °C ϑ_2 - hot water temperature at 45°C. P=(m·c·Δϑ)/(t·η) = (150·1,163·35)/ (1·0,98) =6230 Watt=6,23 kWh.

Therefore, in order to heat up 150 liters of water with the help of electricity, taking into account heat losses, payment is from 7 to 8 kWh. * 450 soums = from 3150 to 3600 soums, and for 300 liters - from 6300 to 7200 soums. To summarize: in winter, one solar collector, whose area is 3 m^2, will save your expenses from 6300 to 7200 soums per day. Let's calculate the consumption of hot water for a family of three people. If the day starts with a 10-minute shower for each of the family members, then the use of warm water is 8 liters per minute. Therefore, the shower takes:

$$3 \text{ people}\cdot 10 \text{ min}\cdot 8 \text{ l/min}=240 \text{ liters of warm water} \tag{12}$$

Next is breakfast, after which it takes about 15 minutes to wash the dishes with a consumption of warm water of 3 l/minute. So, in order to wash the dishes, you need:

$$15 \text{ minutes}\cdot 3 \text{ l/min}=45 \text{ lite.rs of warm water} \tag{13}$$

If we assume that in the evening the water consumption will be approximately the same, and also add cleaning, laundry and other needs, then we will add another 100 liters. As a result, the consumption of warm water in the morning or evening will be: 240+45+100=385 liters.

Calculations show that, on average, one family member has 100-150 liters of hot water per day. Then, in order to provide the family with hot water during the cold season, you will need two collectors and a 300-liter tank. If you plan to make the most of solar heat and use it for heating, then you are recommended to buy six collectors and a storage tank for 500 liters of water. A solar installation is very efficient and you can save a significant amount of money.

The above calculation is a simplified calculation, which is based on the winter period, and with the advent of spring and summer, solar activity will increase significantly, therefore, the efficiency of such equipment will increase. In summer, a person is more active and uses hot water more: takes a shower, pool, washes dishes, does laundry, etc. In summer, the water temperature rises from 60 to 95 ° C, and then a new question arises. arises - where to put excess water, but you should remember that you will not pay money for heating it.

Bottom line: in a warm sunny period, the efficiency of using a solar plant doubles, and a six-collector solar plant with an area of 18 sq.m. will save from 12150 to 27000 soums per day in the cold season and from 24300 to 54000 soums per day in summer. If the number of cold and warm days in a year is approximately the same, then a calculation can be made in which the savings will be from:

$$(12150+27000)/2=19575, \text{ to } (24300+54000)/2=39150 \qquad (14)$$

now multiply by 365 days and get the amount from 7144875 to 14289750 sums a year [4].

Full payback of all costs for the purchase of solar equipment can be expected from one to two years. When buying a collector solar installation, you pay only once. Its service life is from 15 to 25 years, despite the fact that it works constantly.

It is possible to heat 1 kg of water by 1 degree by spending 1.16 Watt/h. This means that it is possible to heat a ton of water by 30 degrees (from 20 to 50) by spending

$$1.16 \cdot 1000 \cdot 30=34800 \text{ Watt/h} \qquad (15)$$

It is believed that the minimum power at which the solar system will work even more or less is 100 W/m². In summer in Uzbekistan, the arrival of solar energy is approximately 7 kWh/m², taking into account the average efficiency of the solar collector of about 60%, we get 4.2 kWh of energy from 1 m² of the solar collector. On average, up to 15-30% more energy can be obtained from a vacuum collector during the year than from a flat one, and this additive will be due to more efficient operation at low temperatures (that is, just when it is necessary to maintain the heating system and heat most needed). On the other hand, this increases the cost of the system. The expediency of installing vacuum or flat collectors is decided in each specific case.

In autumn-spring, the average monthly solar radiation per 1 m² of inclined surface ranges from 40 to 100 kWh/month. In summer, at its peak, the arrival of solar radiation can reach up to 240 kWh/month, but usually in summer it is not necessary to heat the building.

Even if we want to get a quarter of the energy required for heating (accumulating solar energy for heating does not make sense, so usually solar heat is added to the heating system online, i.e., only when the sun is shining and warming), we need about 3000 kWh of thermal energy. With a winter efficiency of a system with solar collectors of a maximum of 50% (taking into account losses both in the collector itself and in pipelines from the collector to the consumer), $3000/50 \cdot 0{,}5=120$ m² of solar collector area is required to collect this amount of energy. One 20 tube vacuum manifold has a usable area of about 1.8m² and covers an area of about 3m². Thus, 40 such collectors are required.

In summer, these collectors will produce 5-8 times more thermal energy, i.e., up to 24,000 kWh. For comparison, for the purposes of hot water supply for 1 person at a rate of 100 l/day of hot water at a temperature of 40°C, approximately:

$$100 \cdot 1.16 \cdot 30 = 3.48 \text{ kWh} \quad (16)$$

A family of 4-5 people will need up to 15-20 kWh of energy. It is necessary to foresee where to put the remaining 20,000 kWh of energy.

Depending on solar radiation and ambient temperature, the efficiency of a solar collector can range from 20 to 70%. So, in bright sunlight, up to 650 W/m² can be diverted, and in cloudy weather - 10 W / m². And when the tank is 50°C, and in cloudy weather the collector is 40°C, then at the moment the collector efficiency = 0. This situation can be corrected with heat pumps, but this solution also increases the overall cost of the system.

CONCLUSION. Solar collectors should be oriented as far south as possible. However, without a significant drop in performance, a southerly direction deviation of 30 degrees is possible. For photovoltaic panels, a deviation of up to 45 degrees is possible without significant degradation. Exceeding these recommended values will seriously reduce the efficiency of the solar heating system or power supply.

It is generally recommended to locate SC and SB for year-round use at an angle to the horizon approximately equal to the latitude of the area. If the system is operated mainly in summer, then it is necessary to reduce this angle by 15°, if it is predominantly in winter, increase it by 15°. If the latitude is more than 60 degrees, then the SC can generally be installed vertically this also solves the problem with snow - it usually does not linger on vertical surfaces. If the vacuum manifold is installed at an angle of less than 80°, there must be free space under the manifold for snow falling from it.

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STUDY OF THE INFLUENCE OF DESIGN PARAMETERS ON ENERGY-SAVING AND PERFORMANCE INDICATORS OF WATER-LIFT PUS

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Abstract: *The performance of a water-lifting PU, which is characterized by such an important technical and economic indicator as the specific power consumption for supplying a unit volume of water to a hydraulic pressure pipeline while ensuring the required water consumption schedule, is significantly affected by the design and operational parameters of the PU. Through the application of organizational and technical measures for their appropriate adjustment and the necessary change in the characteristics of hydraulic power equipment, it is possible, in addition to applying methods for regulating the water supply of the PU or other technical solutions associated with significant changes in the established technological process of raising water, to achieve some reduction in electricity costs for water supply to rational values. The introduction of such corrections to the values of design and operational corrections should be based on detailed studies of the dependence of energy indicators on the indicated values. The developed mathematical model of the PU makes it possible to obtain these dependences for their subsequent analysis and making an appropriate decision.*

Keywords: *pumping stations, machine water lifting system, PU, pressure pipeline, electric drive, supply, pump performance.*

INTRODUCTION: Each PU (PU) has suction and pressure pipelines through which the liquid is moved to the main hydraulic pressure pipeline under the influence of the pressure developed by the centrifugal pump. The PU is usually divided into two parts: communication (within the premises of WPS) and supply (from the premises of WPS to the place of connection to the main hydraulic pressure pipeline). The design parameters of each of these pipelines affect the energy performance of the PU due to the pressure losses that occur in them [1-4]. The mathematical model makes it possible to determine the nature and magnitude of the influence of the marked design parameters of pipelines on the performance of the PU. Of course, they cannot be changed during the operation of the PU.

However, at the design stage, when the calculation and selection of the PU pipeline network is carried out according to a given hydraulic power equipment of a WPS, taking into account such an influence can be quite valuable, contributing to the identification of the most rational sizes of suction, communication and supply pressure pipelines of a water lifting PU.