

## An analysis of proficiency and commercial feasibility of solar thermal systems for domestic water heating

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### Abstract

Climate trade and power have turn out to be the fashion of universal discussions in current years. It's far genuine that using conventional fossil fuels has a negative effect on our planet, consequently, inside the totality of renewable electricity moves. However, in the modern-day kingdom, the sector can't but absolutely depend upon renewable power for its wishes. Alternatively, the use of maximum opportunities for renewable strength might have a positive impact on climate exchange. Many styles of renewable energy, wind strength, tidal energy, solar power, and so on. They can be exploited. The most common renewable power is sun energy, it can be used for special functions (power era thru photovoltaic / thermal systems, water heating for domestic functions, and so on.). Governments round the arena encourage the use of solar water heating for domestic use, for its simple use, low renovation requirements and the performance of solar heating systems. The objective of this work is to observe a solar water heating gadget in a residential constructing, expand a numerical model primarily based at the photo approach to are expecting the thermal behavior of the solar device and compare the outcomes with the actual facts amassed by means of the system sun. An energy meter referred to as SunEye.

**Keywords:** solar thermal system, domestic water heating, SunEye, solar panel

### 1. Introduction

#### 1.1 Solar resources

Sun power is the maximum natural energy; the floor temperature of the big burning megastar is set 5500 ° C. The solar gives light and warmth to the earth, its position within the solar system's sports is so important that there might be no existence without it. The exploitation of the solar for technical functions did not start until the seventeenth century. Lavoisier, one of the first humans to apply converging lenses to pay attention sunlight to dissolve the iron bars located within the focal factor of the lens.<sup>[7]</sup>

In one hour, the Earth gets enough power from the solar to fulfill the energy call for of the entire planet for greater than a 12 months, that is, this amount of electricity is 5000 times extra than the traditional energy furnished inside the earth<sup>[4]</sup>.

The entire amount of energy received at the ground level of the solar on the zenith depends on the distance from the sun and, consequently, from the time of the yr. If the extraterrestrial sun radiation is 1367 watts consistent with rectangular meter, the direct sunlight in the world's surface while the solar is at the zenith is about 1050 W / m<sup>2</sup>, however the total quantity (direct and indirect from the ecosystem) that reaches the soil 1120 W / m<sup>2</sup>.<sup>[11]</sup>

### 2. Material and Methods

The cited percent, the minimum sun coverage, is proposed to be calculated by the CTE using the graph-f approach. This realistic approach is used to size the optimum dimensions of warm water systems heated by means of sun power.

**Table 1:** Hot water demand references<sup>[30]</sup>

S. No.	Demand criterion	Sanitary hot Water at 60°C (l/day)	
1	single family house	30	per person
2	Multifamily housing	22	per person
3	Hospitals and clinics	55	per bed
4	Hotel/Hostel	40	per bed
5	Elderly/student residence	55	per bed
6	Schools	3	per student
7	Factories and workshops	15	per person
8	Administrative buildings	3	per person
9	Restaurant	5 to 10	per meal

The motive of the solar gadget hooked up is to offer domestic hot water to the residents of the constructing. To

get a good concept of the way the solar machine works, a quick description of the paintings process will be made.

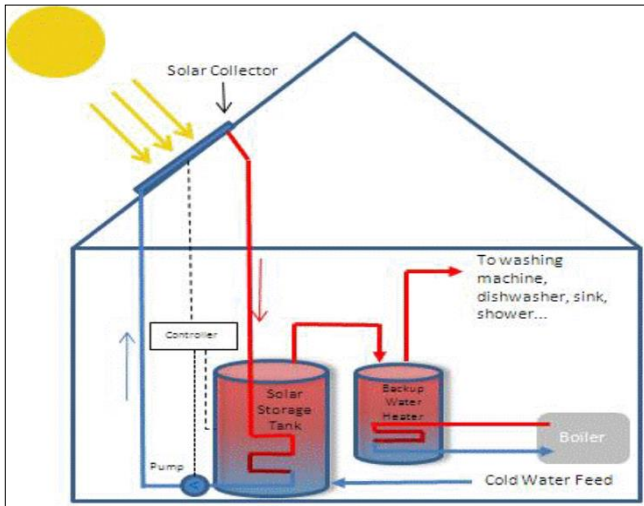


Fig 1: Conventional solar water heating system [34]

The sun radiation is absorbed via the sun collector and transferred to the operating fluid. Then, the operating fluid passes through the open water circuit and transfers its strength to the cold water in the storage tank. There are different mechanisms of heat transfer between the running fluid and the water circuit (external heat exchanger, inner warmth exchanger, coil tubes and many others.). Warm water is used directly if necessary; in any other case it's far saved inside the tank until it's far wished. when hot water is wanted, it's miles drained from the tank, passes via auxiliary water heating, also referred to as boiler, the manage gadget measures the water temperature, if the temperature isn't always excessive enough (generally less than 60 ° C), flip the boiler on so that the water is on the favored temperature, if the water temperature is high sufficient, the boiler stays off.

Table 2: technical features of water tanks [37]

Accumulator	ZANI 48 BSMV 100	ZANI 48 BSMV 150
Volume	100 L	150 L
Number of units in system	10	7
Maximum pressure	8 bar	8 bar
Maximum temperature	99 °C	99°C
Total volume	1000L	1050L = 2050L

**2.1 Auxiliary boiler**

The boiler is accountable for heating the water while the temperature is not sufficient through sun strength. Use an external energy supply to warmth the water (herbal gas, energy, and so on.). When deciding on an auxiliary boiler, exclusive characteristics should be taken into consideration. The form of external strength supply is essential; it have to be taken into consideration for its charge and availability. Furthermore, the power of the boiler is essential, it is selected in line with the energy call for, the greater the system, the greater the quantity of strength required, the greater the strength of the boiler.

**2.2 Solar water heating**

Sun water heating (SWH) is the conversion of sunlight into warmth for heating water through a sun thermal collector [16]. This conversion of light utilizes the formerly illustrated electricity transfer mechanisms (radiation, conduction, convection).

**2.3 Main Components of solar water heating systems**

**Collector:** Solar thermal collectors capture and retain heat from the sun and use it to heat a liquid.

**Pump:** It forces the water to circulate through the system.

**Tank:** It stores the hot water coming from the solar collectors; normally the tanks are equipped with insulation to reduce heat loss.

**Controller:** It detects the temperature differences among the water leaving the solar collector and the water within the garage tank near the warmth exchanger. The controller starts off evolved the pump whilst the water inside the collector is satisfactorily approximately eight-10 ° C warmer than the water inside the tank and stops it whilst the temperature difference reaches 3-5 ° C. This ensures that the stored water gains always warmth whilst the pump is running and forestalls the pump from turning on and off excessively [17].

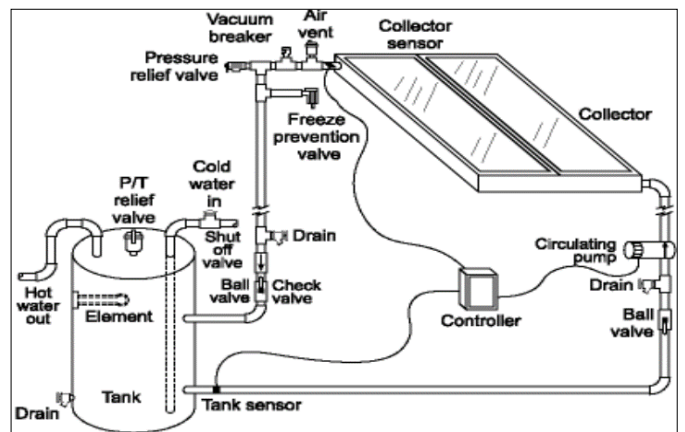


Fig 2: Solar water heating system components [18]

**2.4 Solar water heating systems**

Solar heating structures are a fixed of additives and assembled subsystems, with the principle motive of exploiting and converting sun power into domestic hot water.

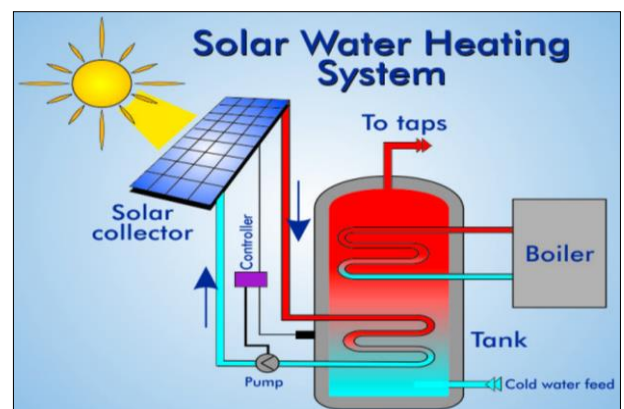


Fig 3: Conventional solar water heating system [29]

Domestic solar water heating systems can be divided into two categories [19].

**i) Passive DSWH systems**

This sort of sun device uses heat-driven convection as a precept for circulating water or heat switch fluid. The water works in an open circuit, where it circulates from the deposit to the solar collector with a thermosiphon impact.

**ii) Active DSWH systems**

This kind of solar system makes use of pumps to circulate the operating fluid. You can find one-of-a-kind systems in this category; the first is direct stream, wherein water is the fluid that flows from the garage tank and via the solar collector and returns to garage or use, whilst the indirect circulation uses a warmness switch fluid. Circulating in a closed circuit among a warmness exchanger and the solar collector, the heat switch fluid resources the strength to the water thru a warmth exchanger.

**2.5 Evaluation of the performance of solar water heating systems**

The evaluation of the performance is whether the machine is fulfilling its reason definitely or otherwise, regardless of

whether the device is profitable or not. It lets in the professional to recognize which era works best, which heat switch fluid is most green and to understand the limits of the systems.

Many researches had been performed to evaluate exclusive varieties of solar structures in one-of-a-kind areas of the arena to better apprehend the conduct of sun water heating structures within the domestic. Ghorab *et al.* [22] carried out an in depth evaluation and evaluation of the performance of the solar system for home warm water, which incorporates an ACS recirculation loop in Indian climatic situations for common family employment (2 kids and a pair of adults); the gadget that has been studied is illustrated inside the following scheme:

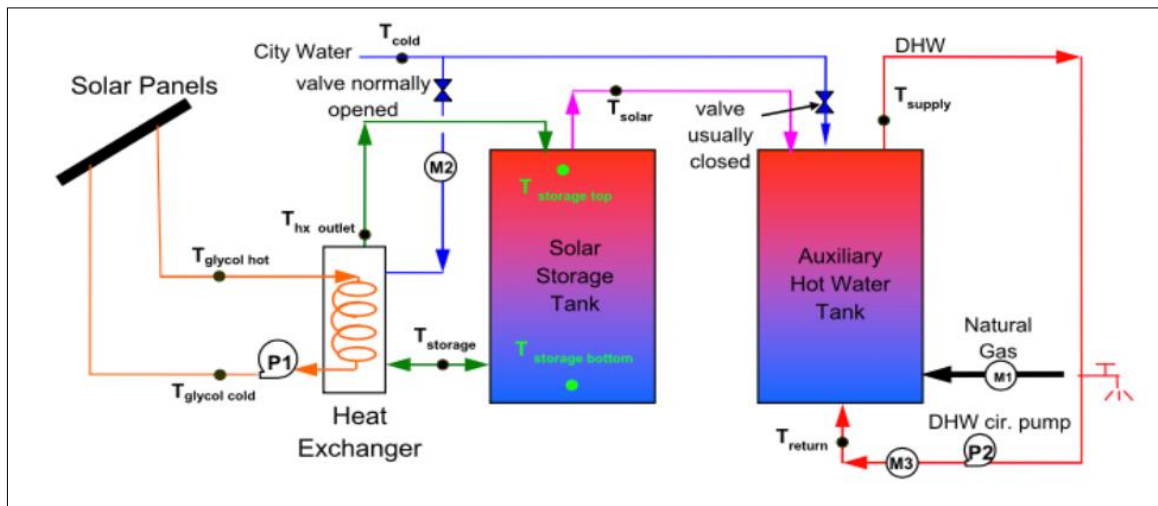


Fig 4: Schematic of solar domestic hot water system [22]

the use of a information logger, Ghorab *et al.* [22] amassed statistics on the temperature, float and standing of various gadgets within the solar system (thermocouples, glide meters, pulse meters, etc.); the statistics had been taken each 10 seconds and then saved in a memory for evaluation. These records collected and analyzed are used to estimate lengthy-term overall performance underneath actual device circumstances:

- A. common sun tank temperature at specific out of doors climate situations
- B. heat exchanger temperature profiles
- C. solar tank and recirculation loop temperatures
- D. DHW temperature, nature gas consumption, and DHW load

**2.6 Solar water heating systems for economic and environmental evaluation**

When comparing a solar device, further to its performance, it's miles vital to have a look at its financial viability and its environmental effect. Regularly, the decision is based at the result of the economic evaluation; but, given that many government offers and subsidies are conditioned via the environmental footprint, numerous studies had been performed to evaluate the financial viability and environmental footprint of solar systems.

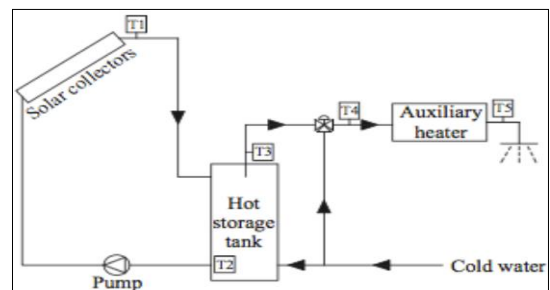


Fig 5: Schematic diagram of a solar water heating system [5]

**3. Result and Discussion**

**3.1 Acquisition and Measurement**

**i) Suneye, Omnilus Database**

Solar Eye "Seye" is a shrewd electricity meter / regulator utilized by the company RDmes to screen its solar systems in real time. The controller measures the temperatures and volumetric flows of the currents that enter and leave the solar creditors.

Use this statistics to calculate the energy absorbed with the aid of the creditors and estimate the saving of cash and the CO<sub>2</sub> reductions via the use of thermodynamic parameters and equations integrated into its minicomputer (Raspberry pi). SunEye also has an integrated SIM card that is used to ship measured facts to the Omnilus database for review via

humans running in Rdmes. The platform become evolved by using J. Cadafalch, R. Consul, A. Gonzalez Valero and R. Ruiz, gives programs to help market-oriented engineering, planning and renovation activities within the field of heating and ecological cooling (RHC). It uses unique databases for the design and upkeep of renewable heating and cooling structures: technical statistics, theoretical models (for sun collectors, heat exchangers, and many others.), commercial catalogs, locations, weather and regulation.

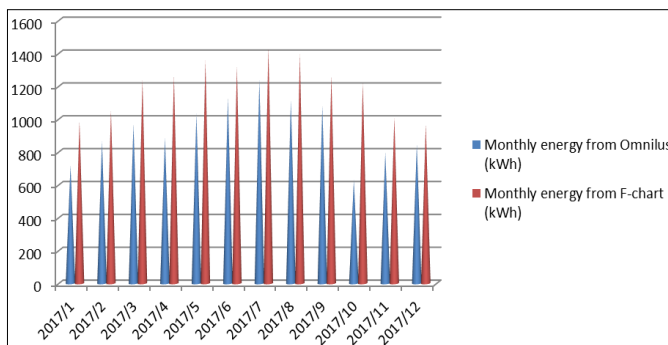
**ii) Data comparison**

1. Ultrasonic flow meter Data Vs Omnilus data
2. A "Flexim" ultrasonic flowmeter become used to calculate the power absorbed via the sun collector for three days; those statistics were as compared with the power absorbed by means of the Omnilus platform.
3. F-chart numerical model results vs Omnilus data

On this component, the numerical graph of the numerical model may be used to calculate the sun strength absorbed monthly for the yr 2016; those consequences might be compared with the facts of the Omnilus platform. Meteorological records had been used by the "weather" software at the Omnilus platform (average monthly room temperature, month-to-month sun radiation, month-to-month clarity index, soil reflectance / absorbance, etc.), the general loss coefficient and the optical performance formerly calculated calculations were extensively utilized as well as the everyday warmth load stated above in (5).

**Table 4:** Data of monthly energy from Omnilus (kWh) and monthly energy from F-chart (kWh)

Date	Monthly energy from Omnilus (kWh)	Monthly energy from F-chart (kWh)
2017/1	718	986
2017/2	864	1050
2017/3	969	1238
2017/4	888	1265
2017/5	1032	1358
2017/6	1129	1318
2017/7	1240	1435
2017/8	1116	1395
2017/9	1080	1265
2017/10	629	1218
2017/11	797	1010
2017/12	846	967



**Graph 1:** Data of monthly energy from Omnilus (kWh) and monthly energy from F-chart (kWh)

**3.2 Data comparison and accuracy**

Comparison among the strength absorbed through the Omnilus platform and the "flexim" ultrasonic flowmeter

records indicates a slight distinction among the values. The difference is because of the knowledge of the measure. The thermometers inside the solar gadget utilized by SunEye continuously degree, however, Suneye can handiest send facts to Omnilus each 60 minutes (due to the fee of facts site visitors set with the cellphone agency), and on the opposite, Flexim has been programmed to take values every 60 seconds.

But what may be learned from this evaluation is that sometimes certainties need to be exchanged for a low charge of operation. It is not feasible to have a flexim related constantly to a solar device, the ultrasonic float meter expenses about € 8000 and has a complex configuration, but does now not provide real-time records (the records should be stored all through measurement after which concerned about a pc)). Therefore, its miles more possible to use a SIM card which could send records each 60 mins. The evolved f-chart model is primarily based on an empirical method and correlations; the graphical approach at f has exceptional situations of use (restrained range of collector regions, slope, and many others.), Accuracy of meteorological statistics, among others. But, Omnilus facts are more correct, primarily based on parameters and data measured in real time.

**4. Conclusion**

The aim of this paintings become to have a look at a solar water heating system for home use, develop a numerical model primarily based at the f-diagram technique and compare the effects acquired from the model with records obtained from the Omnilus platform. Paintings starts off evolved with an introduction on solar electricity, its uses and some bodily principles that take part within the makes use of solar electricity. Therefore, the numerical version became advanced based on the F-diagram method of John A. Duffie and William A. Beckman. Ultimately, the annual and month-to-month contribution of solar electricity become calculated the usage of the numerical model and as compared with information obtained from the Omnilus platform. The money stored and the CO2 discount turned into calculated later.

The effects acquired from this work highlight the fine elements of using solar power to warmth home water. On the only hand, we've the environmental component, the CO2 discount may be very vital; the usage of traditional fossil fuels has been prevented, so not handiest carbon dioxide is emitted, but also methane nitrogen oxide, etc. on the other hand, we have the monetary aspect, the cash financial savings received with the sun system studied is not so high, however in Spain it is mandatory to install a sun water heating device, so there's no choice however to install it. Despite the fact that saving cash isn't always so crucial, every now and then, to attain a higher environment for our lives, economic gains must be considered as a secondary aspect.

Our planet is suffering badly from technological improvement, international warming is a real risk and is getting worse each day, the ozone layer is always degrading, sea degrees are growing and some human beings hold to disclaim these statistics. Humanity ought to locate another form of development in addition to drown our planet. It's far simply important to attempt to globalize as a good deal as feasible the use of renewable power, because using sun strength to heat water isn't always a very profitable manner,

but it is sincerely extremely beneficial for our environment.

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