CLIMATIC CONDITIONS INFLUENCES ON CONVERSION EFFICIENCY OF RENEWABLE POWER RESOURCES

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ABSTRACT

The main purpose of this paper is to analyze measured data from photovoltaic system placed on the building of Faculty of Electrical Engineering in Pilsen, to figure out optimal inclination of installation, to evaluate measured and calculated characteristics and to set possible way of research.

1. INTRODUCTION

The present work deals with analyzing of measured data from photovoltaic system placed on the building of Faculty of Electrical Engineering in Pilsen, figuring out optimal inclination of installation, evaluating measured and calculated characteristics and setting possible way of research.

2. MEASURED DATA AND CALCULATIONS

2.1. Measured data

Photovoltaic system was installed in 2004. It consists of 192 photovoltaic panels Isofoton I106 supplied by Solartec company. The whole installed power is 20 352 Wp. Panels are organized to eight independent arrays. Each array consists of 24 panels. Panels in each array are interconnected in 3 series-parallel combination networks. Each array is connected to electrical grid by single SunProfi SP2500-450 grid-tie inverter made by Sun Power company. Electrical data are measured directly from panels, other data (like irradiation) are measured by sensors located in proximity of photovoltaic system. Automatic measuring is performed in ten minute intervals from 3:50 am to 11 pm, so that every day 116 measurements are made. Measured data are stored in text files, each file for single day. The most complex data set is available for year 2008 – records for 328 days. Text files have to be converted by parser based on Gawk software to be imported in Excel. I got over 38 000 rows of data in Microsoft Excel for further analyzing.

Table 1 – Preview of imported data

Datum of measur.	Time of measur.	Horizontal irradiation [W/m2]	Ambient temp. [°C]	Panel irradiation [W/m2]	Temp. ref. cell [°C]	Temp. panel [°C]	Voltage DC [V]	Current DC [A]	Power DC [W]	Power AC [W]
1.1.2008	3:50:00	0,48	1,31	-0,33	-0,03	-0,24	0,48	0,01	0,01	-3,75
1.1.2008	4:00:00	1,04	1,8	-0,33	0,26	0,03	0,49	0,01	0,01	-3,75
1.1.2008	4:10:00	0,68	2,08	-0,33	0,19	0,14	0,49	0,01	0,01	-3,77
1.1.2008	4:20:00	0,32	2,08	-0,33	0,27	0,24	0,49	0,01	0,01	-3,77
1.1.2008	4:30:00	0,28	2,05	-0,34	0,26	0,24	0,49	0,01	0,01	-3,76
1.1.2008	4:40:00	-0,01	1,85	-0,33	0,15	0,1	0,48	0,01	0,01	-3,76
1.1.2008	4:50:00	-0,39	1,44	-0,32	-0,12	-0,19	0,47	0,01	0,01	-3,76

2.2. Calculations of optimal installation angle

Measured data contain values of irradiation in horizontal plane and also panel irradiation, so irradiation in optimal angle calculation can be performed relatively easily. After that, it is possible to calculate optimal installation angle of whole photovoltaic system.

Equation system of irradiation:

$$Gh = G.\cos\alpha$$
$$Gi = G.\cos\beta$$
$$\beta = \frac{\pi}{4} - \alpha$$

Gh presents irradiation in horizontal plane, *Gi* presents panel irradiation, *G* is total irradiation, α is angle between irradiation and normal line and β presents distinct angle between irradiation and photovoltaic system inclination (45°). Calculations were performed numerically, but mathematical approximation is also possible:

$$G = \pm \frac{\sqrt{\frac{x^2 - 2\sqrt{2}xy + 2y^2}{x^2 - \sqrt{2}xy + y^2}}\left(\sqrt{2}x^2 - 2xy + \sqrt{2}y^2\right)}{x - \sqrt{2}y}$$

$$\alpha = \pm\arccos\left(\frac{x\sqrt{x^2 - 2\sqrt{2}xy + 2y^2}}{\left(-x + \sqrt{2}y\right)\sqrt{2x^2 - 2\sqrt{2}xy + 2y^2}}\right) \text{ or } \alpha = \pm\arccos\left(\frac{x\sqrt{\frac{x^2 - 2\sqrt{2}xy + 2y^2}{x^2 - \sqrt{2}xy + y^2}}}{\sqrt{2}x - 2y}\right)$$

Gh is substituted by *x* and *Gi* by *y* for better lucidity. Calculated optimal installation angle is 27°. It is much lower than theoretical 34°, but it characterizes specific climate properties in Pilsen (elevated cloud cover and diffusion light, air-borne dust).

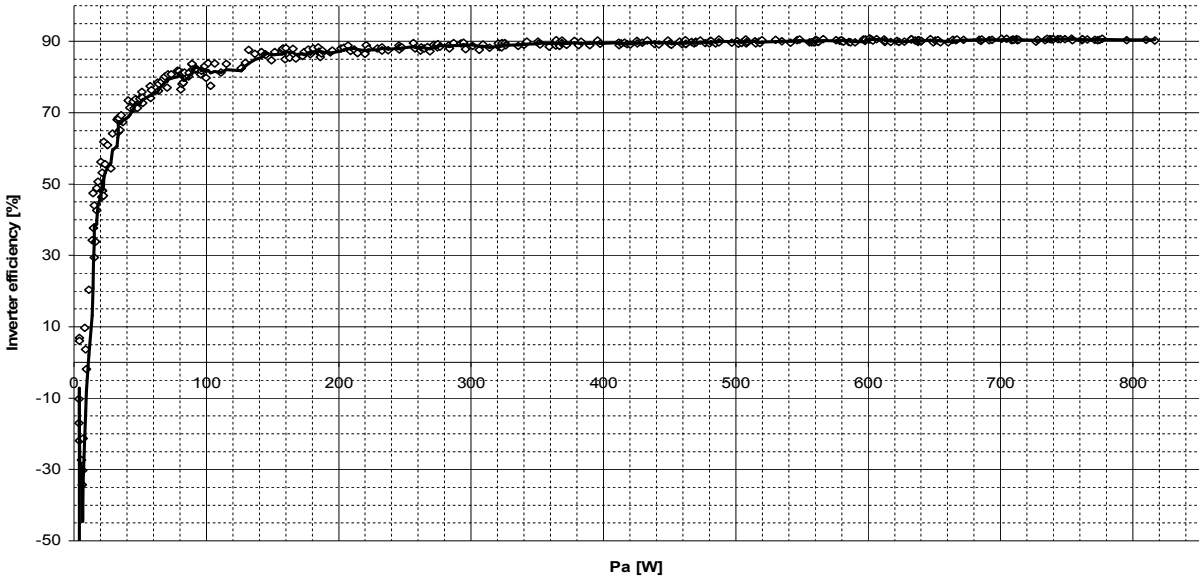

Chart 1 – Measured inverter efficiency

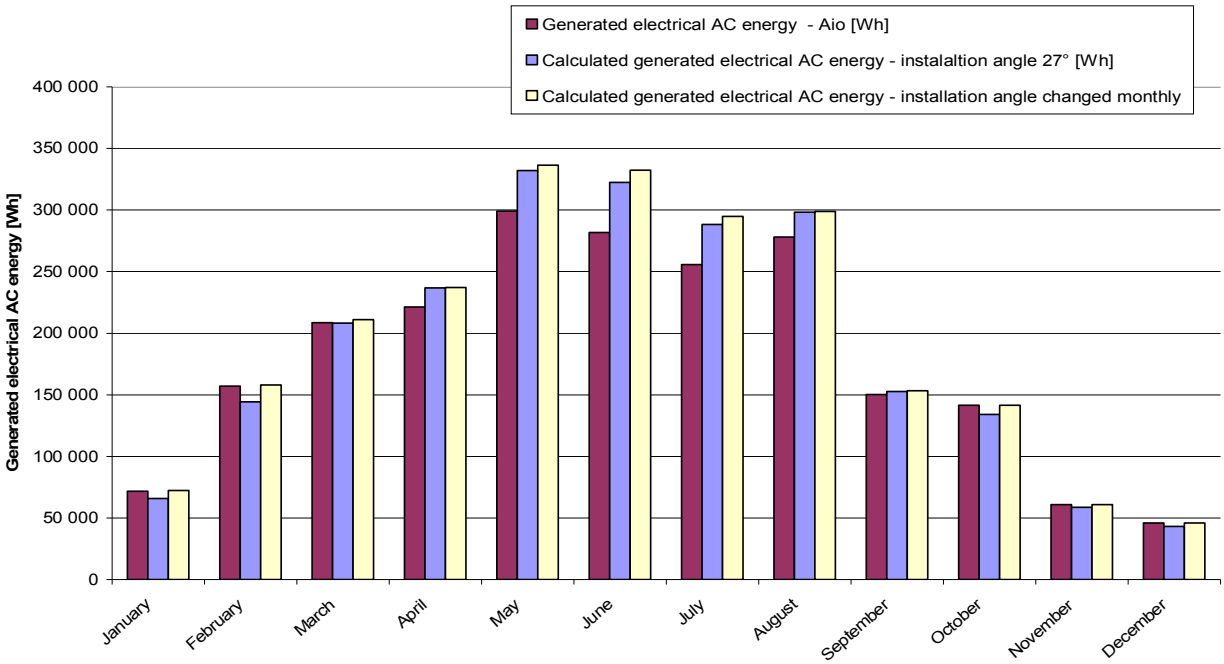

Chart 2 – Measured and calculated generated electrical AC energy

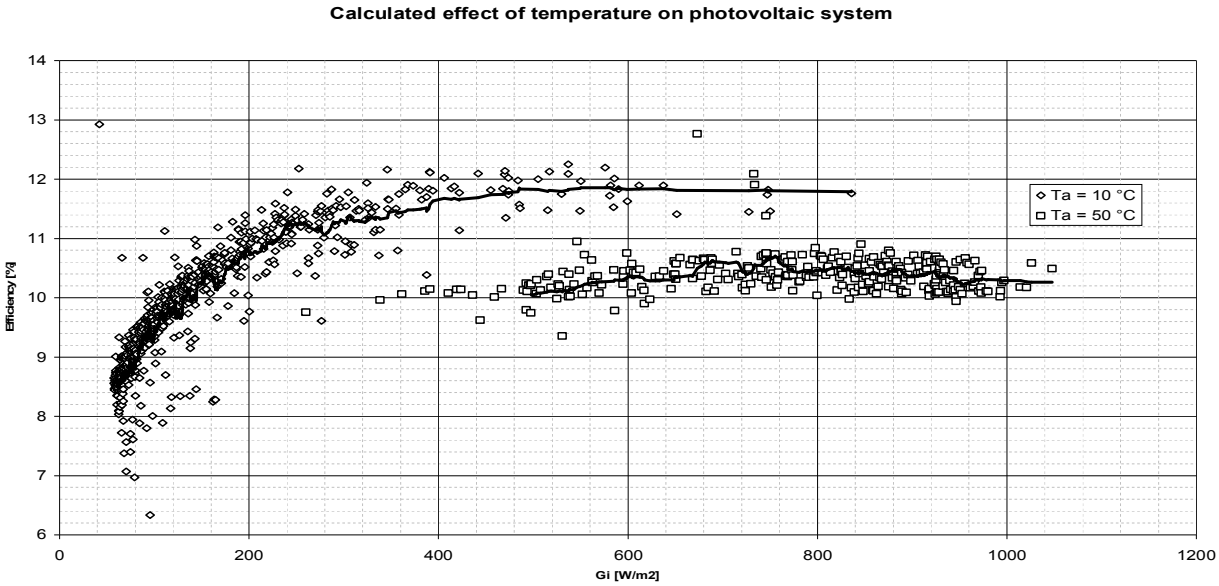

Chart 3 – Calculated effect of temperature on photovoltaic system

3. CONCLUSIONS

Behavior of inverter during starting-up is unpredictable. It can lead to problems with electrical energy quality (higher-order harmonics and poor power factor), especially soon after synchronization. 80% efficiency is achieved above 70 W (DC power of array). Peak efficiency of inverter is almost 91 %. Very interesting is comparison of measured and calculated generated electrical AC energies. It is evident that for calculated optimal installation angle (27°) generated energy during winter is much lower than for 45°. But it is so much higher in summer thus annually generated energy gain is over 5 %. In this calculation some negative factors are not included (self-cleaning capability and heat build-up). For illustration, generated energy is also calculated for monthly changed installation angle. This solution is probably usable only for small power plants.

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