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Domestic hot water heating with photovoltaic panels

In this article are the results of simulations of solar heating system with photovoltaic panels, which is then compared with the results of simulations of the standard solar heating system with collector. There were chosen two very different meteorological locations - Greece Athens and Swedish Stockholm. It was compared economical, energetical and environmental view.

Keywords: solar DHW heating, solar domestic hot water heating, photovoltaic panels, solar collectors.

I. INTRODUCTION

Solar hot water heating using solar collectors has become a standard way of solar energy using. In the studied locations is possible to achieve the share of solar energy for water heating for a four person household up to 82% respectively 54% [1] by two powerful flat collectors. This technology is already today called an adult and can't expect major innovations that improve the performance parameters of the system. Improvements are ongoing especially in the field of better thermal insulation and selective layers on absorber. Certain limits and disadvantages can be seen in the construction of solar heating systems. Quantity of valves, pumps, solar system, safety features are necessary. Also heat transfer fluid has to be changed after a few years. Another fundamental limitation is the decrease in collector efficiency in colder weather. Here arises the possibility of using solar energy instead of traditional circuit with solar collectors and heat transfer fluid, photovoltaic panels with MPPT electronics and a simple electric heating coil built into a storage tank [2]. The advantage of photovoltaic solar circuit is likely more efficient in the winter months where photovoltaic panels achieve increased efficiency, unlike solar collectors have recorded a significant decline. The second major advantage is considerably easier to install solar photovoltaic panels with not very expensive electronics and cables.

II. LOCAL CONDITIONS

They were selected two sites in Europe with very different profiles of meteorological conditions. These conditions were the average monthly horizontal irradiation of the plane and the average daily temperature in the month. The first locality was Stockholm, Sweden with the geographical location 59.333N, 18.064E. The second selected locality was Athens with the geographical location 37.979N, 23.717E. Meteorological data were obtained from PVGIS using a new satellite database CM-SAF, constructed from average monthly values from 1998 to 2010. Stockholm was already out of CM-SAF database, so for it was used earlier PVGIS Europe database which was created from the values measured during the ground-based meteorological stations between 1981 and 1990. For this type of analysis is as accurate meteorological input data sufficient. Graphically are required meteorological values shown in Figure 1 and 2.

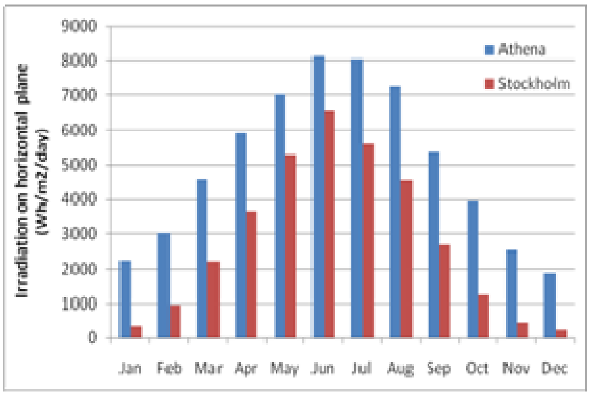

Fig.1 Irradiation on horizontal for Athena and Stockholm.

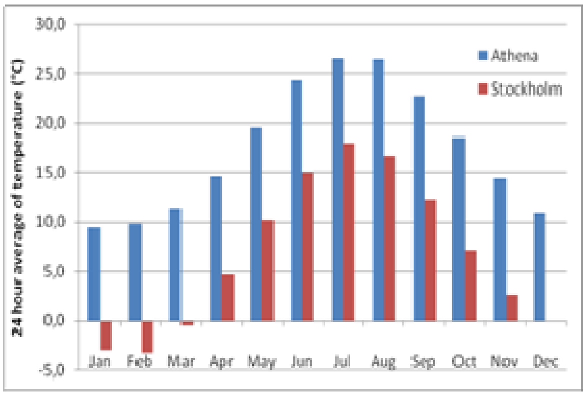

Fig.2 24 hour average of temperature for Athena and Stockholm.

The same meteorological data was used for simulations of both kinds of solar thermal heating system for DHW.

III. CONSUMPTION OF DOMESTIC HOT WATER AND SCHEMES OF SOLAR SYSTEMS

Domestic hot water consumption has been designed according to the standard profile of household consumption with the evening peak. Consumption profile was obtained from the T * SOL Pro and is shown in Figure 3 and 4.

The average daily hot water consumption in the family house during the year was assumed at 160 litters. Parameters required for installation of the solar system were as follows: distance of solar collectors or photovoltaic panels to the storage tank is 10 m. 5 m of that is outside. In the house was not used circulating circuit. Additional heating provide condensing boiler. It was expected full year use of the house. The total energy needed to heat water was 2708kWh.

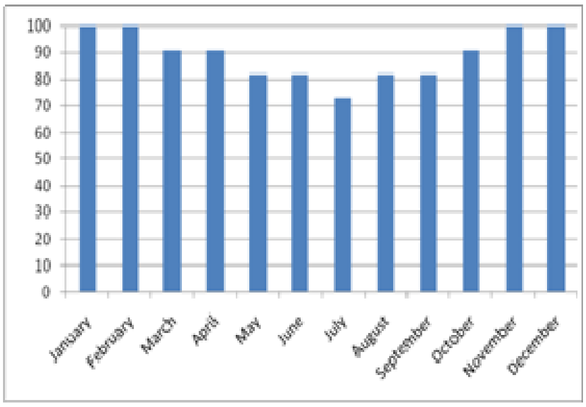

Fig.3 Average annual domestic hot water consumption profile.

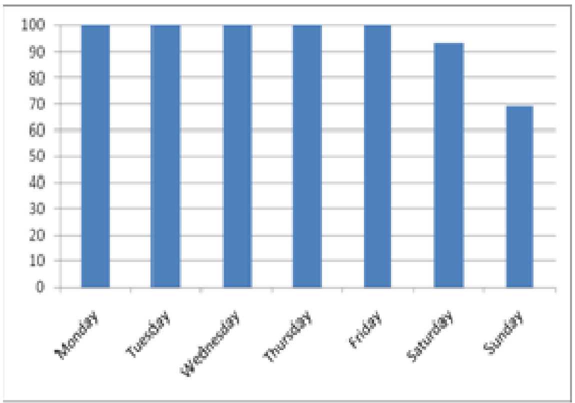

Fig.4 Average weekly domestic hot water consumption profile.

On fig.5 and 6 are schemes of solar system with collectors and also with photovoltaic panels. Solar collector circuit includes tubes, expansion vessel, circulation pump, safety valves, control unit, and measuring of the temperature in the collector. Photovoltaic circuit needs only maximal power point tracker, simple control unit which switch on/off heating and DC safety components.

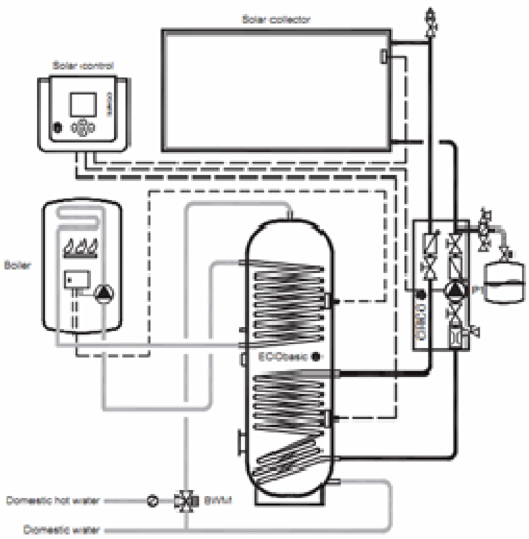

Fig.5 Scheme of the solar system with collectors.

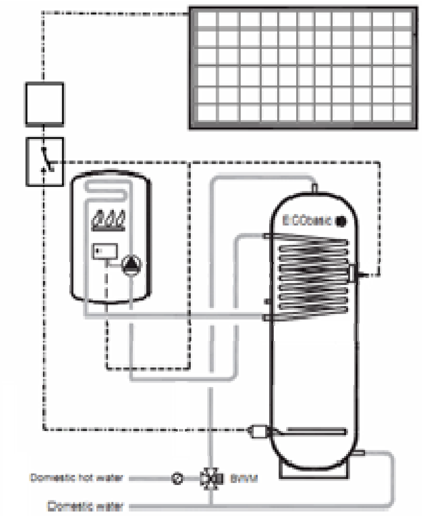

Fig.6 Scheme of the solar system with photovoltaic panels.

IV. SOLAR DHW WITH SOLAR COLLECTORS

This solar system used two standard solar panels with the following parameters: Gross area 2.25m^2, aperture area 2.01m^2, collector efficiency parameters related to aperture area η_{0a}=0.78, A_{1a}=3.95, A_{2a}=0.0139, effective thermal capacity c_{eff} = 4.5kJ/(m^{2}K) and incidence angle modifiers $K_\theta d$ = 0.82 and K_θ (50°) = 0.88. The slope of the panels in both situations was 50° from the horizontal plane. Losses in storage tanks are not all placed, but are counted in the total energy solar circuit. For both systems were using the same accumulator tank.

Tab. 1 Achieved performances of DHW system with solar collectors.

	Athena	Stockholm
Solar fraction	81,2%	53,8%
Solar energy incident on collector	6715kWh	4825kWh
Energy achieved with solar collector	2932kWh	1857kWh
Energy achieved from solar circuit	2514kWh	1566kWh
System efficiency (solar circuit to the surface of collectors)	37,4%	32,5%
Losses in solar circuit tubes	418kWh	291kWh
Max. temperature of solar collector	95°C	85°C
Estimated price	3000Eur	3000Eur

V. SOLAR DHW WITH PHOTOVOLTAIC PANELS

By using the software Homer was calculated size of photovoltaic array. Efficiency of photovoltaic panels was 19.6%. The simulation is also planned with the influence of temperature on the effectiveness of -0.40%/°C and annual drop panel performance degradation due to -0.9%/year Were found size photovoltaic arrays with adequate size solar fraction as was found for the standard solar collectors. In addition to these benchmarks were found and values for economically viable solutions to maximize the solar fraction. The total system price is 2.5 Euros, converted to watts. The results of simulations photovoltaic heating are reported in Table 2.

Tab. 2 Achieved performances of DHW system with PV panels.

	Athena	Stockholm
Solar fraction	83%	54,5%
Solar energy incident on collector	15701kWh	14763kWh
Installed power	1,84kWp	2,4kWp
Surface of photovoltaic field	9,4m^2	12,3m^2
Energy achieved from solar circuit	2569kWh	1586kWh
System efficiency (solar circuit to the surface of collectors)	16,4%	10,7%
Losses in PVE circuit	10,3kWh	6,3kWh
Max. temperature of solar collector	51°C	45°C
Estimated price	4600Eur	6000Eur

VI. COMPARING OF COLLECTOR AND PV PANEL SOLAR WATER HEATING

From the energy perspective, the efficiency of solar circuit with solar collector array with respect to surface use is higher. However photovoltaic panels, allow more efficient use of energy, whereas the resistive losses are wired led 30 to 40 times lower than the loss of pipe. The advantage of photovoltaic panels is greater efficiency in the winter months, since suffering from a loss of power as collectors. Also, the energy which is not used in the summer months can be used in the form of electricity easier, than in the form of low potential thermal energy. Economically, the photovoltaic system is more expensive than heating collector system. With a marked decline in the prices of photovoltaic panels, may get similar or lower price levels of classical heat collector. From an ecological point of view solar collectors will be likely more favourable since their production consumed not so much energy as the photovoltaic panels. Energy payback time for solar collector is 1.3 years in the case of Athena, or 2.1 years for Stockholm. The photovoltaic panel EPBT is extended to 3 years for Athena or 4.8 years for Stockholm respectively. Good features of both technologies are the possibility of recycling, where today both technologies can be recycled to 100%. [4] The advantage of PV technology could be easier assembly. On the other hand, the electric heating needs more strict safety requirements.

VII. CONCLUSIONS

It proved to be advantageous to apply photovoltaic system in the both locations, but at the expense of higher costs for solar system which in the future with an expected fall of price of photovoltaic panels can overcome the economic advantage of classical solar heating using solar collectors. From an ecological aspect of photovoltaic panels have not yet such good EPBT value as solar collectors. But also this value is improving for photovoltaic panels. In terms of installation are much better photovoltaic panels, which require only simple MPPT control electronics and DC safety features. Cables are easier to install than pipe while achieving lower power loss.

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