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Estimation of Solar Energy Compensation with Electrical Energy for Hot Water Production in the South-Eastern Part of Albania

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***Abstract*—Solar systems for hot water production in residential buildings are now widely used all over the world. The intensity of solar radiation in Albania is approximately equal to 1300-1500 kWh/m^2/year. Electrical energy is the conventional source of energy in our country, but its price is increasing more and more, therefore the production of hot water using solar collectors offers a good economic alternative. Since solar energy has an uneven distribution throughout the year, we can use another source to fullfill the solar energy. In this study, we have calculated the amount of annual needs using solar energy for the production of hot sanitary water and supplementing it with electricity. The South-Eastern part of Albania, specifically the cities of Prrenjas, Pogradec, Korca and Erseka, are the focus of this study. The calculations show that December is the month with the highest value of electricity use. For all citiess, about 62% of the energy needed for hot water production must be compensated with electricity. June, July are the months when the solar energy produced by the solar collectors is sufficient, even July is the month where the solar energy exceeds the energy needs for the production of hot water. Pogradec is the city with the lowest value of the average annual cost of compensated electricity of about 112€ and Prrenjasi with the highest value of 117€.**

Keywords—solar collector; solar energy; electrical energy compensation

I. INTRODUCTION

Meeting energy needs is the challenge the whole world is facing. The use of new energy sources and the development of technologies related to them is the main focus of our days. Some of the energy sources are relatively cheap while some others are too expensive **[1]**. Almost all of energy based on fossil fuels. The last two centuries non-renewable energy resources have brought a great prosperity but, the energy demand is continuously increasing and fossil resources are depleting **[2]**. Furthermore, use of fossil sources causes an environmental pollution and global warming. Based on these reasons, renewable energies, over about the last three decades, are seen as cost-effective and environmentally sustainable energy sources worldwide **[3].**

Energy production using renewable energy sources brings numerous socio-economic benefits for all countries around the world, including employment, income generation, reduction of air pollution and local industrial development also. Renewable energy technologies generally have higher initial costs than conventional technologies but they have lower operating and maintenance costs **[4]**.

Solar energy is one of the most important renewable energy sources and there are great opportunities for using it. Solar technologies for hot water production in residential buildings today have the highest rate of development and the widest spread among renewable energy technologies, following hydropower.

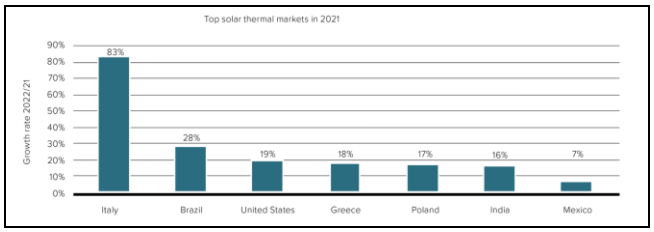

Figure 1: *Solar heat markets with the highest growth rates in 2021* **[5]**

Electrical energy is the conventional source of energy used in our country, but its price is increasing more and more, therefore the production of hot water using solar collectors offers a good economic alternative.

According to the latest statistics of 2020 the total capacity of solar collectors for hot water production was 205.8MWth. Total area of solar collectors, their installed capacity and distribution by technologies used in Albania during 2020 are presented in Table 1:

No	Technology	Total area (m^2)	Installed capacity (MW_{th})	Added during year 2020 (m^2)
1	Flat - plate solar collectors	282,703	197.9	10680
2	Evacuated tube solar collectors	11,262	7.9	968

Table 1: *Total area of solar collectors, their installed capacity and distribution by technologies used*

The quantity of energy produced by a solar collector in a specific area depends on the solar energy potential in this area.

There are a lot of factors that are directly related to the amount of insolation available at a certain region such as latitude, altitude, orientation of the land surface, time of day, time of year, cloud cover, shading obstructions and atmospheric turbidity **[6].**

A typical solar water heating (SWH) system with a collector area of 3-4m^2 that an Albanian family can use for a 150-200liter water tank, and the minimum operational lifetime is 15 years **[7**].

Seasonal variation of the solar radiation and a changeability of cloud cover, strongly effect on the amount of the solar energy use in our country.

So it is that, another source of energy would need to assure the insufficiency of solar energy for hot water production daily needs, in certain periods of the year.

II. MATERIALS AND METHOD

In this paper we have estimated the amount of electrical energy used from the central grid as the only alternative source in Albania to fulfil the needs of hot water through the year when solar energy is insufficient.

Data base was obtained from NASA surface meteorology and solar energy for RETScreen for estimating annual average value of solar energy for all of four cities: Prrenjas, Pogradec, Korca and Erseka.

The price of electrical energy is 0.08 € / kWh. The required daily value of energy for hot water production, according to SRCC conditions, is about 12.03kWh **[8].**

We have used flat solar collector, settled in an apartment house for a four member's family located in each region. The glazed flat plate solar collector model chosen in our study, is present in the Albanian market. It is set with change of inclination with horizon and has an aperture area of 2.33 m^2, Fr (tau alpha) 0.71 and Fr UL 4.41 $(W/m^2)/^oC$.

The solar collector's price is taken 1,600 €, but it can fluctuate from a year to another and it is also related to a lot of factors such as manufacturers, retailers, the location, market fluctuations, etc.

In this study we have calculated the electrical energy compensated by the simple method:

$$E_c = E_S - E_N \quad (1)$$

Where:

- E_C stands for Energy compensated
- E_S stands for Daily solar energy
- E_N stands for Daily needed energy

III. CALCULATION OF ENERGY COMPENSATED

To calculate the solar energy regime in a specific area for a certain period, it is essential to look into the daily, monthly and annual data of radiation intensity. Albania characterized by an uneven distribution of solar radiation from season to season and from a region to another. Even though our country is considered with good regime of solar energy, effective use of solar energy is related to seasonal and regional variation of solar radiation. This leaded us to make a calculation of amount energy compensated every month of the year. In the Tables 2,3.4.5 are presented monthly average solar energy, monthly average electrical energy from the grid, the relative values for each city taken in consideration and average cost of electrical energy compensated. In order to have a clear picture of the fluctuations of the energy compensated we have presented a graph of variation of energy compensated from the central grid for each city. Firstly, we have study the data and have make the calculations for the city of Pogradec.

Month	Monthly average consumption of energy (kWh)	Monthly average solar energy (kWh)	Electrical energy compensated (kWh)	Relative value of electrical energy compensated (%)	Average cost of electrical energy compensated (€)
January	372.9	192.3	180.6	48	14.6
February	336.8	183.9	152.9	45	12.4
March	372.9	241	131.9	35	10.7
April	360.9	215.4	145.5	40	11.8
May	372.9	279	93.9	25	7.6
June	360.9	363.8	-2.9	-1	-0.2
July	372.9	397.4	-24.5	-7	-2
August	372.9	347.7	25.2	7	2
September	360.9	270	90.9	25	7.4
October	372.9	236.4	136.5	37	11.1
November	360.9	160.8	200.1	55	16.2
December	372.9	144.6	228.3	61	18.5
Yearly	4391	**3031.2**	**1385.8**	**32**	**112.3**

Table 2: *Monthly average solar energy, monthly average energy compensated from the grid and the relative values in Pogradec*

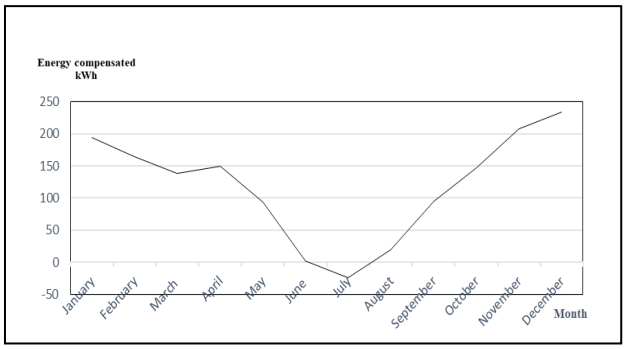

Figure 2: *Variation of energy compensated from the central grid in in Pogradec*

We have proceeded with the calculations for the city of ***Prrenja***

Month	Monthly average consumption of energy (kWh)	Monthly average solar energy (kWh)	Electrical energy compensated (kWh)	Relative value of electrical energy compensated (%)	Average cost of electrical energy compensated (€)
January	372.9	179	193.9	52	15.7
February	336.8	172.8	164	49	13.3
March	372.9	234.4	138.5	37	11.2
April	360.9	211.4	149.5	41	12.1
May	372.9	279	93.9	25	7.6
June	360.9	358.8	2.1	1	0.2
July	372.9	396.4	-23.5	-6	-1.9
August	372.9	353.3	19.6	5	1.6
September	360.9	266	94.9	26	7.7
October	372.9	225.6	147.3	40	11.9
November	360.9	153.4	207.5	57	16.8
December	372.9	139.5	233.4	63	18.9
Yearly	4391	**2970.8**	**1444.6**	**33**	**117**

Table 3: *Monthly average solar energy, monthly average energy compensated from the grid and the relative values in Prrenjas*

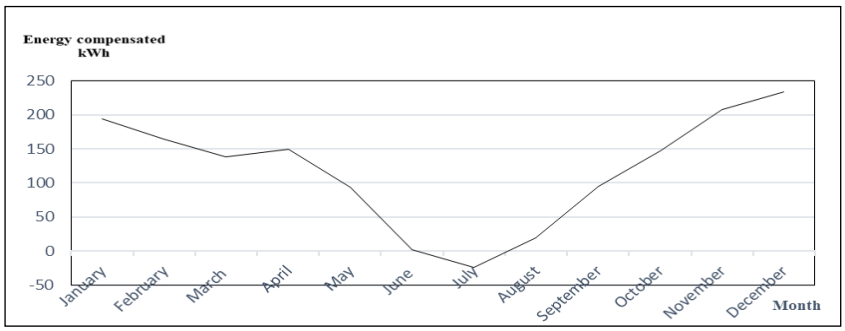

Figure 3: *Variation of energy compensated from the central grid in Prrenjas*

In the table below we have given the estimations for the city of Korca.

Month	Monthly average consumption of energy (kWh)	Monthly average solar energy (kWh)	Electrical energy compensated (kWh)	Relative value of electrical energy compensated (%)	Average cost of electrical energy compensated (€)
January	372.9	179	193.9	52	15.7
February	336.8	172.8	164	49	13.3
March	372.9	234.4	138.5	37	11.2
April	360.9	211.4	149.5	41	12.1
May	372.9	279	93.9	25	7.6
June	360.9	358.8	2.1	1	0.2
July	372.9	396.4	-23.5	-6	-1.9
August	372.9	353.3	19.6	5	1.6
September	360.9	266	94.9	26	7.7
October	372.9	225.6	147.3	40	11.9
November	360.9	153.4	207.5	57	16.8
December	372.9	139.5	233.4	63	18.9
Yearly	4391	**2970.8**	**1444.6**	**33**	**117**

Table 4: *Monthly average solar energy, monthly average energy compensated from the grid and the relative values in Korca*

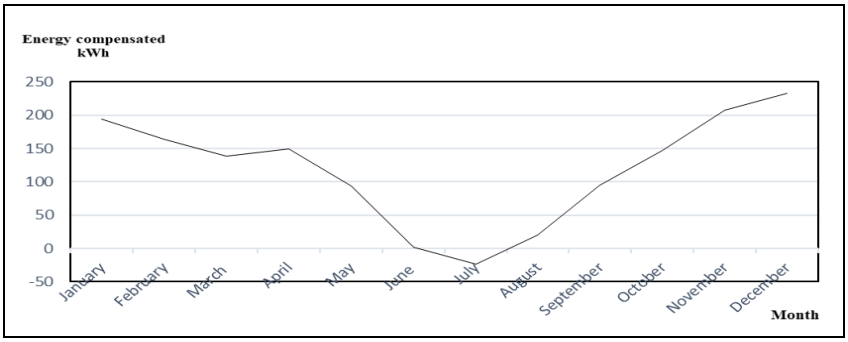

Figure 4: *Variation of energy compensated from the central grid in Korca*

And the last city of our calculations is city of Erseka.

Month	Monthly average consumption of energy (kWh)	Monthly average solar energy (kWh)	Electrical energy compensated (kWh)	Relative value of electrical energy compensated (%)	Average cost of electrical energy compensated (€)
January	372.9	188.7	184.2	49	14.9
February	336.8	181.6	155.2	46	12.6
March	372.9	238.5	134.4	36	10.9
April	360.9	213.9	147	41	11.9
May	372.9	277.4	95.5	26	7.7
June	360.9	361.8	-0.9	0	-0.1
July	372.9	395.4	-22.5	-6	-1.8
August	372.9	345.6	27.3	7	2.2
September	360.9	267.5	93.4	26	7.6
October	372.9	233.3	139.6	37	11.3
November	360.9	157.8	203.1	56	16.4
December	372.9	141.5	231.4	62	18.7
Yearly	4391	**3001**	**1411.1**	**32**	**114.3**

Table 5: *Monthly average solar energy, monthly average energy compensated from the grid and the relative values in Erseke*

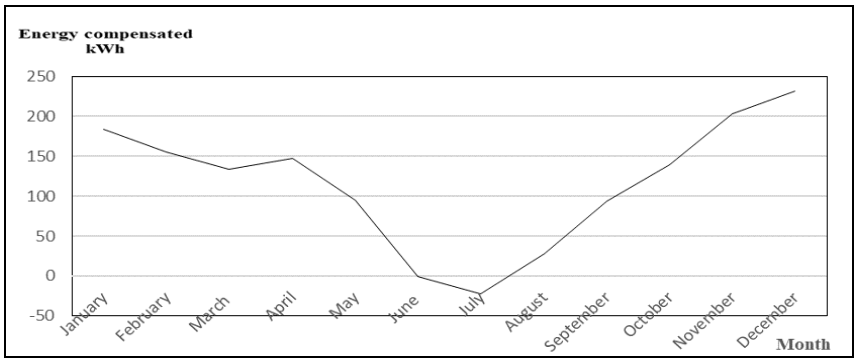

Figure 5*: Variation of energy compensated from the central grid in Erseka*

So, from the calculations that are presented in the tables above it is seemed that, the variation of solar energy leads to the variation of the electrical energy used from the grid. Obviously, the relative values show the variation of electrical energy compensated. We have sign '+' for values of electrical energy compensated from central grid, and the sign '-' for the values of solar energy larger than the needed energy. July for the cities of Erseka and Pogradec, results the month when solar energy produced by solar collectors exceeds the needs of energy for sanitary hot water production, while June and July for the cities of Prrenjas and Korca. December is the month with the highest value of electrical energy use for all the cities.
The graphs above obviously illustrate that solar energy values vary from one month to another and consequently the requirements for the electrical energy from the grid.

IV. CONCLUSIONS

Solar water heating technology is one of most economical renewable energy sources extensively used worldwide. 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 during the year, solar energy can result in certain periods insufficient to cover daily making it necessary to use an alternative source of energy to compensate the insufficient 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 average monthly electrical energy compensation varies from 294 7 kWh to 43.5 kWh.

The month with the highest need for electrical energy compensation for all three types results January, with an average value of about 10kWh per day while the month with the lowest need for electrical energy compensation results July, about 2 kWh per day. The relative values show clearly the variation of electrical energy compensated. They vary from 11.7% to 80.7%. Cost of electrical energy compensated varies from € 23.87 in January to € 3.52 in July.

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