Improved exploitation of solar energy by Photovoltaic Generator and Active Thermo System

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ABSTRACT. Solar Energy Centre (SEC) of Southwest University (SWU) has been created with financial support of EU and SWU to study the conversion of solar energy into electricity and thermo power by modern solar technologies. Photovoltaic generator (1.5 kWp) and thermo system (160 l) have been installed on the roof of the university to supply SEC with electricity and hot water. The PV generator has been designed to work in the grid connected or stand alone regimes. The active thermo system has possibility to produce a hot water in direct and indirect regimes. The improved exploitation of solar energy by combined modern solar systems for a family house has been discussed.

1. INTRODUCTION

This publication presented the improved exploitation of solar energy by combination work of two modern systems for electricity and a hot water supply. The systems are PV generator (SWU PVSOLAR) and active thermo system. SWU PVSOLAR has started to operate as Solar Energy Centre of South-West University from April 1999 introducing the new lecture courses of materials and technologies for PV solar energy utilization for the students in Physics and Chemistry. The thermo system has built in 2002 year.

2. EXPERIMENTAL

The solar systems are installed on the flat roof of Southwest University "N. Rilski" (SWU). The coordinates of the solar energy complex are latitude - $42^0$1'34''N, longitude - $23^0$5'51'' and altitude – 350 m. The place is an open site city location. The creation of PV solar complex and the thermo system was realized according EU recommendation [1].

PV generator use the visible part of solar spectrums and thermo system has high efficiency conversion in the infrared wavelength.

PV SYSTEM DIAGRAM AND DATA MONITORING SYSTEM

Fig. 1 presents the schematic system diagram of 1.5 kWp PV solar generator. The main blocs of PV generator are 14 m^2 PV array, inverter, battery package and monitoring system. Twenty-one modules in serial and parallel connections organize the PV array. The three strings are connected parallel in the combiner box linked to the inverter. The ADC of the inverter is connected to RS232 of PC by optical link. The analog data from ESTI sensors and temperature sensor are converted to digital signals by ADC11 connected to CENTRONICS port of the PC.

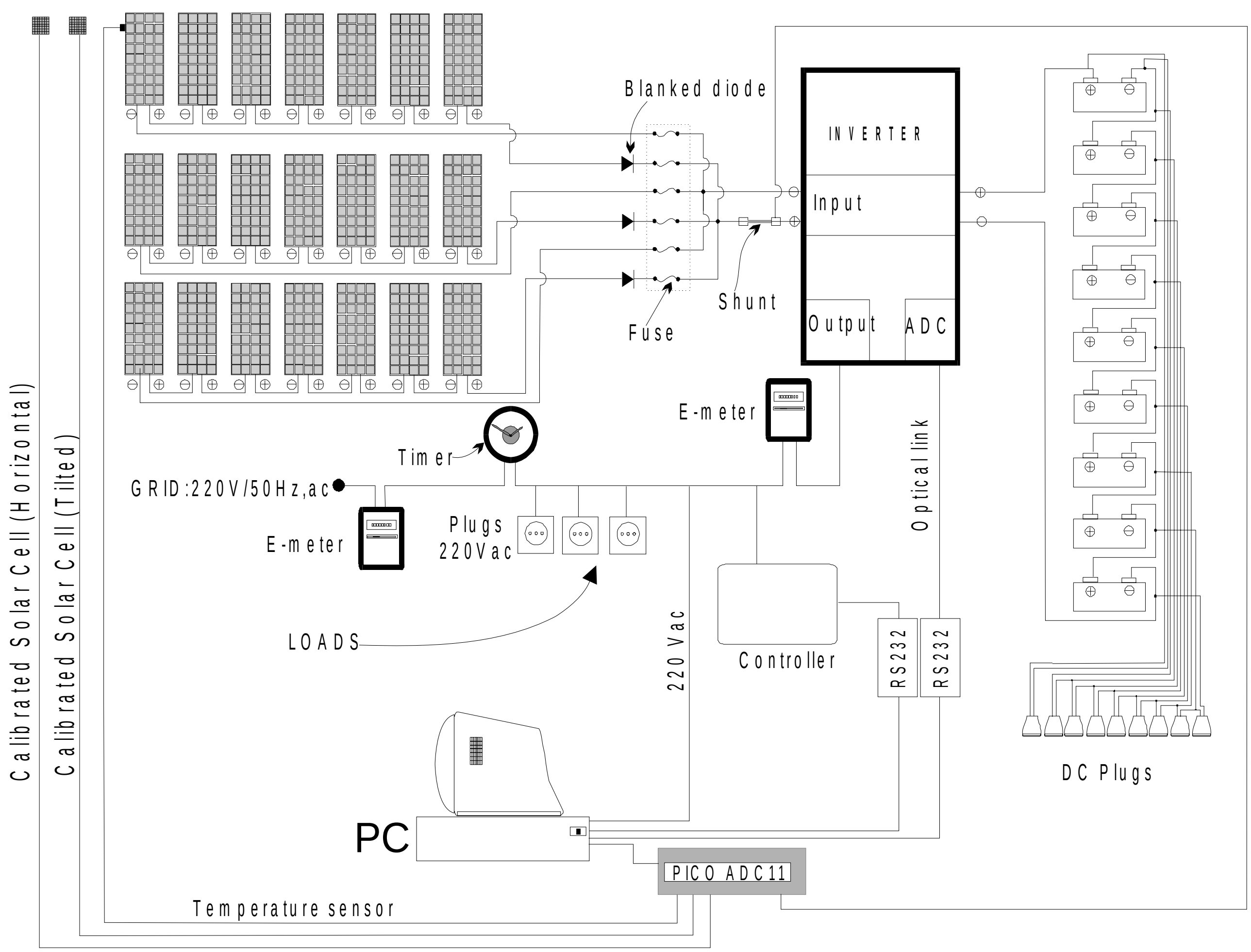

FIGURE 1. The schematic system diagram of 1.5 kWp PV generator

The PC data storage is connected to Internet for long-distance control of PV generator. The battery package is 9 Pb-acid batteries 12 V, 100 Ah connected in series. The operation time of PV solar generator is controlling by a timer. The monitoring system consists of two ESTI sensors, temperature sensor, calibrated shunt, ADC output from inverter, PICO ADC11, E-meters measure the input and output energy from inverter and utility grid, PC data storage system and PC data treatment system. The ESTI-sensor is based on a monocrystalline silicon solar cell, packed in a glass-tadlar/poliester,-aluminium'tedlar laminate. The cell is cut in half, one half is connected to a precision shunt and caters for the irradiance proportional I_{SC}-signal in order of 28mV; the other half remains at open circuit and serves as temperature monitor, using the temperature dependence of the open circuit voltage. The warrantees and the estimated lifetime of ESTI-sensor are 20 years and the re-calibration values are within +1 to –2% from the original calibration values 5 years of operation [2, 3].

THERMO SYSTEM DIAGRAM AND DATA MONITORING SYSTEM

The base futures active thermo system are: surface area 2 m^2, volume 160 l, possibility to work in direct or indirect regime. The design and realization of the system was be turn to simulated yearly consumption of heat water in one family house. The system is equipped with flat solar collector 2 m^2 , accumulation vessel has a volume 160l, into which is implanted three copper serpentines along in the all height of the vessel, expansion vessel, pump, water meter, heat meter, 12 thermo sensors assembled in accumulation vessel, 6 thermo sensors in collector circle, one thermo sensor for a measurement the air temperature. The solar collector and a part of the thermo sensors have being installed on the roof. The connection of serpentines was be realized to switch anyone combination of them. The measurement equipment included tracking control of 15 thermo sensors (12 in accumulation vessel, one in inlet of solar collector, one in outlet and air thermo sensor) has been design and realized. The scheme of installation is presented in Fig. 2.

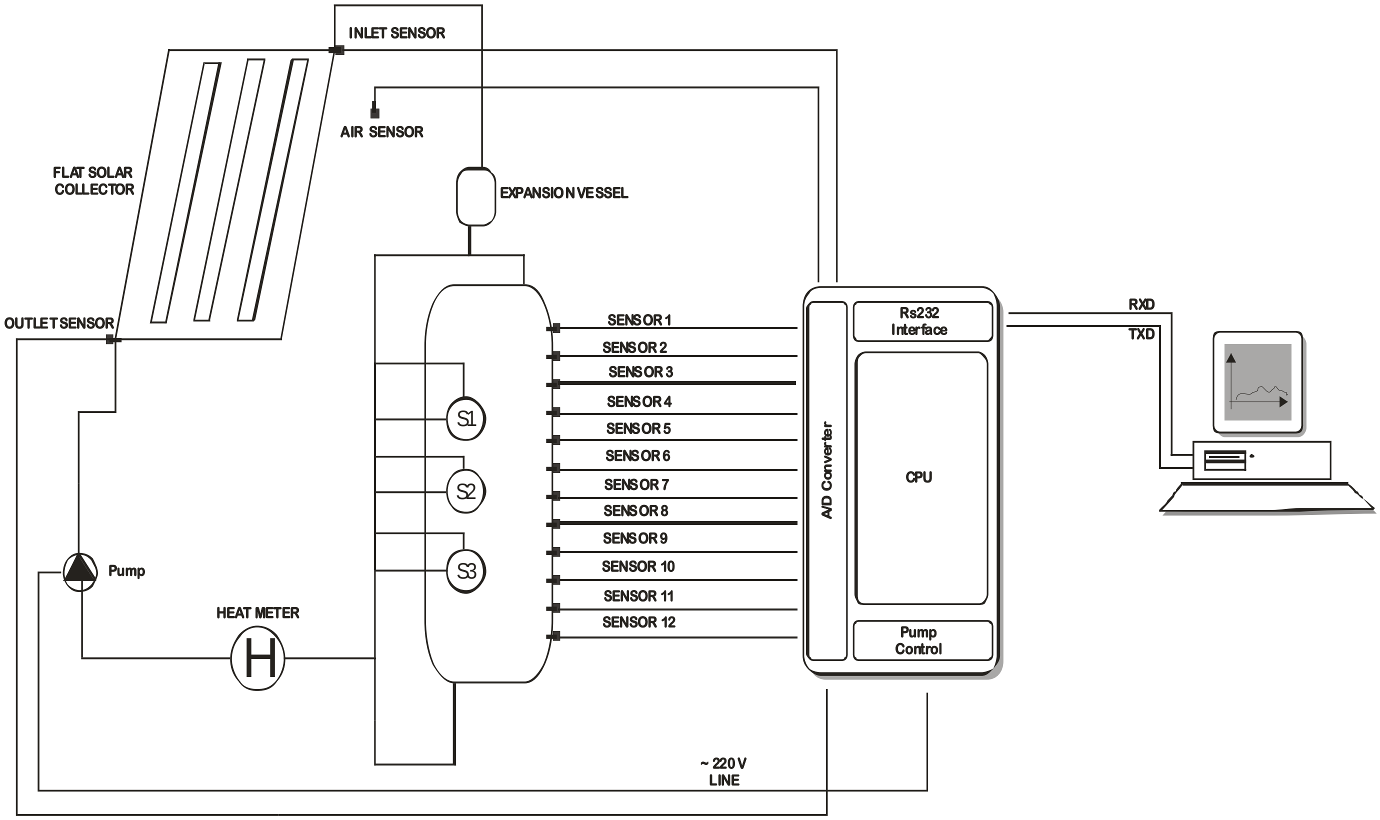

FIGURE 2. The schematic system diagram of thermo system

3. RESULTS AND DISCUSSIONS

Fig. 3 shows the annual production of electricity for 2002 year from PV generator. The maximum output is in July and minimum is in January. The most effective period of energy supply to utility grid is from April to October. The data are for a year but this tendency is correct for every one of the investigated period (1999 - 2002). The electricity consumption per month for a family house (four persons) is about 450 kWh including all domestic electric devices. If we exclude electric devices as a cooking stove, electric heat device etc. which used reactive power then the energy consumption is 150 kWh. The efficiency use of this energy is by office devices as computer, monitor, scanner, printer, TV, efficiency lamps and thermo solar system. The power supply of thermo solar system is for 30W water pump.

The other part of the energy balance of one family house is heat energy. Fig. 4 presents efficiency of conversion of solar radiation by active thermo system. The measurement is realized with simulation of heat water consumption. The volume of consumption of hot water per day is 200 l, the temperature of water is min 45 ^{o}C.

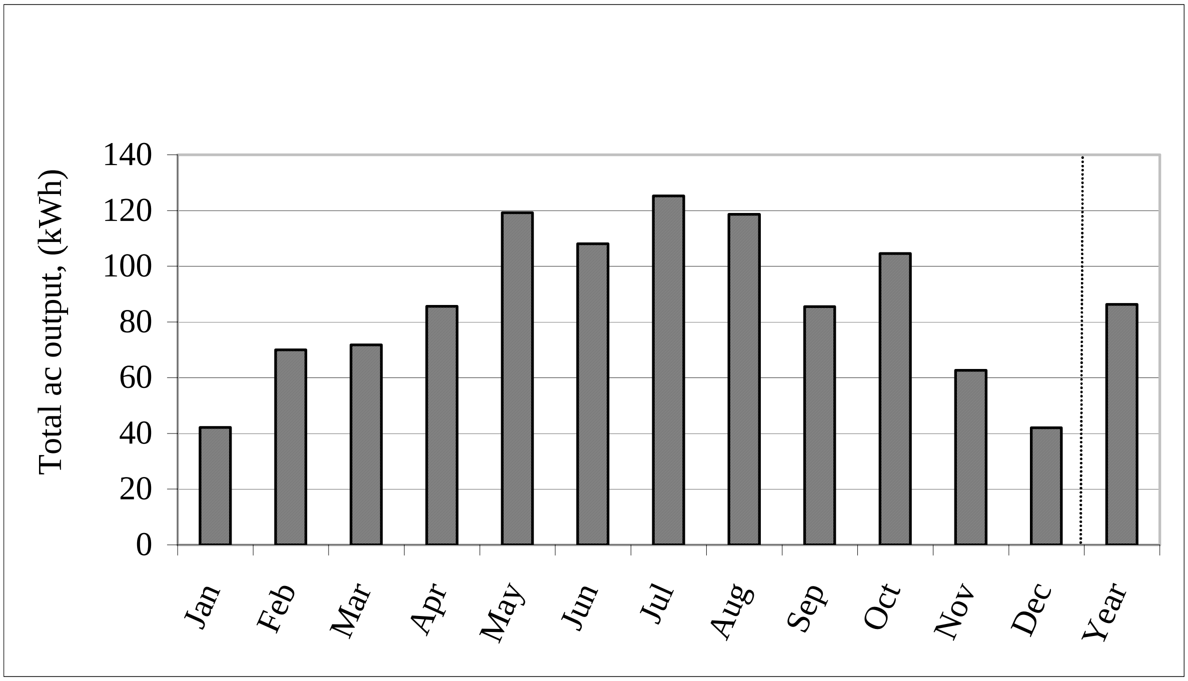

FIGURE 3. The annual energy output from PV generator during 2002.

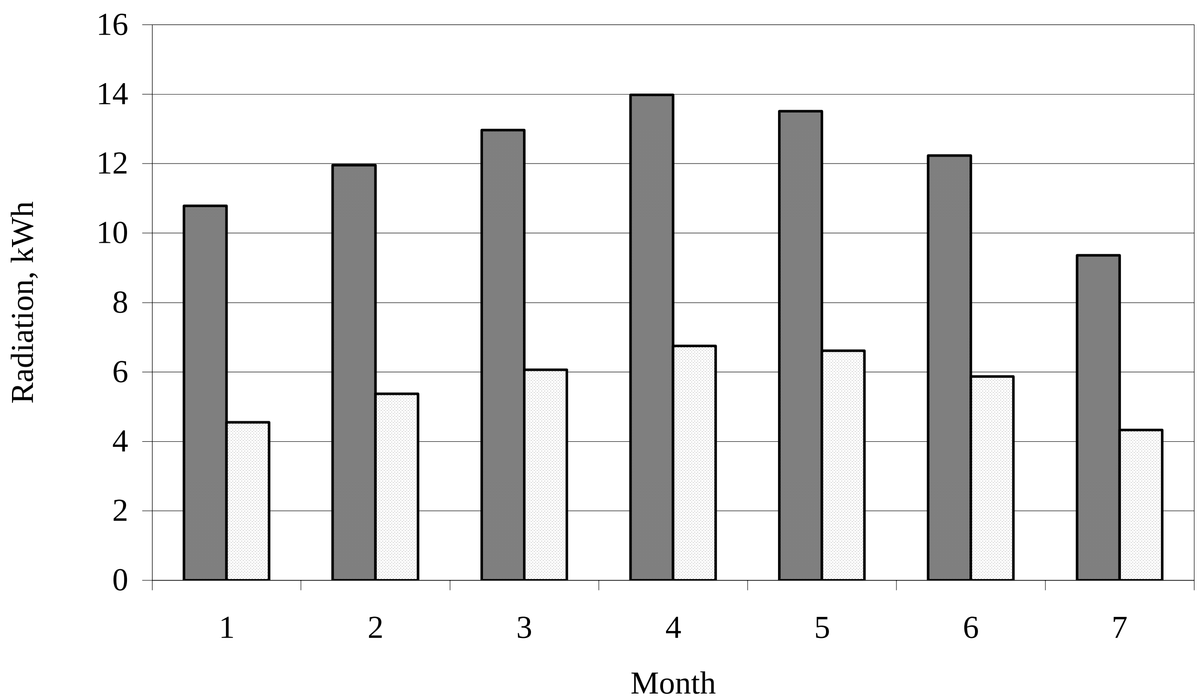

FIGURE 4. The fall and utilized radiation from thermo system for the period April - October 2002.

Fig. 5 shows solar covering of energy needs of a family house and the thermo systems in this model covered from 40% to 60% from a hot water. In the base of experimental results the covered of energy needs of a family house is split on three parts: Low level of efficiency – from November to January, Medium level of efficiency – from February to April and from September to November and High level of efficiency – from May to August.

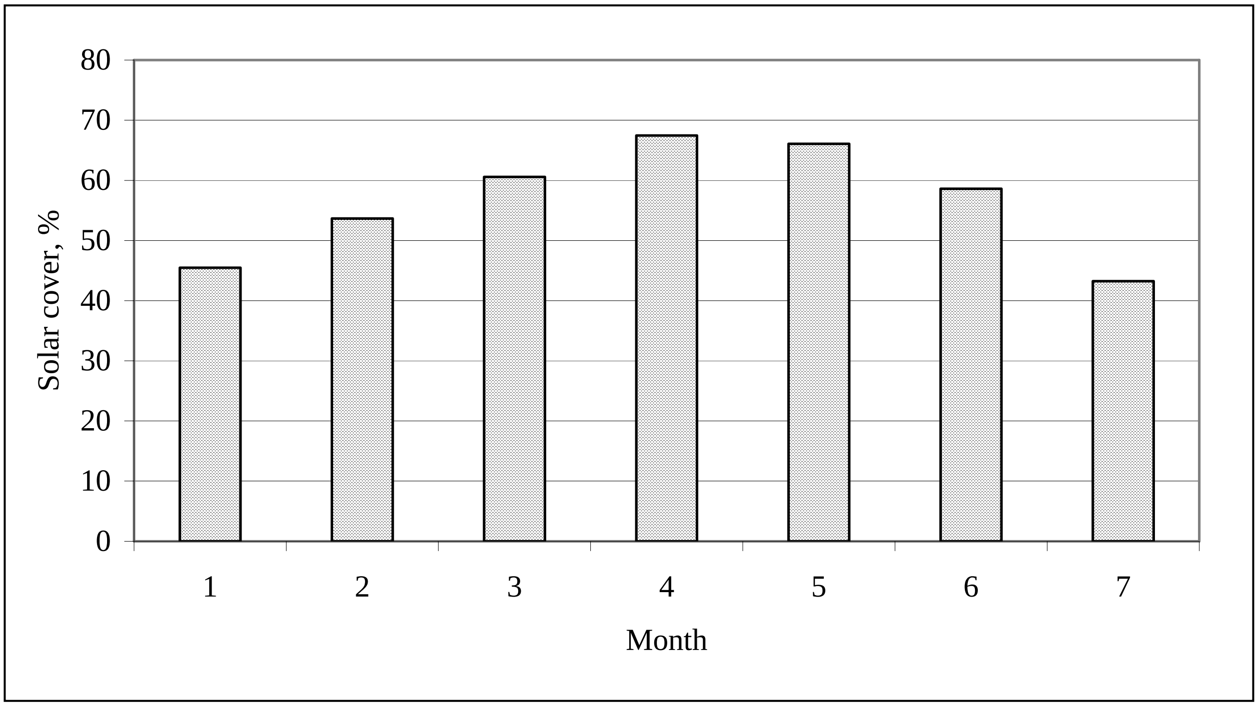

FIGURE 5. The solar cover of hot water needs of family house from April 2002 to October 2002

4. CONCLUSIONS

The PV generator covered 18 % electricity needs of one family house. If excluded the domestic electric device how use reactive power the percent is 53 %. The thermo solar system in the model presented in publication covered 57 % need of hot water.

The PV generator and thermo active system cover 50 % of the energy needs of a family house.

References

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