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HYBRID RENEWABLE ENERGY SYSTEMS: CASE STUDY-BASED ANALYSIS CONSIDERING VARYING SEASONAL CONDITIONS

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ABSTRACT
Hybrid renewable energy systems are becoming popular for remote area power generation applications due to advances in renewable energy technologies and subsequent rise in prices of petroleum products. A hybrid energy system usually consists of two or more renewable energy sources used together to provide increased system efficiency as well as greater balance in energy supply. Hybrid power systems can provide a good solution for such problems because they integrate renewable energy along with the traditional power plants. Among several alternative technologies, wind-and solar-based energy is given special importance to realize. These are the best sources on conventional means of energy production from many aspects, but total dependence on meteorological conditions (wind speed, solar radiation, temperature, etc.) of wind and solar systems, as they are not completely reliable in every instant. In this study, to ensure the supply of the load in all of the cases, a combined system is applied for our country.
Keywords: solar energy, solar collectors, sanitary water, hybrid renewable energy

1. INTRODUCTION
Off grid renewable energy technologies satisfy energy demand directly and avoid the need for long distribution infrastructures. A combination of different but complementary energy generation systems based on renewable energies or mixed, is known as a hybrid power system ("hybrid system") [1]. Increase use of solar energy and the promotion of wider use, justifies not only for the positive impact on environmental preservation, but also for the fact that technological advances in this field have made it possible to increase the quality and reduce the cost of equipment to transform solar energy into other types of energy (heat, electricity, etc.). Among the most common systems, solar panels are the solar collectors. Currently, there are multiple uses for solar energy, including the production of hot water for household needs and technological systems through solar water heating and heating housing. People today use solar energy for lighting and heating by converting solar energy to power energy [2].

2. EQUIPMENT FOR USE OF SOLAR ENERGY
Solar energy for domestic purposes can be used in several ways systems respectively. They are: photovoltaic systems (PV), which convert the sun's energy into electricity, solar systems for air heating and solar systems for water heating. The main part of a solar thermal system is the solar collector. It absorbs solar radiation, converts it into heat and through fluid (eg. water) makes the heat transfer in the solar system. Depending on the needs of the user, there are several types of collectors

ranging from simple absorbers used to heat the pool water to the collectors to reach high temperatures such as flat collectors, especially collectors with vacuum pipe.

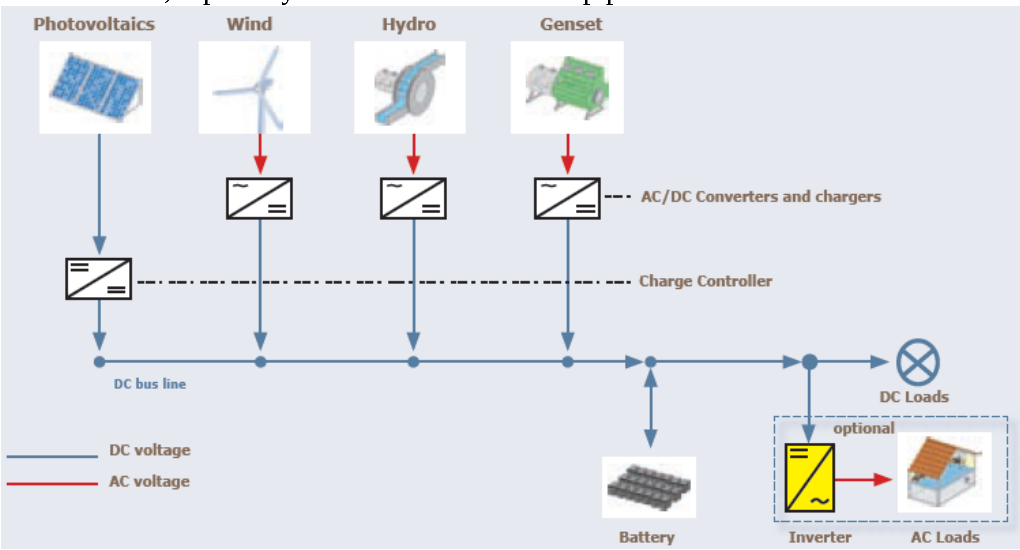

Fig. 1. Hybrid energy systems

Solar systems used for sanitary water heating and spaces can be broadcasted directly and indirectly. These systems can be combined with other heating systems implying additional energy (from boilers or geothermal system, etc.)

It should be emphasized that as much solar water used, the more reasonable it is investing in them. Additionally, solar water systems can also be used for car washing and dishwashing machine. So will significantly shortened working time machine, and thereby electricity will be spared. To use the water for washing machine only need additional equipment (see Fig. 2) mounted on the machine. Each manufacturer of washing machines has special equipment for making hot water from the solar system.

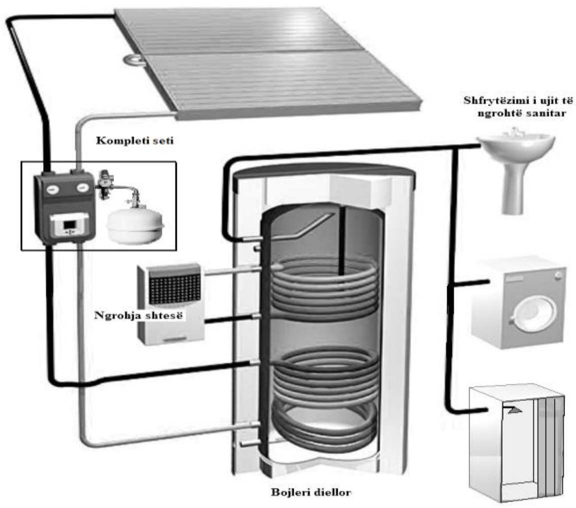

Fig. 2. Hybrid solar heating system and method of use of sanitary water

3. HEATING NEEDS FOR HEAT WATER SANITARY AND BUILDING AREAS

Following is analyzing the use of solar energy given the thermotechnics characteristics of flat collectors and average global radiation (for Kosovo), for a year $\overset{\circ}{Q}{}^{v}_{rr}=1400\ \mathrm{kWh/(m^2v)}$ respectively for a day $\overset{\circ}{Q}{}^{d}_{rr}\approx 3836\ \mathrm{Wh/(m^2d)}\approx 3{,}836\ \mathrm{kWh/(m^2d)}$.

The total amount of heat required to heat the water of sanitation needs, space heating facility housing and other needs:

$$\overset{\circ}{Q}{}^{d}_{tër}=\overset{\circ}{Q}{}^{d}_{us,np}+\overset{\circ}{Q}{}^{d}_{nd}+\overset{\circ}{Q}{}^{d}_{ntj} \qquad (1)$$

3.1. The amount of heat required for the preparation of sanitary water

Required daily amount of hot sanitary water for a resident $\overset{\circ}{V}_p$, in *l/day=10*$^{-3}$*m*^{3}*/day*, as shown in the table (tab.1).

Tab. 1. Spending hot water daily per resident

Spending hot sanitary water daily	$\overset{\circ}{V}_p$, *l/day/resident*	
	60 °C	45 °C
small	10 ÷ 20	15 ÷ 30
average	20 ÷ 40	30 ÷ 60
large	40 ÷ 80	60 ÷ 120

Spending hot sanitary water daily $\overset{\circ}{V}_{np} = n_p \cdot \overset{\circ}{V}_p$, *l/day/resident*

The required daily amount of hot sanitary water for n - persons, in *l/d*, is:

$$\overset{\circ}{V}_{np} = n_p \cdot \overset{\circ}{V}_p \qquad (2)$$

The amount of heat required for the preparation of sanitary water in kWh/d, for a person in a day can be calculated by the expression:

$$\overset{\circ}{Q}{}^{d}_{us,p} = \overset{\circ}{V}_p \cdot c_{u,v} \cdot \Delta t = \overset{\circ}{V}_p \cdot c_{u,v}\left(t_d - t_h\right) \qquad (3)$$

The amount of heat required for the preparation of sanitary water, in kWh/d, for n – persons in a day:

$$\overset{\circ}{Q}{}^{d}_{us,np} = n_p \cdot \overset{\circ}{Q}{}^{d}_{us,p} = \overset{\circ}{V}_{np} \cdot c_{u,v}\left(t_d - t_h\right) \qquad (4)$$

The amount of heat required for the preparation of sanitary water, in kWh/d, for n – persons during a year:

$$\overset{\circ}{Q}{}^{v}_{us,np} = 365 \cdot \overset{\circ}{Q}{}^{d}_{us,np} \qquad (5)$$

$\Delta t = t_d - t_h$ - changing temperatures of warm water in the output of solar collector (45 or 60°C) and that cold incoming solar collector (10°C). The amount of heat required to heat the building (in *kWh/y* or *kWh/d*) është:

$$\overset{\circ}{Q}{}^{v}_{nd} = \overset{\circ}{q}_{nd} \cdot \tau_{ng} \cdot A_{ng} \text{ respectively } \overset{\circ}{Q}{}^{d}_{nd} = \overset{\circ}{Q}{}^{v}_{nd} / 365 \qquad (6)$$

Tab. 2. - Specific heat and the number of hours of heat

The quality of the building	$\overset{\circ}{q}_{nd}$, W/m^2	τ_{ng}, h/v
Building standards	100	1800
Buildings with improved insulation	70	1600
Buildings with good thermal insulation	50	1400

The total amount of heat, in kWh/d or kWh/y, necessary for sanitary water heating and building areas:

$$\overset{\circ}{Q}{}^{d}_{tër} = \overset{\circ}{Q}{}^{d}_{nd} + \overset{\circ}{Q}{}^{d}_{us,np} \text{ respectively } \overset{\circ}{Q}{}^{v}_{tër} = \overset{\circ}{Q}{}^{v}_{nd} + \overset{\circ}{Q}{}^{v}_{us,np} \qquad (7)$$

3.2. Investment costs and savings when used hybrid systems

Investment costs (in euros) include all costs including the cost of collectors and other necessary installations, the costs of implementing the solar system and legal costs I_C. Annual costs savings (in euros/year) of heat energy mean necessary expenses the amount of heat from solar radiation saved for sanitary water heating, space heating needs of the building and other possible A_C.

Thus, as the criterion for calculating economics use of solar energy used economics amortization time of the system (in years) of which is the ratio between Investment costs and Annual costs savings: $\tau_A = I_C/A_C$. Annual energy savings are spent in years τ_v is: $K = -I_C + \tau_v \cdot A_C$. Achieved results that reflect the technical characteristics, thermal and economics for solar energy from hybrid systems and tariff plan for consumers are given in Table 3 and in the following diagram (Fig. 3 and 4).

Tab. 3. Some parameters that justify the use of solar energy

Temperature	60 °C		
$\overset{\circ}{V}_p$, *l/day/resident*	10	50	100
$\overset{\circ}{V}_{np}$, *l/day/resident*	8000	40000	72000
I_C, m^2	201.559	1008	1814
n_k, colector	856	428	769
A_C, €/Y	9738	48690	87640
τ_A, year	16.6	3.329	1.85

As seen from the above figures (fig. 3 and 4), depending on the needs of using sanitary water quantity also the need for solar collector surface respectively for their number and thus the investment price. Based on the needs for sanitary hot water shows that spending time recovering investment costs saved through hybrid solar systems respectively the time of economic depreciation is 16.6 years (10 liters/person /day), 3.3 years (50 liters/person/day) and 1.85 years (about 100 liters/person/day).

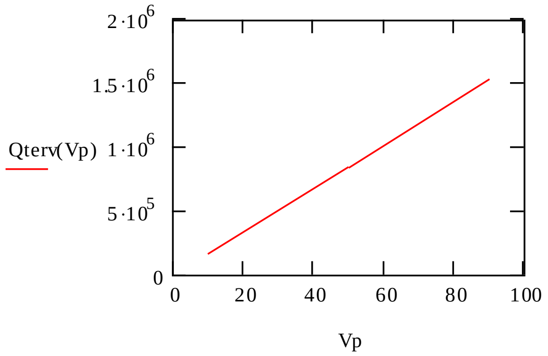

Fig. 3. The total amount of heat needed per year

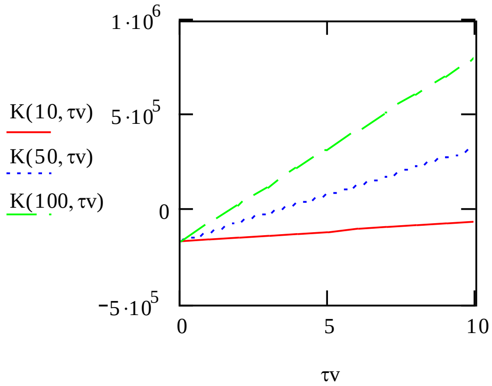

Fig. 4. Energy savings in years

4. CONCLUSIONS

In this paper are presented the data for solar radiation and for the use of solar energy namely the use of equipment and solar systems in residential facilities. Also at work are given theoretical analysis required daily amount of annual domestic hot water and space heating of the building, expressed analytically and tabular. The total heat is modified by converting solar collectors for a certain number of persons and temperature water heating collector output. Analytically, tables and diagrams are unified and reflected the number of solar collectors, the time of economic depreciation and annual savings. The results are important since put out the opportunities and needs for the application of these systems in terms of energy saving and also in terms of environmental protection.

Building such a hybrid system for water heating and sanitary housing areas bring in good results effectively, especially in the economic and ecological. Through this system, allow huge savings of the amount of energy that our country is blessed with good conditions and productivity. Given good conditions of radiation in Kosovo concluded that similar systems and more advanced can and should have a wider application. The first of many more hybrid systems used previously as well start saving family and constructive energy state.

5. LITERATURA

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