Feasibility Study of Solar Water Heater System and Ambient Heating for the Laboratory Complex of Ahvaz Branch of Islamic Azad University with Valentin T*SOL Software

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Abstract –Iran is located between the orbits of 25 to 40 degrees north latitude and is located in a region that is among the highest in terms of solar energy among the parts of the world. The amount of solar radiation in Iran is estimated between 1800 to 2200 kWh per square meter per year, which is higher than the global average. In Iran, on average, more than 300 sunny days are reported annually, which is very significant. This energy can be used in different ways, such as electricity generation, heating and cooling, fresh water production, hot water supply, etc. In this paper, using T*SOL software, a solar heating system (including solar water heater, space heating) has been designed for laboratory complex No. 3 of Islamic Azad University, Ahvaz Branch and has been simulated for different time periods such as annually.

Keywords:T * SOL software, PV system, Solar energy, Photovoltaic, Solar water heater

1. Introduction

Heating and cooling buildings using solar energy was a new idea that was introduced in the 1930s and made significant progress in less than a decade. Today's world is trying to turn to natural and renewable energy to provide its own energy. One of the most important of them is solar energy, which is expected to be widely used in the coming years, and a special part of the world's energy, especially cities, will be supplied through this. With this amount of energy received and having Suitable lands for using the sun and relatively simple technology for various applications of solar energy, all the energy needs of the country can be met by using solar energy. The use of solar energy is increasingly used in the world and countries that have very good potential for solar energy are prone to using this type of energy. Renewable energy, in addition to being inexhaustible, is one of the cleanest energies and does not pollute the environment. Among renewable energies, solar energy is of special importance due to its extent and scope of application. The most common way to use solar energy is through hot water by solar water heaters, and hot water is needed for local and industrial uses such as homes, hotels, hospitals, and service industries and mass production.

Generally, SWHs are simple systems since they only use solar radiation for heating domestic water [1]. These systems are used as a substitution for classic hot water systems. Water heating systems using solar energy are considered the most efficient and, specifically, the most cost-effective and unique systems for cold climates such as Northern Europe, Russia, and especially Canada. In the following, a literature review of solar domestic hot water (SDHW) systems in Canada will be presented.

Hobbi and Siddiqui in 2009 analyzed a forced circulation SWH system for a single residential household in Montreal [2]. Results indicated that the optimized system could cover 83-97 % of hot water demand in May-September and 30-68 % of demand in October-February with an annual value of 68 %. In addition, it was found that even a single locally made non-selective-coated collector could provide around 54 % of the annual water heating energy requirement through solar energy.

Among other studies on SDHW systems in Canada from 2009 to 2011 are support of the Ministry responsible for natural resources and wildlife in Quebec from a pilot project aimed at developing the solar domestic water heater (SDWH) in this province [3] anda study on the performance of two SDHW systems installed at the Archetype Sustainable Twin Houses (ASH) at Kortnight Center,

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Received: 2021.11.17 ; Accepted: 2022.01.19

Vaughan, Ontario [4].

In another research, NikooFard et al. in 2014 studied the effect of energy consumption, GHGs emission, and the economic feasibility of using an SDHW system for all of the households in Canada [5]. It was assumed that all of the houses were equipped with a single-tank hot water system and had roof spaces facing the south, southwest, or southeast in order for a solar water heating system to be installed on. The achieved results suggested 2.1 % (22.7 PJ/year) and 2.2 % (1 Mt of CO2) reductions in energy consumption and GHG emissions in the residential sector of Canada. Furthermore, through governmental support and motivation, SDHW systems would be economically more attractive for Canadian households, which would lead to more requests of such system to the residential sector.

Edwards et al. in 2015 measured DHW profiles from 73 households in Quebec city at a time resolution of 5 min for four DHW consumption levels (mean, median, sparing, and profligate) and 3 temporal consumption patterns (consumption primarily in the morning, primarily in the evening, and dispersive consumption) [6]. These measurements were taken between early November 2006 to mid-April 2007. Significant temporal variability in the consumption patterns was also observed among houses so that about one-fourth of the houses primarily consumed in the morning, nearly one third had a higher DHW consumption rate in the evening, and the rest (around 40 %) did not fit into these temporal patterns. The obtained DHW profiles were used to numerically study the performance of a typical solar DHW system, and the results indicated that these obtained profiles could provide more efficient conditions in the simulation-based studies than the typical daily repeated profile.

Semple et al., in 2016, explored the potential of using large-scale solar heating systems to prevent carbon emissions from the greenhouse sector in Ontario, Canada [7]. Their analysis was carried out by TRNSYS software using actual gas consumption data. The results showed a 35 % reduction in annual heating energy demand, and it was stated that per hectare of a greenhouse, annually, 120 tons of CO2 would be reduced.

To gain a better understanding of the real performance of SDHW systems, Ghorab et al. (2017) studied these systems with regard to a selected house in Alberta, Canada, for a family of four (2 adults and 2 kids) with an annual DHW load of 246 L/day [8]. This system comprised two solar collectors installed on the roof of each house with a total area of 7.716 m2, 272 L solar tank, and 172 L auxiliary gas tank, and it was of a closed-loop type. Results indicated that outdoor conditions (solar radiation and temperature) significantly affected the DHW temperature inside the solar tank. Among other results, it was found that around 91.5 % of solar energy collected by solar tanks was consumed for DHW heating load. The share of DHW heating load accounted for around 69.4 % of natural gas and 30.6 % of solar energy.Narval et al., in 2018, carried out a comparative study on solar thermal storage in residential applications [9]. The sample was a Canadian four-person family, and the parameters studied included various thermal adsorbents. Their results showed that Zeolit 4A-water and Zeolit 13X-water were the most economical and efficient adsorbents, with the lowest amount of mass, with 290 and 226 kg, respectively.

McNally et al., in Canada, examined the absorption cooling and solar heating for home-use cooling applications [10]. Their experimental results showed that if the solar collector system's capacity to maintain a good average temperature was correct, the chiller function would be suitable for residential applications.

In 2019, Rahmatmand et al. carried out an experimental study on the removal of snow and ice from the collector of solar cell system using hot water circulation behind the solar panel [11].

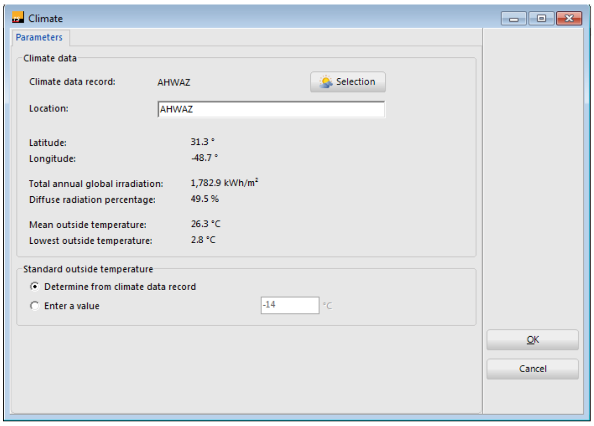
Geographical location of Ahvaz city is shown in Fig.1

Fig.1 Geographical location of Khuzestan province (Ahvaz city)

Table.1.Climatic conditions of Ahvaz city:

System overview (annual values)	
Iran	
Ahwaz	
Longitude	48.72°
Latitude	31.28°
Elevation	30 m

Meteorological information of Hawaz city (study place) is through meteonosyn meteorological software, which is taken through T * sol software, which is shown in Fig. 2.



Information and data of the study place:

Fig.2 T*Sol Software- input data

2. Heating System Design

The figure 3 shows the subsystem designed for case study, which includes a solar water heater and an ambient heating system.

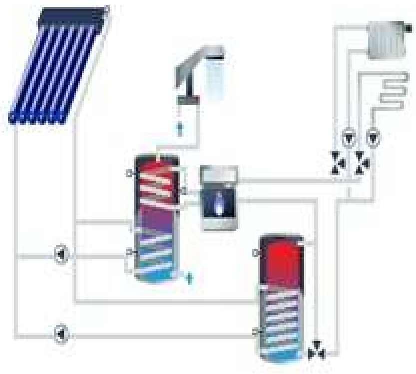


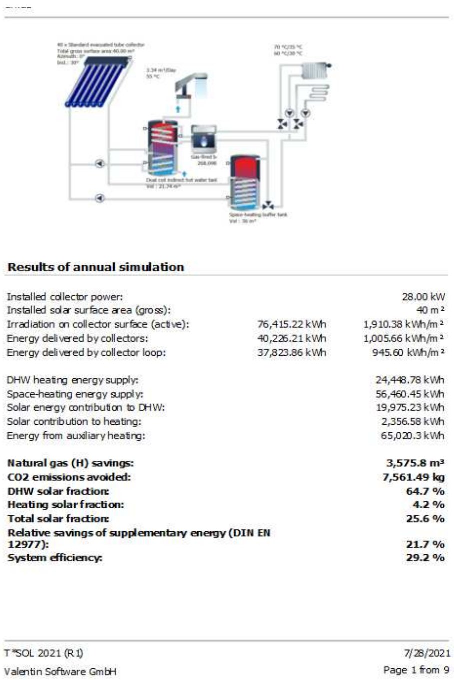
Fig.3. Subsystem design for case study

The table 2 shows the information of the designed system, the number of vacuum collectors and the installation angle of the collectors and the space required to install the collectors are indicated.

Table.4 information of designed system

3. Simulation Results

Figures 4-6 show the information related to the amount of solar energy and ambient heating and the amount of system efficiency and space required installing collectors.



Results of annual simulation

Installed collector power:		28.00 kW
Installed solar surface area (gross):		40 m²
Irradiation on collector surface (active):	76,415.22 kWh	1,910.38 kWh/m²
Energy delivered by collectors:	40,226.21 kWh	1,005.66 kWh/m²
Energy delivered by collector loop:	37,823.86 kWh	945.60 kWh/m²
DHW heating energy supply:		24,448.78 kWh
Space-heating energy supply:		56,460.45 kWh
Solar energy contribution to DHW:		19,975.23 kWh
Solar contribution to heating:		2,356.58 kWh
Energy from auxiliary heating:		65,020.3 kWh
Natural gas (H) savings:		**3,575.8 m³**
CO2 emissions avoided:		**7,561.49 kg**
DHW solar fraction:		**64.7 %**
Heating solar fraction:		**4.2 %**
Total solar fraction:		**25.6 %**
Relative savings of supplementary energy (DIN EN 12977):		**21.7 %**
System efficiency:		**29.2 %**

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Fig.4 Input data for simulation

Figure 5 shows the share of solar system in different months of the year in Ahvaz city.

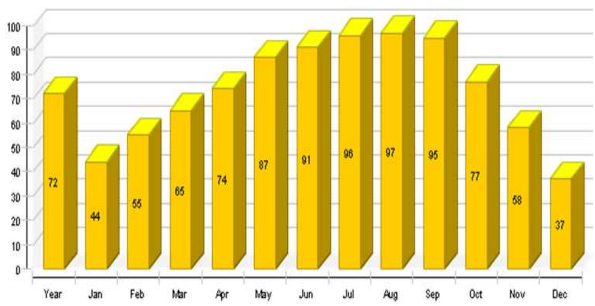

Fig. 5 The amount of solar energy radiation in different months of the year

Figure 6 shows the total energy consumption and the solar radiation.

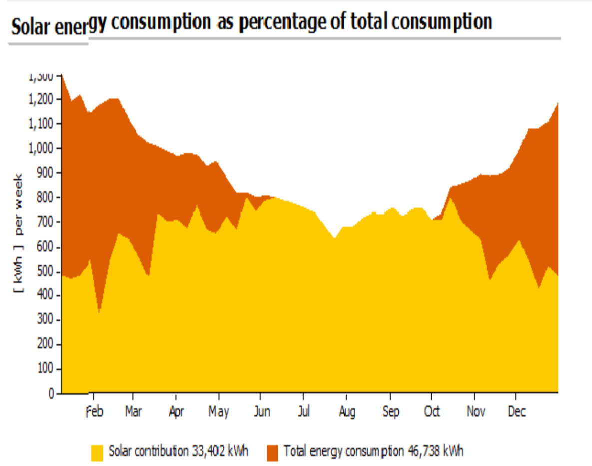

Fig.6 Graph of solar energy consumption as a percentage of total consumption

As can be seen in Figure 7, the temperature of the solar collectors in different months of the year has been studied at the study site, which is technically acceptable.

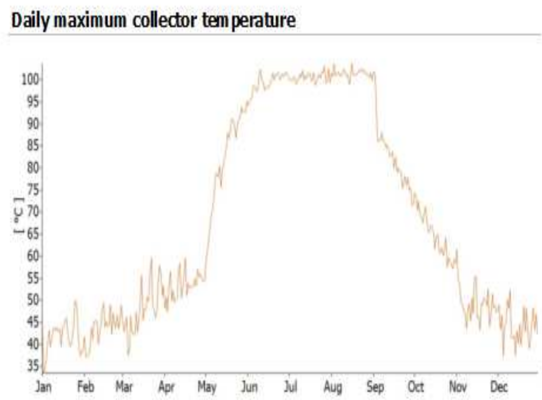

Figure 7: Maximum daily collector temperature

The schematic diagram of the above system is extracted by T * SOL software and financial analysis chart is shown in Fig.8.

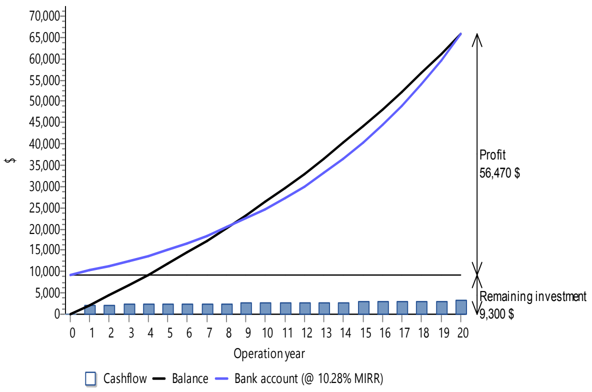

Figure 8: Financial analysis for case study.

3.1 Reduce Costs using Solar Water Heaters

The use of solar water heaters brings other economic benefits to the country: 1- Reducing gas consumption in both domestic and public-commercial sectors, reduces the cost of gas transmission in a complex and long network of city gas. 2- With the increase in demand for solar water heaters and as a result of setting up new factories and increasing production in the country's market, the cost price of this product will decrease and the resulting economic efficiency will increase.

If solar water heaters are used to heat water in the domestic and public-commercial sectors in the country, 7.6 billion cubic meters of gas will be saved annually, which is worth 10.5 thousand billion tomans.

4. Conclusion

Iran has a high potential for solar energy. Due to recent advances in solar energy technologies, the widespread use of solar energy is promising. Therefore, many domestic and foreign investors are interested in investing in solar energy development. The total area of Iran is about 1600,000 square kilometers or 1,012 × 1.6 mm with about 300 bright sunny days in a year and an average of 2200 kWh of solar hours per square meter. In Iran, on average, more than 280 sunny days are reported annually, which is very significant, so the use of free solar energy and its use in space heating and spa is expanding in Iran today. In this article, after designing the laboratory complex No. 3 of Islamic Azad University, Ahvaz Branch was evaluated. TSOL required amount of spa The results obtained using T * sol software is the amount of solar hot water is 64.7% and the amount of solar heating is 21.2% and the total amount of 29.2% of heating is provided using the designed solar system. The system also gets about 30%. And provides the required hot water to the desired location.

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