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Operational experienced of an 8.64 kWp grid-connected PV array

Zoltán Hagymássy[1]

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ABSTRACT

The Department of Agricultural Machinery of the University of Debrecen has a photovoltaic (PV) system. Information's are given about the main operational characteristics and operation experiences. In this research, evaluation of 3 PV modules technologies i.e. monocrystalline PV technology (ST-40), polycrystalline PV technology (KC-120), and amorphous silicon PV technology (DS-40) performed based on points of view energetic in 2011. The produced DC, and AC power, together with the produced energy are as well, and the efficiency can be determined for each used PV technology.

1. Introduction

The Earth receives solar energy (energy from the sun) by way of radiated (light) energy. Refers to quantum theory, light is made up of packets of energy, called photons (tiny particles having no mass), whose energy depends only upon the frequency or color of the light. The energy of visible photons is sufficient to excite electrons, bound into solids, up to higher energy levels where they are relative free to move so that an electrical current can be produce (Nelson, 2003).

Life on Earth is based on solar energy. The outer limit of Earth's atmosphere receives almost a constant amount of radiation of 1352 W/m^2, of which the 23% is absorbed by the atmospheric gases, 26% is reflected, so 51% reaches the Earth's surface in the form of direct or diffuse radiation. In Hungary, the number of sunny hours is 1900-2200 hours per year, the average irradiation intensity is around 1200 Kwh/m^2. (Hagymássy and Fórián, 2009). The Sun emits electromagnetic light in various wavelengths: UV (<400 nm); visible (400-800 nm); infrared (>800 nm). (Rusirawan et al., 2011). Presently, the direct conversion of solar energy into electricity is being accepted as an important form of power generation. This electricity generated by a process known as the photovoltaic effect using photovoltaic (PV)system (cells/modules/panels/array), which are made from semiconductor materials. (Rusirawan and Farkas, 2011)

In Hungary there is a comparable 10 kWp grid-connected PV array system at Szent István University, Gödöllő (Farkas et al., 2008). The PV system in Gödöllő is structured into 3 subsystems (fields). Each subsystem has its own inverter (Farkas et al., 2008).

Vántus (2008) suggested for agricultural enterprises an efficient, environment-friendly solar system.

2. Materials and methods

2.1. The test conditions of the University of Debrecen

There is a demonstration center in the Department of Agricultural-machinery of Educational Research Center where students, teachers and those who interested get an overview of the topic of renewable energy potential and the necessary technological solutions.

The total surface of 8.64 kWp grid-connected PV array system is A=110 m^2.

[1]Zoltán Hagymássy
University of Debrecen, 4032 Debrecen, Böszörményi út. 138, Hungary
hagymassy@agr.unideb.hu

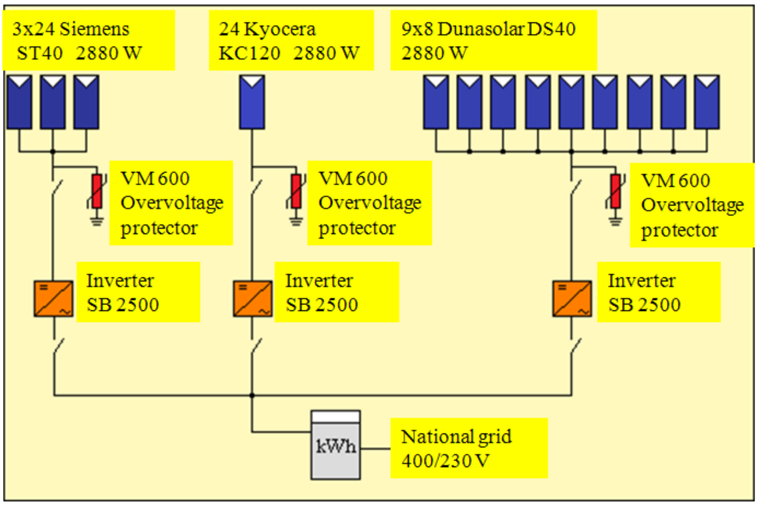

Figure 1. The schematic diagrams of 8.64 kWp grid-connected PV array system

The schematic diagrams of 8.64 kWp grid-connected PV array system can be seen in Figure 1. The PV system in Debrecen is structured into 3 subsystems (fields). The first subsystem has 24 pieces of Kyocera KC 120 W type modules, the second subsystem has 72 pieces of Siemens ST 40W, and the remaining has 72 pieces of Dunasolar DS 40W (Figure 3.). In order to be operable independently of each other three inverter modules (SB 2500) had been installed.

2.2. The inverters

The measured operating and meteorological dates are collected by Sunny Boy Control, produced by the SMA (Figure 2). The Sunny Boy Control has eight analogue and eight digital inputs and eight digital outputs. One of the eight analog inputs is used to measure the air temperature, and one of them measuring the Module temperature.

Figure 2. Sunny Boy (SB 2500) inverters

The recorder can be connected directly to a desktop PC by RS232. Operating and meteorological dates are recorded by MS Excel every 15 minutes.

The power plant is connected to a weather station, which contents a PT 100 type temperature and humidity combined measuring instrument, a CM 11 pyranometer, and a wind speed measuring instrument.

The orientation of the photovoltaic system is nearly to South along with the 30 degrees of fixed inclination angle. Such positioning of the systems means a fairly good yearly optimum value in Hungary concerning to energetic point of view. (Farkas and Seres 2008)

Figure 3. The first subsystem has 24 pieces of Kyocera KC 120 W type modules, the second subsystem has 72 pieces of Siemens ST 40W, and the remaining has 72 pieces of Dunasolar DS 40W modules.

3. Results and discussion

3.1. The energy production in 2011

In 2011, the amount of produced electrical energy is represented by Figure 4 and Figure 5. The energy productions of the subsystems are measured continually and the subsystems are measured separately. As an expected, the produced energy of polycrystalline -Si PV module and monocrystalline -Si PV was higher than amorphous-Si PV module. It is well known that energy analysis is more suitable for energy balance when we design a system, because of this we contribute with the local entrepreneurs helping those designing systems.

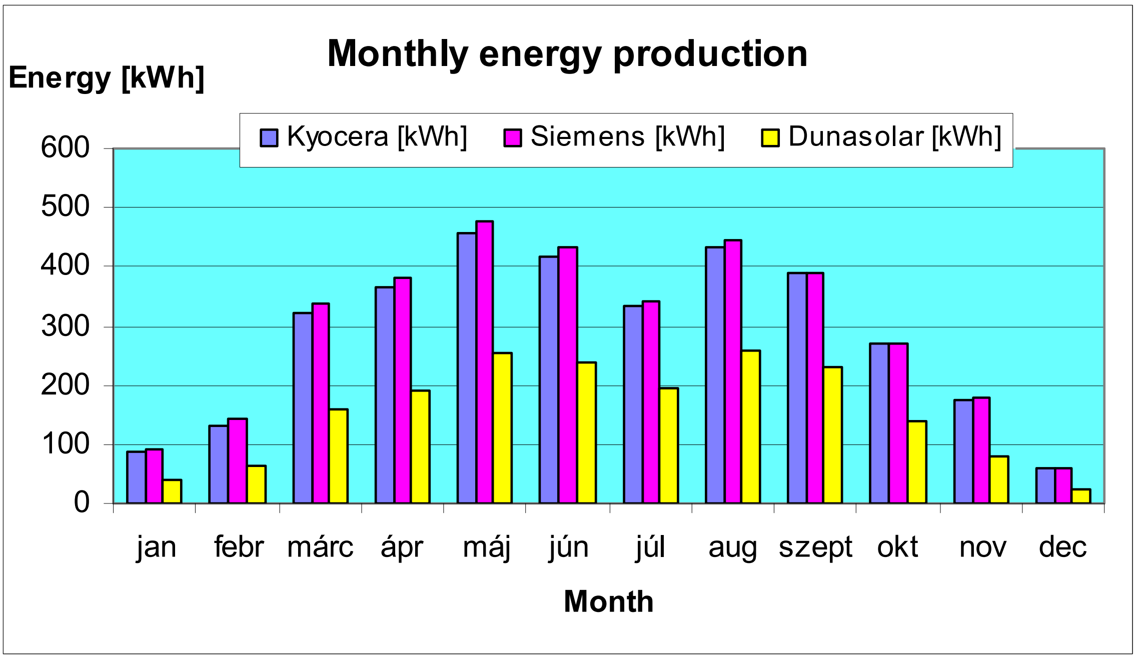

Figure 4. Energy analysis in 2011

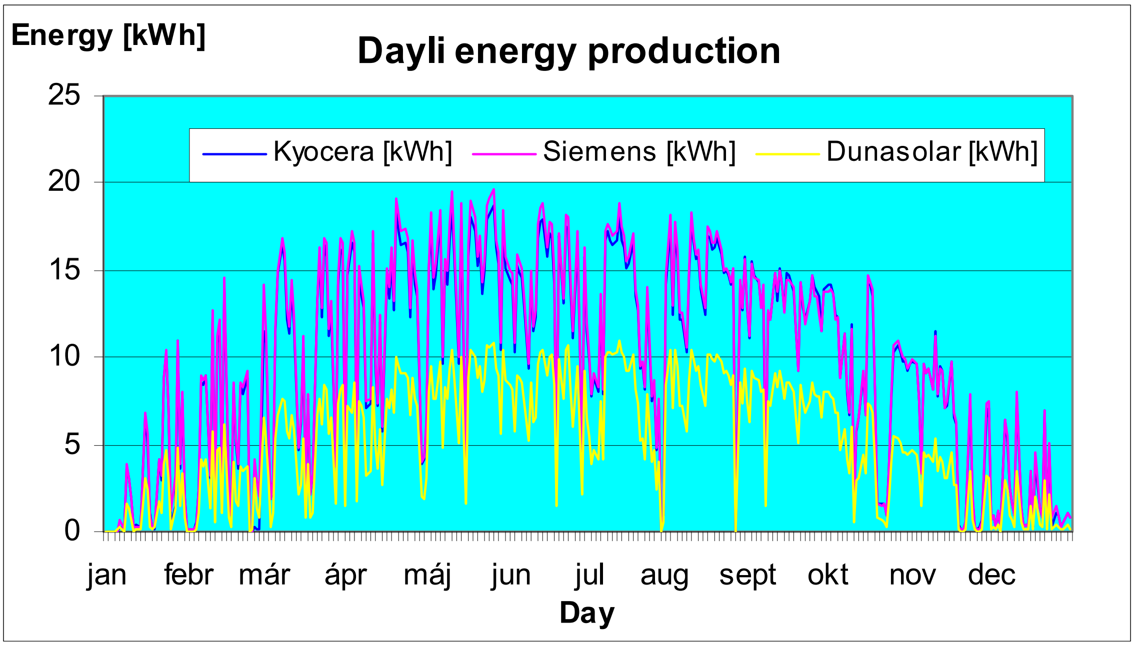

Figure 5. Energy analysis in 2011

3.2. Temperatures and irradiation conditions

The energy of a PV system depends on two major components namely electrical energy and thermal energy (Rusirawan, 2012). While the electricity is generated by photovoltaic effect, the PV cells also get heated due to the thermal energy present in the solar radiation. The air temperature and the temperature of the panels and the global irradiation conditions were measured. In summertime the panel temperature reaches 60-80 degrees in a sunny day. The panel temperatures are in a spring sunny day approximately 30-40 degrees (for example, on the 15th of March 2012). (Figure 6.) It can be concluded that the global irradiation is a major impact feature to influence the amount of energy produced.

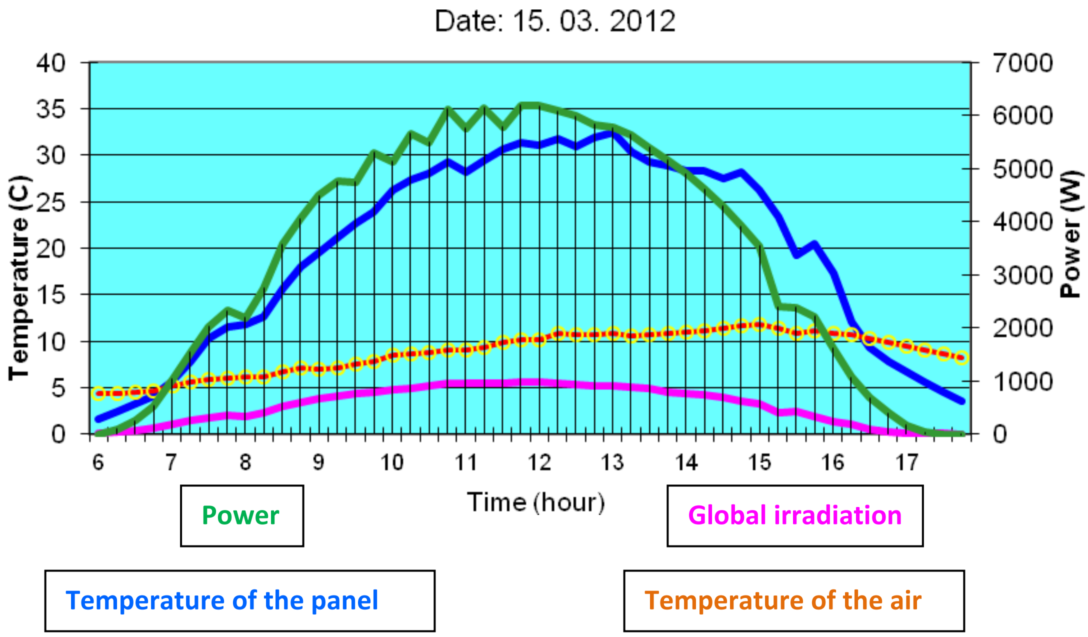

Figure 6. Air temperatures, Temperature of the panels, Irradiation conditions, and Power

3.4. Experiences

The efficiency depends on several parameters (spectral distribution of the incoming light, temperature values, etc.). As the PV system is a multi-component system, the efficiency of the different parts can be calculated and the multiplication of these values provides the system efficiency. In our case not all the part efficiencies are determined, but calculations were carried out for the module efficiency and for the inverter efficiency. According to the suggestion of Farkas and Seres 2008, the cable losses are not taken into the calculations. The time dependence of the efficiency during a month (April, 2012) can be seen in Figure 7.

The energy efficiency of a PV system in general can be defined as the ratio of the output energy of the system to the input energy received on the photovoltaic surface. As an expected, the energy efficiencies of polycrystalline -Si PV module and monocrystalline -Si PV was higher than amorphous-Si PV module. Based on our study, in general it can be concluded that the energy efficiency is lower than theoretical (Figure 7.).

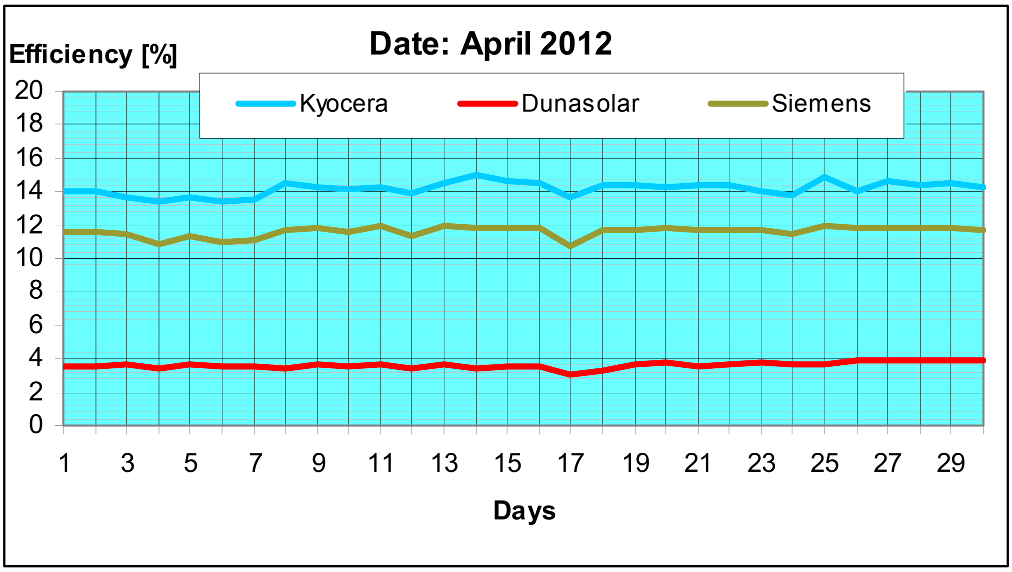

Figure 7. The measured efficiencies

__Module Type:__

1. Kyocera KC 120W 24 pieces in two rows
Measured efficiency in April: 13-15% (Figure 7.)
The operational experiences: good radiation absorbing ability, aesthetic.

2. Siemens ST 40W 72 pieces in two rows
Measured efficiency in April: 11-12% (Figure 7.)
The experiences of operation: Easy to assemble, low weight (7 kg). Good resistance against environmental affects.

3. Dunasolar DS 40W 72 pieces in four rows
Measured efficiency in April: 3-4% (Figure 7.)
The operational experiences: vulnerable, complex assembly, 2 items were cracked (there were manufacturing defects).

4. Conclusions

The data logging system of a 8.6 kWp grid-connected PV system were discussed in this paper, together with the details of the measured quantities. Based on measurements the distribution of the total energy production was presented together with the distribution of the energy production among the different subsystems in 2011. The energy productions of the subsystems are measured continually. By measuring irradiation and DC and AC power of the system, the efficiency of the two important parts of the system (the PV array and the inverter) were determined. The efficiency of the mono crystalline module field was calculated around 11…12%, the efficiency of the poly crystalline module field was calculated around 13…15%, while the amorphous module field was 4%.

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