INFLUENCE OF YEARLY DISTRIBUTION OF SOLAR ENERGY ON THE FEASIBILITY OF SOLAR COLLECTORS IN THE CITY OF TIRANA

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Abstract

Solar energy is one of the main sources of renewable energy in Albania, mainly used for sanitary hot water production in apartment or houses. The object of this study is to estimate the rate of fulfillment of annual needs through solar energy, needs for compensated energy from the grid of electricity and their the influence on the cost and feasibility of solar collectors. This study focuses on the city of Tirana. Three different types of solar collectors are estimated. The average monthly electrical energy compensation varies from 272 kWh to 77 kWh. The month with the highest need for electrical energy compensation for all three types results December, with an average value of about 9 kWh per day. The month with the lowest need for electrical energy compensation results August for the three models of solar collectors with an average value of about 3 kWh per day. The cost of electrical energy compensated varies from 22.00€ in January to 4.00€ in August.

Key words: Solar collector, energy compensation, cost of energy.

Introduction

Use of solar heating systems for water or air heating for residential applications has had a rapid progress worldwide during last 30 years. In order to reach the European Union's 2030 climate and energy targets, approximately EUR 379 billion in investments are needed annually over the 2020-2030 period, mostly in energy efficiency, renewable energy sources and infrastructure (Cañete Miguel Arias, 2016). Use of Solar Heating Systems SHS to produce hot water for sanitary needs offers an economical alternative replacing other conventional technologies as electric or gas boilers (Eric Joseph Urban, 2011). Solar heating can provide 60% or more of the heat necessary for hotels (Mauthner, Weiss, 2014). However, globally, only 1.2% of the space and water heating in the residential sector is covered by solar heating systems.

Albania is considered a country with a high potential of solar radiation. It has about 240-260 sunny days through the year. Thanks to its geographical position and the potential of solar energy, the majority Albanian areas receive more than 1500 kWh / m^2 per year, varying from 1185 to 1690 kWh / m^2 per year. The use of solar energy in residential buildings for hot water production in Albania is actually growing at an annual rate of about 19 percent. Flat solar collectors are actually the best feasible option (Halili, Berberi, 2012). The installed capacity of solar collectors at the end of 2013 was 78.4MWth **(**IEA-ETSAP, 2015)**]** and total area was 111 921 m^2 (Leckner, Zmeurean, 2011).

Solar collectors' technology used in Albania is dominated by glazed flat - plate solar collectors with 99.2% of total installed capacity, compared with only 0.8% of evacuated tube solar collectors. National objective for the year 2020 is that the overall area of solar collectors to achieve 520,000 m^2 **(**Mauthner, Weiss, 2014)**.**

The amount of thermal energy produced by the solar collector in a specific area depends on the amount of solar energy that reaches it. Albanian family consumes an average of about 12kWh energy per day for hot water production. This energy is approximately equal to the average solar energy can be received by a solar collector with an active area of about 2m^2, if the potential of solar energy would be distributed evenly throughout the year. Seasonal change of the intensity of radiation and variability cloud cover has an important impact on the possibility of practical use of this potential.

A solar collector of sufficient installed thermal capacity or active area to cover daily needs for hot water, due to uneven distribution of daily, monthly or yearly potential of solar energy in a given region, can results in certain periods insufficient to cover the needs. In this case, an alternative source of energy is needed to supply energy. In case of Albania, the only alternative source of energy is the electrical energy from central grid. This study we have estimated amount and added cost of electrical energy needed to assure e normal daily supply of hot water through the year in an apartment house for a normal family of four persons situated in the city of Tirana.

Materials and method

Detailed information about solar radiation availability at any location is essential for the design and economic evaluation of a solar energy system (Goswami Yogi, Frank, 2016). The amount of thermal energy received by a solar system at a particular site depends on how much of the sun's energy reaches it, the angle of inclination and orientation of the solar collector.

The solar radiation data were obtained from a meteorological station, located in a building of about 25 meters high, near the building of FIMF, UPT, in Tirana. Solar collector is located at corner 41^0 and to the south direction. Solar radiation is measured every 10 minutes. Our study was done for a period of 4 years, but here we have represented only estimates for 2014. In Table 1 are shown the data of the average monthly amount of solar energy 2014 in Tirana.

Table 1: Monthly solar energy for 2014

Month	Jan	Feb	March	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Solar energy kWh	75.4	67.5	151.1	107.1	147.7	156.6	170.4	178.6	138.2	127.8	103.24	65.6

As seen from Table 1 the amount of solar energy on every unit area of solar collectors varies from month to month. Higher values of solar radiation are taken in August and lowest in December. Solar energy values also vary from a day to another as well as within the day due to climate change and variability of cloud coverage. This means that the amount of energy that would be compensated from the central grid will be different from day to day and from month to month.

The current price of electricity supplied from the central grid is 0.081 euro per kWh. The energy required for hot water production, as rated by SRCC conditions, is 43302 kJ / day or 12.03 kWh per day **(**Halili, Berberi, 2015). There are three different models of glazed flat plate solar collectors used in our study, that are present in the Albanian market for producing hot water. Their characteristics are shown in the table 2

Table 2: Characteristics of the three models of solar collectors

Type of solar collectors	Glazed flat plate	Glazed flat plate	Glazed flat plate
Manufacturer	Vailant	NOBEL INTERNATIONAL EAD	Bosch
Model	Aurotherm	Apollon 2600AL	Bosch FKB-1
Gross area (m^2)	2.24	2.53	2.41
Aperture area (m^2)	2.08	2.33	2.26
Fr (tau alpha)	0.74	0.71	0.72
Fr UL (W/m^2)/ºC	4.20	4.41	4.21
Number of solar collectors	1	1	1

The effective surfaces are comparable for the three models of collectors. Regarding the price, they can be very different from year to year and depends on the location, manufacturers, retailers, market fluctuations, etc. In our estimation we have used a mean value of actual prices in local market. The price is taken 1,600 € for the three models of glazed flat solar collectors. The simple payback method is used in our estimates. The electrical energy compensated is:

$$\text{Energy compensated} = \text{Daily solar energy} - \text{daily needed energy} \quad (1)$$

Based on the analysis and conclusions we will determine the most appropriate solar technology for the Albanian consumer.

Results

Solar insulation observed in Albania fluctuates throughout the year, corresponding to seasonal and regional variation. Seasonal variation has a significant impact on the efficiency of utilization of solar collectors (Halili, Berberi, 2015). This is why it is important to carry a careful study of amount energy needs to be compensated during different periods of the year. In Table 3, 4 and 5 are given monthly and annual energy compensated from the central grid for the three types of the solar collectors in Tirana city.

Table 3: Monthly electrical energy compensated, its relative values and cost, for the model 1 of solar collectors.

Month	Monthly consumption of energy (kWh)	Monthly solar energy (kWh)	Electrical energy compensated (kWh)	Relative value of electrical energy compensated (%)	Cost of electrical energy compensated (€)
Jan	372.9	116.1	256.8	68.9	20.8
Feb	336.8	126.4	210.4	62.5	17
March	372.9	232.6	140.3	37.6	11.4
April	360.9	164.9	196	54.3	15.9
May	372.9	227.3	145.6	39	11.8
June	360.9	241	119.9	33.2	9.7
July	372.9	262.3	110.6	29.7	9
Aug	372.9	274.9	98	26.3	7.9
Sept	360.9	212.7	148.2	41.1	12
Oct	372.9	196.7	176.2	47.3	14.3
Nov	360.9	158.9	202	56	16.4
Dec	372.9	101.1	271.8	72.9	22
Yearly	4391	2314.9	2076.1	47.3	168.2

Table 4: Monthly electrical energy compensated, its relative values and cost, for the model 2 of solar collectors

Month	Monthly consumption of energy (kWh)	Monthly solar energy (kWh)	Electrical energy compensated (kWh)	Relative value of electrical energy compensated (%)	Cost of electrical energy compensated (€)
Jan	372.9	124.8	248.1	66.5	20.1
Feb	336.8	135.9	200.9	59.6	16.3

March	372.9	250	122.9	33	10
April	360.9	177.2	183.7	50.9	14.9
May	372.9	244.3	128.6	34.5	10.4
June	360.9	259	101.9	28.2	8.3
July	372.9	281.9	91	24.4	7.4
Aug	372.9	295.5	77.4	20.8	6.3
Sept	360.9	228.6	132.3	36.7	10.7
Oct	372.9	211.4	161.5	43.3	13.1
Nov	360.9	170.8	190.1	52.7	15.4
Dec	372.9	108.6	264.3	70.9	21.4
Yearly	4391	2488	1903	43.3	154.1

Table 5: Monthly electrical energy compensated, its relative values and cost, for the model 3 of solar collectors

Month	Monthly consumption of energy (kWh)	Monthly solar energy (kWh)	Electrical energy compensated (kWh)	Relative value of electrical energy compensated (%)	Cost of electrical energy compensated (€)
Jan	372.9	122.7	250.2	67.1	20.3
Feb	336.8	133.7	203.1	60.3	16.5
March	372.9	245.9	127	34.1	10.3
April	360.9	174.3	186.6	51.7	15.1
May	372.9	240.3	132.6	35.6	10.7
June	360.9	254.8	106.1	29.4	8.6
July	372.9	277.2	95.7	25.7	7.8
Aug	372.9	290.6	82.3	22.1	6.7
Sept	360.9	224.8	136.1	37.7	11
Oct	372.9	208	164.9	44.2	13.4
Nov	360.9	168	192.9	53.4	15.6
Dec	372.9	106.9	266	71.3	21.5
Yearly	4391	2447.2	1943.8	44.3	157.4

As it shows in the tables above, the electrical energy compensated varies from month to month, because of variations of solar energy. Its values range from 98kWh in 271.8 kWh for the model 1, from 77.4kWh to 264.3kWh for the model 2, and from 82.3kWh to 266 kWh for the model 3. The relative values clearly show the variation of electrical energy compensated. They varies from 26.3% to 72.9% for the model 1, from20.8% to 70.9% for the model 2 and from 22.1% to 71.3% for the model 3. The month with the highest value of energy compensated by the central grid is December, for all three models of solar collectors, with an average value of about 9 kWh per day while, the month with the lowest value of compensated energy is August for all three models with an average value of about 3 kWh per day.

Judging from the data presented and the calculations made in our study, model 2 results more feasible. We can see that solar energy values fluctuate from one day to another, consequently the requirements for compensation of the energy from the grid. Although the monthly electrical energy compensated is lower in August, however only for 5 days in August almost 92% of the energy needs for hot water production are fulfilled with solar energy. For other 22% of the days 80-85% of the energy needs comes from solar energy. More or less the same situation is and for other models for two other models of solar collectors. In figure 2 are shown variations of daily cost of electrical energy compensated for hot water production using model 2 of solar collectors on December and August.

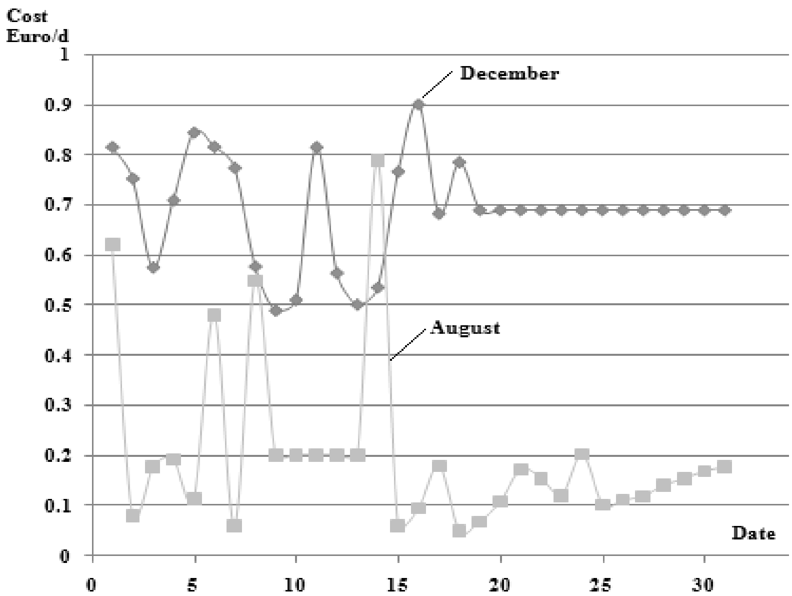

Figure 1: Variation of daily cost of electrical energy compensated in December and August

Conclusions

Solar water heating technology is one of most feasible renewable energy sources for producing sanitary hot water. Due to favorable geographical position, Albania has high potentials of solar energy and good opportunities to apply it for production of hot water for domestic needs. However, because of an uneven daily, monthly or yearly distribution of solar energy, solar energy can result in certain periods insufficient to cover daily needs making it necessary to use an alternative source of energy to compensate the insufficiency of solar energy. In case of Albania, the only alternative source of energy is the electrical energy from central grid. Our study is focused in the city of Tirana, capital city of Albania. Three different types of solar collectors were estimated. The electrical energy compensated varies from month to month, because of variations of solar energy. Its values range from 98kWh in 271.8 kWh for the model 1, from 77.4kWh to 264.3kWh for the model 2, from 82.3kWh to 266 kWh for the model 3. The relative values of electrical energy compensated varies from 26.3% to 72.9% for the model 1, from 20.8% to 70.9% for the model 2 and from 22.1% to 71.3% for the model 3. The month with the highest need for electrical energy compensation for all three types results December, with an average value of about 9kWh per day while the month with the lowest need for electrical energy compensation results August, about 3 kWh per day. The relative values show clearly the variation of electrical energy compensated. They varies from 20.8% to 72.9%..

Regarding the monthly energy cost, it will be depending on the quantity of electrical energy compensated. It ranges from 22 € in December to 7.9 € in August and with annual average cost of 168.2€ for the model 1, from 21.4€ in December to 6.3€ in August and with annual average cost of 154.1€ for the model 2, from 21.5 € in December to 6.7€ in August and with annual average cost of 157.4€ for the model 3. It results from our estimations that for city of Tirana that model 2 from the three models of solar collectors analyzed is more feasible.

References

Cañete Miguel Arias, (2016): Good practice in energy efficiency, for a sustainable, safer and more competitive Europe

Eric Joseph Urban, (2011): Monitoring and Modeling Hot Water Consumption in Hotels For Solar Thermal Water Heating System Optimization. Thesis, May

Mauthner. F, Weiss. W, (2014): Solar Heat Worldwide, Markets and Contribution to the Energy Supply. IEA SHC. http://aee-intec.at/0uploads/dateien1016.pdf

Halili D, Berberi P, Mitrushi D ,Muda – Lame B, (2012): Mapping Regional Variation Of Cost Of Hot Water Produced By Conventional Solar Collectors In Albani, The 8th General Conference of Balkan Physical Union, Constanta, Romania July 5-7.

IEA-ETSAP and IRENA, (2015): Solar Heating and Cooling for Residential Applications.http://www.irena.org/DocumentDownloads/Publications/IRENA_ETSAP_Tech_Brief_R12_Solar_Thermal_Residential_2015.pdf

Mitchell Leckner, Radu Zmeurean, (2011): Life cycle cost and energy analysis of a Net Zero Energy House with solar combisystem. Applied Energy 88 232–241

Mauthner. F, Weiss. W (2014): Solar Heat Worldwide, Markets and Contribution to the Energy Supply. IEA SHC, 2014.http://aee-intec.at/0uploads/dateien 2016.pdf

D. Goswami Yogi, Kreith Frank, (2016): Energy efficiency And renewable energy Hand book , Second Edition, Taylor & Francis Group, LLC 1005-1006

Halili D, Berberi P, Mitrushi D , Muda V, Bërdufi I, Buzra U, (2015): Effect Of Local Environmental Condition On Efficiency Solar Collectors For Production Of Hot Water For Domestic Use In Albania, BPU 9.

Halili D, Berberi P, Mitrushi D, Bërdufi I, (2015): Shpërndarja rajonale e potencialit të energjisë diellore në Shqipëri dhe kostot e prodhimit të energjisë elektrike me anë të sistemeve fotovoltaik. Buletini i Elbasanit.