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DESIGNING PROCEDURE OF INNOVATIVE PHOTOVOLTAIC SOLAR WATER HEATER SYSTEM

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Abstract: The energy consumption of the world is keep on growing nowadays. Due to the continous development of the machine and electronics industry the average energy demand per person has increased fivefold in the last century. Accordingly the utilization of the non-renewable energy sources has extended. It has become more and more important to exploit our renewable energy sources, because of the sustainable development. The topic of our research is the energy-conversation from renewable energy sources moreover it includes the design procedure of a Photovoltaic Solar Water Heater System (PV-SWHS) and its comparison with a Solar Thermal Collector System (STCS).
Keywords: renewable energy, solar energy, domestic hot water, solar panel

INTRODUCTION

The aim of our research project was to reveal an alternative solution for domestic hot water production beside the solar thermal collector systems. The complexity of the PV-SWHS is not up to the subtility of the STCS's, since several devices belong to STCS, e.g. the puffertank, pump, controller and heat-insulated tubes, etc. These decives enlarge the expenses and the return of the systems and require regular maintance and control.

MATERIALS AND EXPERIMENTAL DETAILS

The PV-SWHS's are composed of the PV-panels, solar cables, Maximum Power Point Tracking System (MPPT) and a hot water tank with an electrical heating element. These systems have larger maintenance intervallums, and are cost-effective.

DESIGNING PROCESS OF THE SOLAR THERMAL COLLECTOR SYSTEM (STCS)

First of all it was defined how much heat is needed to produce domestic hot water for a family of four people. Following the determination of the number of the collectors was performed by using Eq. 1:

$$Q = 0.9 \cdot N \cdot A \cdot Q_{annual} \cdot \eta\ , \qquad (1)$$

where N is the number of the collectors, A [m²] is the surface of one collector, Q_{year} $\left[\frac{kWh}{m^2 \cdot year}\right]$ is the annual energy production by unit area (1 m²) of one collector, and η is the collector-efficiency. The number 0.9 is a correction factor, defined by the angular offset of the rooftop and the orientation of the building.

The designing procedure of the STCS have been performed to produce the domestic hot water for a house of four people. The solar collector field, the pipelines, the storage tank, the expansion tank and the pump have been designed, as well. The amount of energy produced by thermal collectors have been calculated for each month of the year.

According to our calculation 2 collectors are needed if the production of domestic hot water is completely derived from solar energy. Nevertheless avoiding the stagnation behaviour of the STCS, only one collector should be chosen for the system. The STCS includes one flat plate collector with the absorber surface of 1.84 m², a hot water storage tank with capacity of 300 l, 18 l expansion tank and thermal insulated copper pipeline with length of 30 m.

Avoiding the stagnation behaviour and the over-heating conditions at summertime the following arrangements should be made:

- cooling down the water tank
    - at night, through the collectors
    - with cold water
    - controlled lowering
    - with thermo-ventilator
- partial or full shade (covering the absorber surface)
    - manually

» automatically

Figure 1. Automatic shading system

DESIGNING PROCESS OF THE PHOTOVOLTAIC SOLAR WATER HEATER SYSTEM (PV-SWHS)

Beside the high efficiency of the Solar Thermal Collector Systems, frequent maintenance and wear of the mechanisms can be occurred. A system was simulated, which produce the domestic hot water by applying solar panels. The panels are linked with a storage water tank by solar cables and with a water heater. The PV-SWHS have been sized for the same house of four people, as well as the Solar Thermal Collector System. The solar panel field, the storage tank, the water heater and the solar cable have been designed. The amount of energy produced by solar panels have been calculated as well. The PV-SWHS includes six polycrystalline solar panels with peak power of 250 W_p, solar storage tank with capacity of 80 l, 183 V / 1500 W water heater and 30 m of solar cable.

THE PROFITABILITY OF SOLAR POWER

In order to assess the potential return to a solar energy investment, the analization of the cost of constructing and operating a solar utility, and the forecast of the potential revenue provided by the system should be done.

There are numerous methods for energy production cost calculation - and the result depends on method to a large extent. The following costs were derived by the annuity method. The basis of this method is that annual income must cover annual expenditure throughout the full depreciation period. There is a distinction between the nominal annuity method which works out costs and income using appropriate inflation factors; and the real annuity method which uses current costs and income on an uninflated basis. Annual income is calculated from the product of the energy production costs to be calculated and annual energy production, which is estimated as a constant over the period under consideration.

RESULTS AND DISCUSSION

Table I. shows that the photovoltaic system possesses even less investment, maintenance, operation costs than the collector system and they possess nearly the same income. The photovoltaic system's payback period is shorter accordingly. We must admit that the PV-SHWS requires more surface on the rooftop than the STCS.

Table 1. Comparison of the PV and the Collector systems

Appellation	Solar Thermal Collector System	Photovoltaic Solar Water Heater System
Produced energy [kWh/year]	1 547	1 543
Surface [m2]	1.84	9.56
Investment [Ft]	768 100	523 800
Maintenance [Ft/year]	11 200	6 700
Operation [Ft/year]	9 200	3 900
Income [Ft/year]	65 200	65 000
Payback period [year]	17.36	10.21

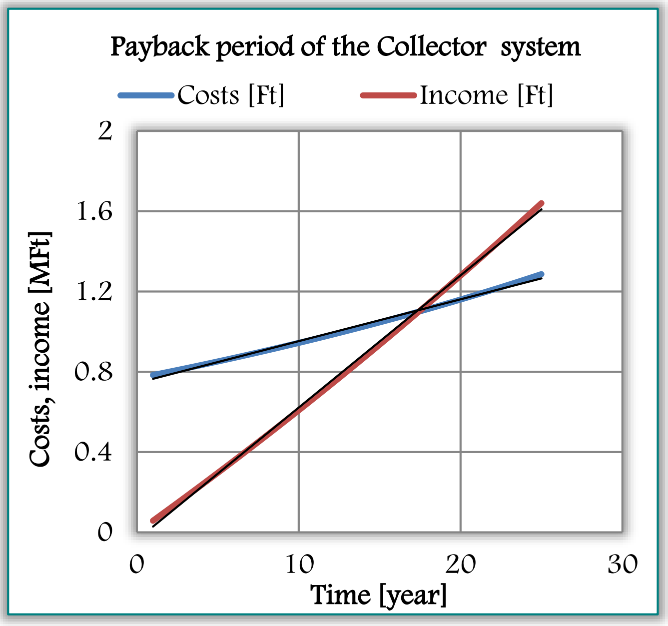

Figure 2. Functions of costs and income of the Collector System

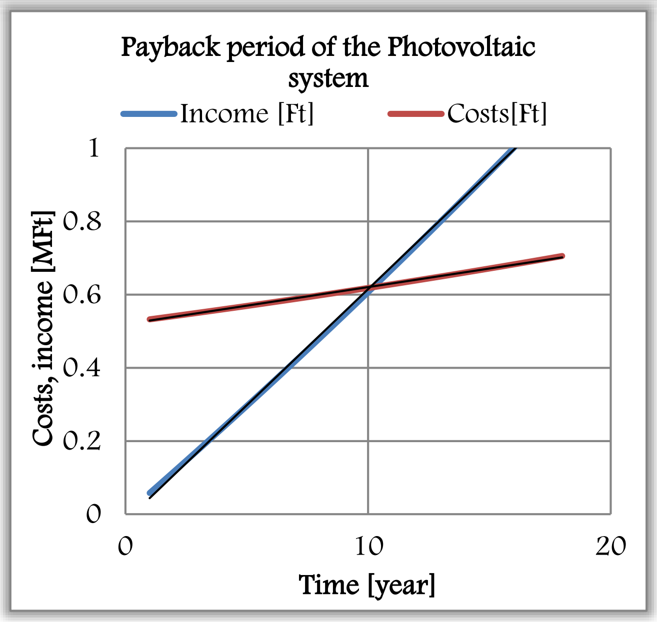

Figure 3. Functions of costs and income of the Photovoltaic System

CONCLUSION

In this paper it was shown that a photovoltaic system could eliminate several disadvantages of the solar collector system in terms of domestic hot water production. Our calculations pointed that the PV-SHWS is more cost-effective than the Solar Collector System. A small-scale Photovoltaic Water Heater System is going to be assembled in the departmental laboratory, so that measurements can be performed.

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