EXPLOITATION OF PHOTOVOLTAIC INSTALLATION IN OSTOJA IN SUMMER 2009

Z. Zapałowicz[1], **D. Szyszka**[2]

1. Department of Heat Engineering, Department of Mechanical Engineering and Mechatronics, West Pomeranian University of Technology, Szczecin, Poland
2. Training and Research Center for Renewable Energy Sources in Ostoja, West Pomeranian University of Technology, Szczecin, Poland

ABSTRACT

The paper presents two off-grid photovoltaic installations started working in Training and Research Center for Renewable Energy Sources in Ostoja by Szczecin in November of 2008. The center is at present an administrative unit of the West Pomeranian University of Technology in Szczecin. After the installations were started up, their characteristic parameters were monitored. Results of analysis of the above monitoring are given in the present paper and they apply for the summer 2009. They allow to consider the working efficiency of the installations.

INTRODUCTION

Photovoltaic systems (PV) are relatively rarely applied as the source of electric energy in Poland. Investments costs are very high, and thus, they are refunded in a very long time. Newest stand of development of photovoltaic applications in Poland are given in paper [Pietruszko 2009].

Prevailing number of PV installations built and operating in Poland are off-grid systems to supply particular recipients. The systems supply properties or receivers, e.g. mountain shelters, road signs, emergency telephones, navigation buoys, etc., that are distant from the power network. PV systems are also applied as emergency power sources. They are connected to accumulators that are used as power sources in the case when the main supply fails to work. PV installations are also applied as elements of hybrid systems, e.g. PV power plant and wind power plant. PV systems can also be applied as complementary, or rarely as basic, sources of power for private or industrial properties that are connected to power network. In objects where the produced electric energy is aimed to be used for own needs, it is important to secure the inside network properly. The surplus of electrical energy produced by PV panels cannot be delivered to commonly accessible power network. It can only be stored in accumulator systems. For the reason of complicated procedures of administration, it is extremely difficult to connect the PV system with power network. Results of long-term research on on-grid PV installation connected with power network are given in paper [Zapałowicz 2009].

In November of 2008, two off-grid PV installations were set in operation in Training and Research Center for Renewable Energy Sources in Ostoja near Szczecin. The installations were financed from sources of European Regional Development Fund within the programme of INTERREG IIIA Poland (West Pomeranian Voivodeship – Meklemburg Vorpommern/Brandenburg). The Training and Research Center is an administrative unit of West Pomeranian University of Technology in Szczecin – ZUT (the university is a fusion of University of Agriculture in Szczecin and of Szczecin University of Technology). Working parameters of the above installations were monitored from the beginning of their work.

The aim of the present paper is to analyse working parameters of the installations in the summer period of the first year of their work.

PV INSTALLATION IN THE OSTOJA CENTER

Two PV installations are set in work in the Ostoja Center, located not far away from Szczecin. Both of them are free-standing, of off-grid type. The produced electrical energy is used to lighten the area of the property [Zapałowicz et al. 2009].

The scheme of installations is shown in Fig.1. They differ by kind of photovoltaic cells that form modules. The first installation consists of 6 mono-crystalline PV modules of the STP 180S-24/Ac type, produced by Suntech Power. The latter one is equipped with 12 thin CIS layer, PV modules of the type SCG50 – HV, produced by Sulfurcell. In both cases, the panels are mounted on movable frameworks, the so called trackers. Thus, panels can track the apparent trail of the Sun on the horizon. The movement of panels is possible only in the east-west plane (single-plane tracking system). Each of the installations works autonomously.

Direct current produced in PV installation is used to charge the set of solar accumulators, or it is transferred directly by the inverter of the type Quattro 5000. There, the current is converted into alternating current. Optimal working conditions for the direct current installations are secured by charging regulators of the type MPPT 100/20-1 (for mono-crystalline modules) and CXN 40 (for CIS modules). Monitoring of parameters of accumulator sets for each PV installation is carried on by means of BMV-501 units. Each set of accumulators consists of 12 batteries and the voltage rating for each one equals 24 V. Capacitance of the sets equals 800 Ah.

In the basic working mode of both installations, when the sun shines, the accumulator sets are being charged. In the night, the current collected in accumulators is passed on to the inverter, and then, used to lighten the area of the property in Ostoja. At present, PV installation with CIS modules supply 2 lamps with total power of 150 W, whereas the PV installation with mono-crystalline modules supplies 2 lamps with total power of 300 W. Lighting in the property is switched on automatically by a dusk sensor.

Table 1 shows essential working parameters of PV modules and panels. In turn, Table 2 presents fundamental technical data of the inverter.

RESEARCH RESULTS

The summer working period of the PV installations covered the time of 4 months, that is June, July, August, and September.

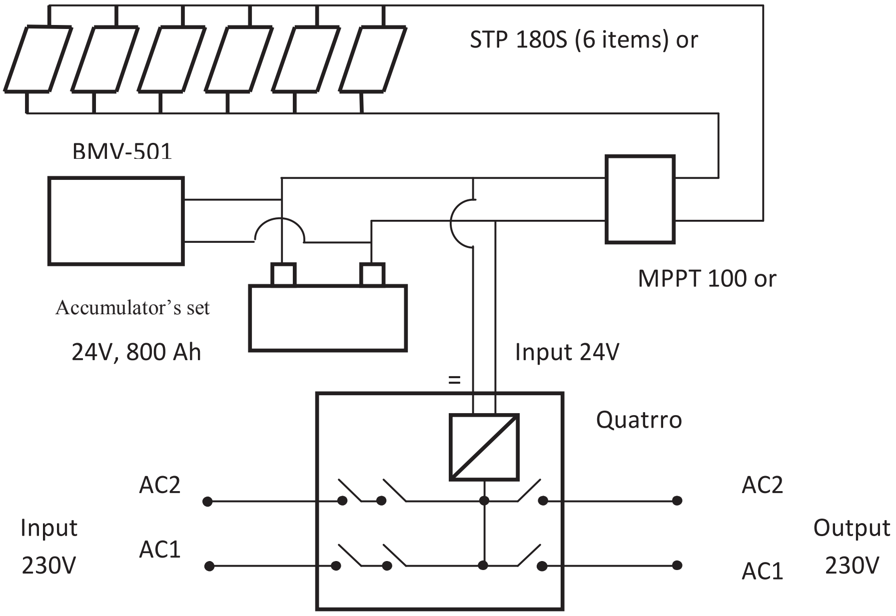

Fig. 1. Scheme of PV installations in Ostoja center

Table 1. Technical data of PV panels and modules

Parameter	Unit	Value	
Module		STP 180S-24/Ac	SCG50 - HV
Number of cells in module	items	72	80
Maximal power	W_p	180	50
Guaranteed minimal power	W_p	174,6	47,5
Open circuit voltage	V	44,8	50
Short circuit current	A	5,3	1,65
Voltage at maximum power (in MPP point)	V	36	37,5
Current at maximum power (in MPP point)	A	5	1,35
Temperature coefficient of short circuit current	A/K %/K	0,06	0,04
Temperature coefficient of open circuit voltage	V/K mV/K	-155	-130
Temperature coefficient of power	%/K	-0,5	-0,3
Length/Width	m	1,580/0,808	1,256/0656
Area of module	m^2	1,277	0,824
Masse	kg	16	13,7
Panel			
Number of modules in panel	items	6	12
Panel's power	W_p	1080	600
Area of panel	m^2	7,662	9,888

Table 2. Technical data of receiver Quattro 24/5000/120

Parameter	Unit	Value
Nominal power	W	5000
Input voltage	V	180-265 AC 19-33 DC
Output voltage	V	210-245
Frequency	Hz	50
Maximal efficiency	%	94
Height	m	0,444
Width	m	0,328
Length	m	0,240
Masse	kg	30
Recommended capacity of accumulators set	Ah	400-1400

In this period, the installations were used as the main electric energy source to lighten the area of the property in Ostoja.

Measurements data (most of all, values of voltage and current) were collected every 1 minute. In the time of 4 months, over a million of parameter values were analysed.

In June, both installations worked in the follow-up mode and the electrical energy collected in this time during the day was stored in accumulators, which supplied the lamps lightening the property after the dusk. Daily amounts of produced and consumed electric energy in June are shown in Figs 2 and 3.

Figs 4 and 5 show the comparison of the amount of produced and consumed electric energy for the PV installations. It can be assumed from the analysis of data given in Figs 2÷5 that mean daily electric energy production in June 2009 equaled ca 2,2 kWh for PV installation with thin CIS layer panel and ca 4,4 kWh for PV installation with mono-crystalline panel, respectively.

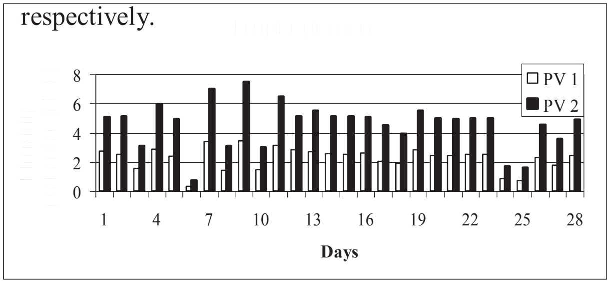

Fig. 2. Electric energy produced by PV installations in June 2009; 1 – CIS panel, 2 – mono-crystalline panel

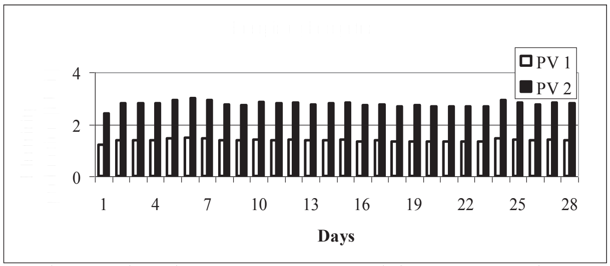

Fig. 3. Electric energy consumed from accumulator sets of PV installations in June 2009; 1 – CIS panel, 2 – mono-crystalline panel

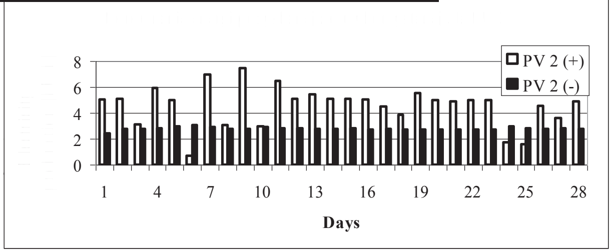

Fig. 4. Comparison of produced and consumed electric energy in June 2009 for the PV installation with CIS panel

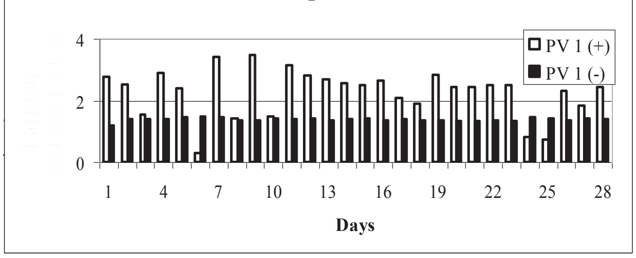

Fig. 5. Comparison of produced and consumed electric energy in June 2009 for the PV installation with mono-crystalline panel

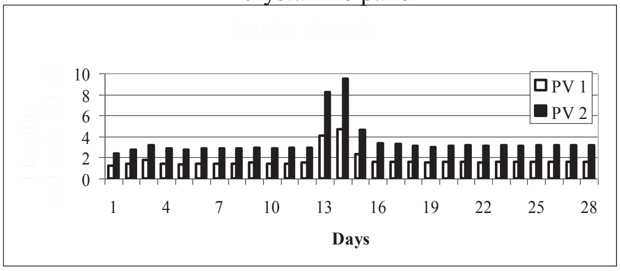

Fig. 6. Electric energy produced by PV installations in July 2009; 1 – CIS panel, 2 – mono-crystalline panel

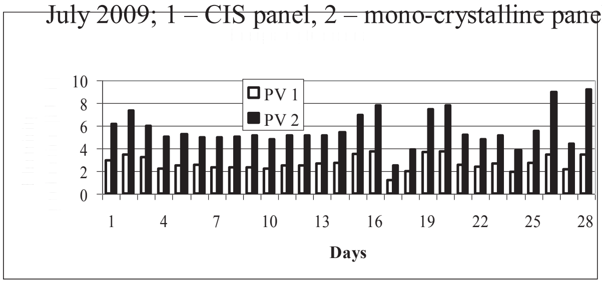

Fig. 7. Electric energy consumed from accumulator sets of PV installations in July 2009; 1 – CIS panel, 2 – mono-crystalline panel

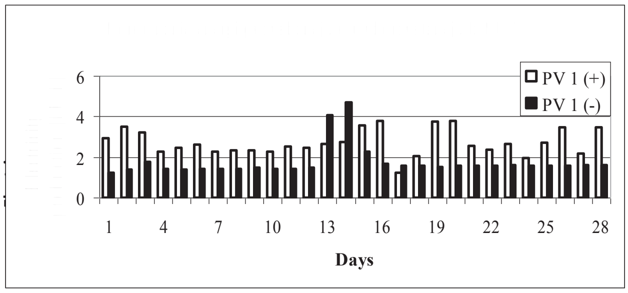

Fig. 8. Comparison of produced and consumed electric energy in July 2009 for the PV installation with CIS panel

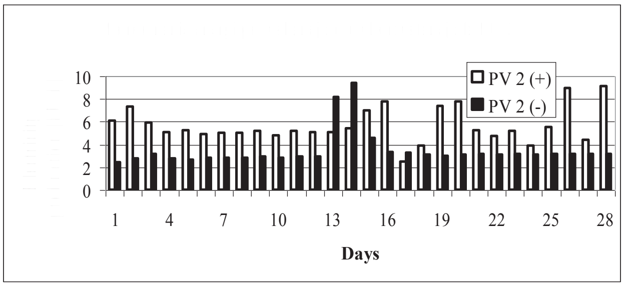

Fig. 9. Comparison of produced and consumed electric energy in July 2009 for the PV installation with mono-crystalline panel

At night in June, the load of accumulator sets did not cause the electric energy consumption higher than electric energy production by PV installations during the day.

At night, ca 1,3 kWh of electric energy was drawn from accumulators connected to CIS modules, and ca 2,7 kWh of electric energy was drawn from accumulators connected to mono-crystalline modules.

In turn, daily amounts of produced and drawn electric energy in July for both PV installations are given in Figs 6 and 7. Mean daily production of electric energy equaled ca 2,7 kWh for PV installation with CIS panel and ca 5,7 kWh for PV installation with mono-crystalline panel, respectively.

In July, the time of lightening the property lengthened systematically and thus the need for electric energy increased. Mean daily electric energy consumption equaled, respectively: 1,5 kWh for the unit with CIS modules, and 3,0 kWh for the unit with mono-crystalline modules. The analysis does not regard the 13th, 14th, 15th days of the month, as the lightening was purposely switched on for continuous work. This way, accumulators of both panels were loaded day and night.

In July, the amount of electric energy obtained by PV installations during day was still higher than energy amount drawn by the lightening system (Figs 8 and 9).

June and July 2009 were the months when there occurred very few cloudy days and the solar radiation reached the panels with only minimal attenuation. In June, there were only 3 cloudy days, that is 6th, 24th, 25th. In turn, the 17th day of July was cloudy.

There occurred more cloudy days in August, and the time of lightening the property at night lengthened, too. Nonetheless, it was stated on the basis of Fig. 10 that the amount of produced electric energy in this month was at highest. Figs 10 ÷ 13 show working results of both PV installations in August 2009.

It can be assumed from the analysis of data for the above month that daily production and mean daily consumption of electric energy equal respectively: 3,4 kWh and 2,1 kWh for the CIS panel, and 6,7 kWh and 3,1 kWh for the mono-crystalline panel.

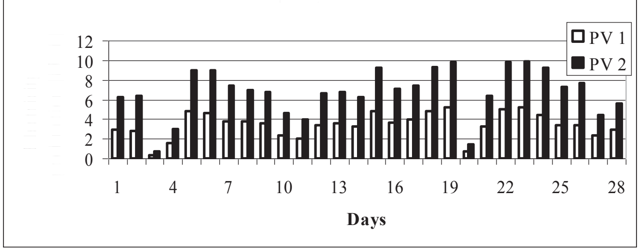

Fig. 10. Electric energy produced by PV installations in August 2009; 1 – CIS panel, 2 – mono-crystalline panel

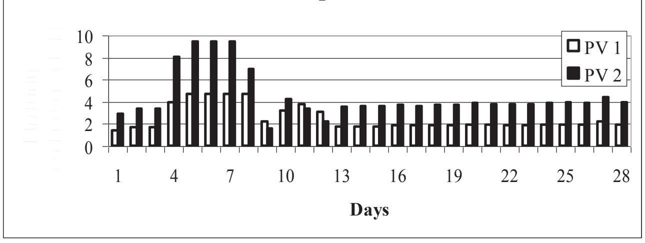

Fig. 11. Electric energy consumed from accumulator sets of PV installations in August 2009; 1 – CIS panel, 2 – mono-crystalline panel

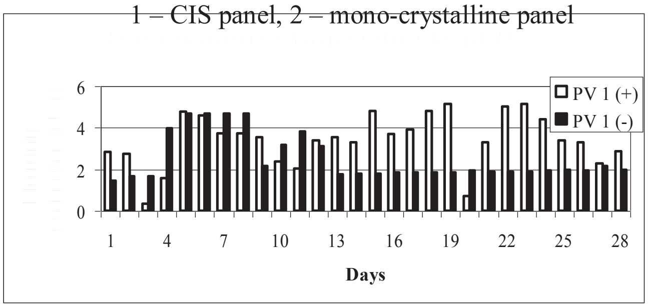

Fig. 12. Comparison of produced and consumed electric energy in August 2009 for the PV installation with CIS panel

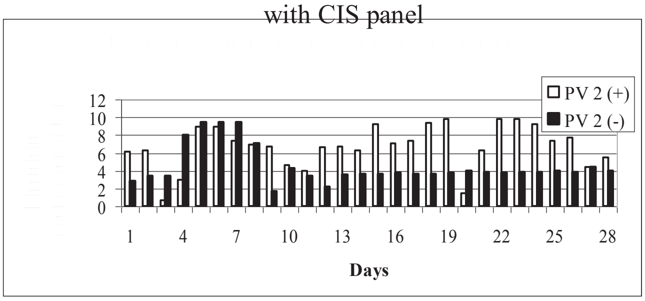

Fig. 13. Comparison of produced and consumed electric energy in August 2009 for the PV installation with mono-crystalline panel

Weather conditions in September were very variable. Cloudy days occurred more often and production of energy was disturbed or the obtained amounts of electric energy were low in both PV installations (Figs 14 ÷ 17).

Mean daily production and consumption of electric energy equal respectively: 2,8 kWh and 2,5 kWh for the CIS panel, and 5,6 kWh and 4 kWh for the mono-crystalline panel.

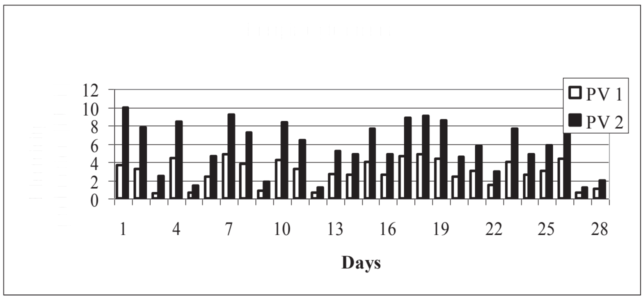

Fig. 14. Electric energy produced by PV installations in September 2009; 1 – CIS panel, 2 – mono-crystalline panel

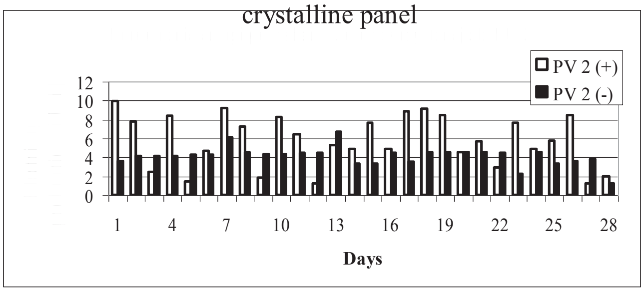

Fig. 15. Electric energy consumed from accumulator sets of PV installations in September 2009; 1 – CIS panel, 2 – mono-crystalline panel

In September 2009, it was decided to carry on research in conditions of higher load of accumulator set fed by the thin CIS layer panel. Hence, there is visible higher consumption of electric energy on the 8th and 9th day. At this time, additional receivers from the laboratory in the building were connected with accumulator set. High load of 3500 W caused fast drop of the voltage at accumulator terminals. Accumulators were in a position to supply the inverter with current at value of 150A an only in the time of 30 min. Then, voltage at accumulator terminals dropped below 20 V. As a result inverter switched off and the supply of the property had to be connected with the standard power network.

Irregular electric energy consumption from accumulator sets in last days of September (Fig. 16) was caused by the automatics.

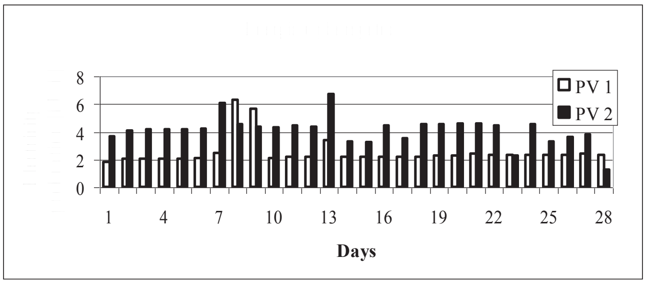

Fig. 16. Comparison of produced and consumed electric energy in September 2009 for the PV installation with CIS panel

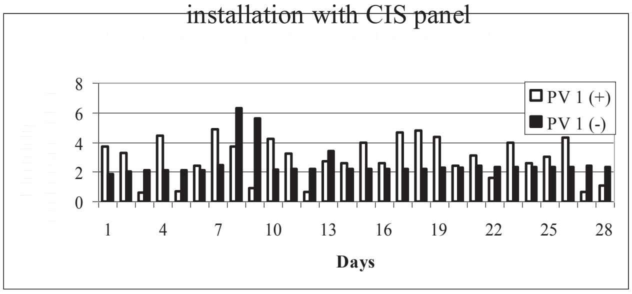

Fig. 17. Comparison of produced and consumed electric energy in August 2009 for the PV installation with mono-crystalline panel

By voltage drops on accumulator terminals below 23,5 V, accumulator sets were disconnected and the property was supplied from power network. The above behaviour of automatics was conditioned by protection of accumulators against excessive unload. Thus, there occurs a high probability that solar panels can exhaust quickly in autumn and winter.

The amount of produced and consumed electric energy in installations with CIS modules and mono-crystalline modules in particular months of 2009 are given in Table 3. Most electric energy was produced in August. At the same time, consumption of electric energy was at highest in this month. Mean daily demand for electric energy in particular months of the summer season increased systematically (tab.4). Regular shortening of the day phase affected also the mean amount of electric energy obtained during the day by the panels under research. Table 5 shows the mean rate of consumption of produced electric energy in tested PV installations. Both installations work under their capacities.

Table 3. Amount of produced and consumed electric energy in installations in the period from June till September

	PV installation with CIS modules		PV installation with mono-crystalline modules	
Month /Unit	Electric energy production	Electric energy consumption	Electric energy production	Electric energy consumption
	[kWh]	[kWh]	[kWh]	[kWh]
June	63,22	38,86	127,66	78,14
July	78,62	50,33	164,86	101,02
August	98,56	72,19	194,28	129,86
September	80,80	70,92	161,21	115,60
Total	321,2	232,29	648,01	424,62
Average of month	80,30	58,07	162,00	106,15

Table 4. Mean daily demand for electric energy for lightening in summer 2009

Month /Unit	PV installation with CIS modules	PV installation with mono-crystalline modules
	[kWh]	[kWh]
June	1,34	2,69
July	1,51	3,03
August	2,07	3,60
September	2,45	3,99

Table 5. Mean daily production of electric energy in PV installations in summer 2009

Month /Unit	PV installation with CIS modules		PV installation with mono-crystalline modules	
	Electricity production	Rate of consumption	Electricity production	Rate of consumption
	[kWh]	%	[kWh]	%
June	2,18	61,5	4,40	61,1
July	2,71	55,7	5,68	53,3
August	3,40	60,1	6,70	53,7
September	2,79	87,8	5,56	71,8

SUMMARY

On the basis of analysis of data collected in the summer season of 2009, it could be stated that both PV installations worked with low effectiveness. The above fact was confirmed by low mean rate of consumption of produced electric energy. At night, accumulators supplied the lightening lamps in the property of Ostoja. In the moment of sunrise, the dusk sensor switched off the current consumption and discharged accumulators were charged stepwise. It was stated that in summer, at cloudless sky, the accumulators were fully charged at already about ten a.m. Since then on, electric energy produced in PV panels only kept the accumulators warm.

Because of the above fact, attempts were made in order to increase the load of photovoltaic system (July 2009). Artificially, by means of deceiving the dusk sensor, the lightening was switched on during the day. As it turned out, accumulators were more discharged. The above test was applied to state the moment when the installation was set automatically into the charging mode. However, as it was stated, the automatics did not work properly. The installation was not connected with the power network automatically and accumulators were discharged instead. The installation had to be connected with the power network manually. The defect of automatics was then repaired.

The summer season was the time for tests with connecting various receivers with varied load to the PV installations. The succeeding test was carried on

in order to state if it would be possible to supply all the equipment in the property from the PV installations. It was stated that the load was too high for the installations in operation. Further research is planned for the coming months in order to find out the optimal working conditions for both PV installations.

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