Study of Electric Grid Networks for Delivering Energy using Systems Networks

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ABSTRACT: *The network of electric grids and their various effects in delivering energy are addressed in this work. We propose a comparative analysis of roof type photovoltaic generator. We have used the PVSyst software to study the impact of the electric grid networks. We intend to measure, record and do comparative analysis of the accuracy and other issues.*

Keywords: Roof type PV generator, PVSyst Software, Model, Experiment

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1. Introduction

A comparative analysis of the data obtained both from the model and the experiment conducted on photovoltaic generators is proposed. These are of roof type, built with modules from two different technologies.

The data from the model are obtained using the PVSyst software [9] in designing the generators. The experimental data are year-round operation of the system PV-generator - converter.

The aim of the study was to identify the factors influencing the errors in the models and approaches to correct the design of the system. Also, the comparison of the data from the models with the experiments should complement the studied literature [1, 2, 4, 5, 6].

2. Analysis

The wiring diagram of the experimentally investigated PV generators is shown in Figure 1. The two generators have the following main characteristics:

2.1. Main characteristics of a PV generator, built with Sanyo HIT-205NHE5 modules (Figure 1.A.)
Characteristics of the modules:
• **module type:** Sanyo HIT-205NHE5 (Hybrid type); U_{oc} = 50,3V; I_{SC} = 5, 54A; U_{mpp} = 40, 7V; I_{mpp} = 5,1A; P_{mpp} = 205Wp;

• Total number of modules 60.

Characteristics of the inverters:
• **Inverter type:** SMA Sunny Boy SB 1100; DC Power: 1,23kWp; AC Power: 110 kW;

• Total number of inverters 10.

Arrangement of the strings:
• Total number of strings 10;

• Number of modules in each string 6;

• Number of strings attached to each inverter 1.

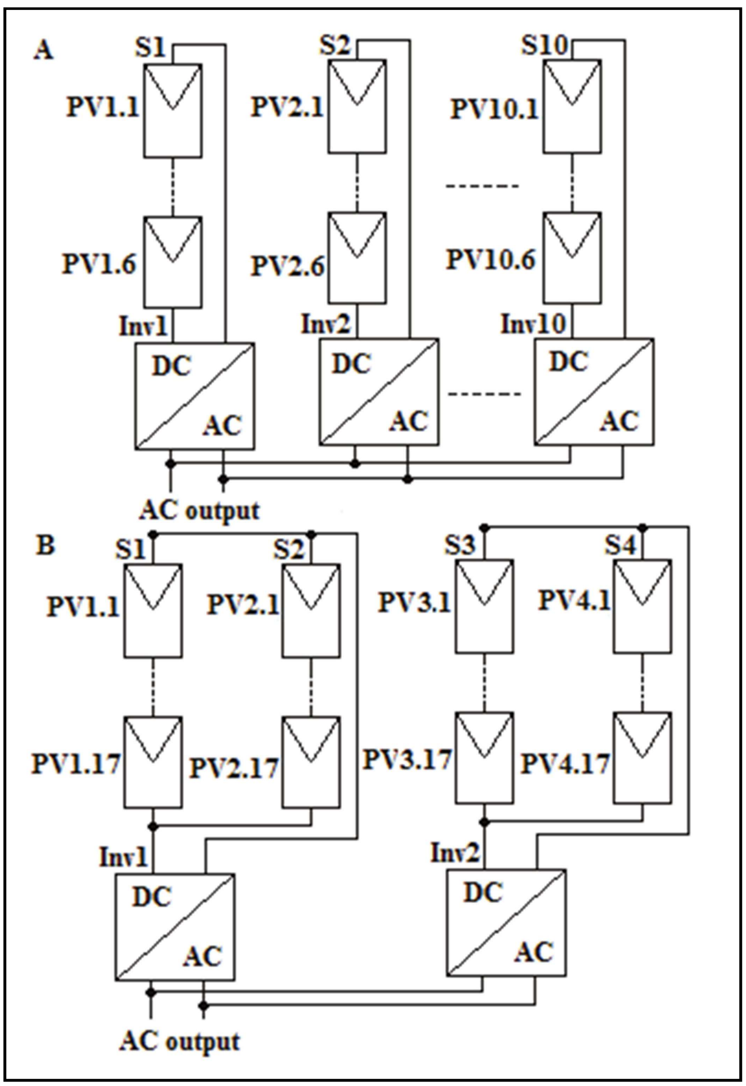

Figure 1. Architecture of the investigated PV generators

2.2. Main characteristics of a PV generator, built with Suntech STP180S-24/AC modules (Figure 1.B.)
Characteristics of the modules:

• **Module type:** Suntech STP180S-24/AC (Monocrystalline type); U_{oc} = 44,8V; I_{SC} = 5,3A; U_{mpp} = 36V; I_{mpp} = 5A; P_{mpp} = 180Wp;

• Total number of modules 68.

Characteristics of the inverters:

• **Inverter type:** SMA Sunny Boy SB 5000 TL HC Multi- String; DC Power: 6, 12 kWp; AC Power: 5,00 kW;

• Total number of inverters 2. Arrangement of the strings:

• Total number of strings 4;

• Number of modules in each string 17;

• Number of strings attached to each inverter 2.

All modules are directed to the south (azimuth angle: 180 deg), at an angle of 30° (tilt angle: 30 deg).

The installation is stationary made on sloping roof, the angle at which you are unable to change.

Geographical coordinates of the analyzed PV system are: latitude - 43,12; longitude - 27,55; altitude - 20 m.

The factors subject to correction during the building of the models are as follows: Mismatch losses, Correction factor NOCT, Correction factor Albedo, Ohmic losses in the conductors.

The mismatch losses factor reflects on the performance discrepancy between the modules connected in series in the string. These losses are usually minimized by selection of components of the same characteristics, such as within the range of a few percent.

The Albedo factor describes the part of the global radiation which reaches the PV module surface due to the ground reflection of some parts of the direct or diffuse radiation.

The Ohmic losses in the conductors ($R.I^2$) are dependent on their diameter and length. As initial condition of the project maximum loss of 3% of this type was set.

The Nominal Operating Collector Temperature (NOCT) factor describes the temperature attained by the PV modules without back coverage under the standard operating conditions defined as: irradiance – E_N = 800 W/m²; ambient temperature – T_{amb} = 20°C; wind velocity – 1 m/s.

The model is based on the fundamental equations proposed by a number of references [1, 5, 6, 7].

The I-V curve of a module can be described using a fiveparameter model [3,], mathematically representing the I-V curve data of a module, using the following five parameters: V_{oc}, I_{sc}, R_s, R_p, and *ekt* [3,4]:

$$I = I_{sc} - \left[\frac{I_{sc} - \dfrac{U_{oc}}{R_P}}{\exp(ekt.U_{oc}) - 1} \right] \quad (1)$$

$$\left\{\exp\left[ekt\left(U+R_S I\right)\right]-1\right\}-\frac{\left(U+R_S I\right)}{R_P} \quad (1)$$

where: *I, A* – module output current; *U, V* – module voltage; I_{sc}, A – short circuit module current; U_{oc}, *V* – open circuit module voltage; R_s, Ω – module series resistance; R_p, Ω – module parallel resistance; $ekt = q / nkT$; *q, C* – the electron charge; *n*, unitless – ideality factor per cell; *k*, Joule/K – Boltzmann's constant; *T, K* – temperature.

The five-parameter model was fitted to the corrected NOCT data obtained from each I-V curve run.

With the measured ambient temperature T_{amb} and NOCT the cell-temperature T_j can be approximately calculated. Then follows the calculation of the cell temperature, depending on the irradiance and the ambient temperature.

$$T_j\left(E_{eff}, T_{amb}\right) = T_{amb} + \left(NOCT - T_{amb|N}\right)\frac{E_{eff}}{E_N} \quad (2)$$

where: *Tj, K* – junction-temperature; E_{eff}, phox – effective irradiance; T_{ambN} – 20°C ambient temperature for NOCT; E_N - irradiance.

The comparative analysis is shown in Table 1, Table 2, Figure 2, Figure 3. The following indications are used:

• Invertor data – experimental data obtained by the inverters.

• Model data 1 – data obtained from the PVSyst model, build during the design of the system.

• Model data 2 – data obtained from the PVSyst model, after correction of the considered factors.

• Error – the resulting error in the comparison between Invertor data and Model data 1 (2), in %.

All figures show the average received electricity by month.

In Table 1, the results for modules of type Sanyo HIT- 205NHE5 are presented. The average error in the Model data 1 amounted to 8,6%, and after the correction of the model is reduced to 4,6%. The comparison is given graphically in Figure 2.

Similarly the Table 2 shows the values for Suntech STP180S-24/AC. After the correction of the model the error decreased from 13,6% to 5,7%.

Table 3 provides a comparison between the factors and their influence on the resulting error. In the final column "All factors" are selected all the values of the correction factors, which give a minimum error.

3. Conclusions

The obtained results show that the error in the initial model is significantly higher in the winter. To obtain the most accurate results from the PVSyst model it is necessary to make corrections to the discussed factors in the following way:

• The correction of the Ohmic losses requires to point that due to the low transmission power the losses in the cables in the winter are smaller. The correction of this factor in the model should define losses less than 2%.

• The correction of the Albedo factor should comply with the recommended values for the season [8,9].

• Because the PV generators are for relatively low power, the mismatch losses are minimized by selecting the modules according to their characteristics. This is reflected in the corrected model, where they are reduced to 1%.

• The Nominal Operating Cell Temperature (NOCT) correction factor is corrected by reporting his value every month according to the average ambient temperature.

Recommended values proposed in [2,4] are used.

The PVSyst model should be calculated separately for each month, which increases the accuracy of the obtained results

	Inverter data	Model data 1	Error	Model data 2	Error
	kWh		%	kWh	%
Jan 13	330,06	280,5	17,7%	300,4	9,9%
Feb 13	550,2	450,8	22,0%	480,6	14,5%
Mar 13	1070,23	1000,3	7,0%	1040,5	2,9%
Apr 12	1410,53	1370,1	3,0%	1370,7	2,9%
May 12	1220,92	1230,2	-0,8%	1230,7	-0,8%
Jun 12	1890,31	1930,4	-2,1%	1920,4	-1,6%
Jul 12	2100,07	2180	-3,7%	2190,2	-4,1%
Aug 12	1900,22	1810,2	5,0%	1820,1	4,4%
Sep 12	1500,51	1440,7	4,2%	1450,4	3,5%
Oct 12	1170,48	1010,4	15,8%	1050,8	11,4%
Nov 12	560,4	550,1	1,9%	570,4	-1,8%
Dec 12	320,18	240,5	33,1%	280,7	14,1%
		Average :	8,6%	Average :	4,6%

Table 1. Comparative analysis of a pv generator, realized with sanyo hit-205nhe5 (hybrid type) modules

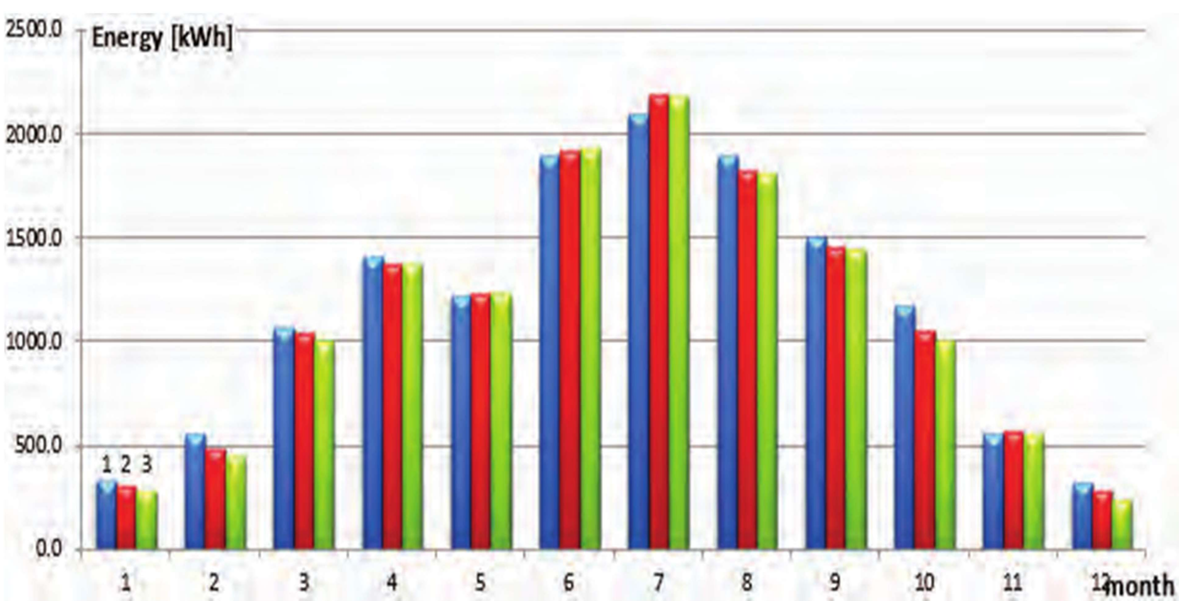

Figure 2. Comparative analysis of a PV generator, realized with Sanyo HIT-205NHE5 (Hybrid type) modules. 1 – Inverter data; 2 – Model data 2; 3 – Model data 1

	Inverter data	Model data 1	Error	Model data 2	Error
	kWh		%	kWh	%
Jan 13	408,2	300,0	36,1%	350,1	16,6%
Feb 13	620,1	456,0	36,0%	540,0	14,8%
Mar 13	1106,1	936,0	18,2%	968,0	14,3%
Apr 12	1428,1	1348,0	5,9%	1412,0	1,1%
May 12	1228,1	1252,0	-1,9%	1248,2	-1,6%
Jun 12	1868,2	1914,0	-2,4%	1900,1	-1,7%
Jul 12	2060,1	2160,0	-4,6%	1998,1	3,1%
Aug 12	1912,1	1814,0	5,4%	1896,0	0,8%
Sep 12	1560,1	1444,0	8,0%	1508,0	3,5%
Oct 12	1240,1	1034,0	19,9%	1182,2	4,9%
Nov 12	596,1	568,0	4,9%	576,0	3,5%
Dec 12	340,0	260,0	30,8%	310,2	9,6%
		Average :	13,0%	Average :	5,7%

Table 2. Comparative analysis of a PV generator, realized with suntech STP180S-24/AC (monocrystalline type) modules

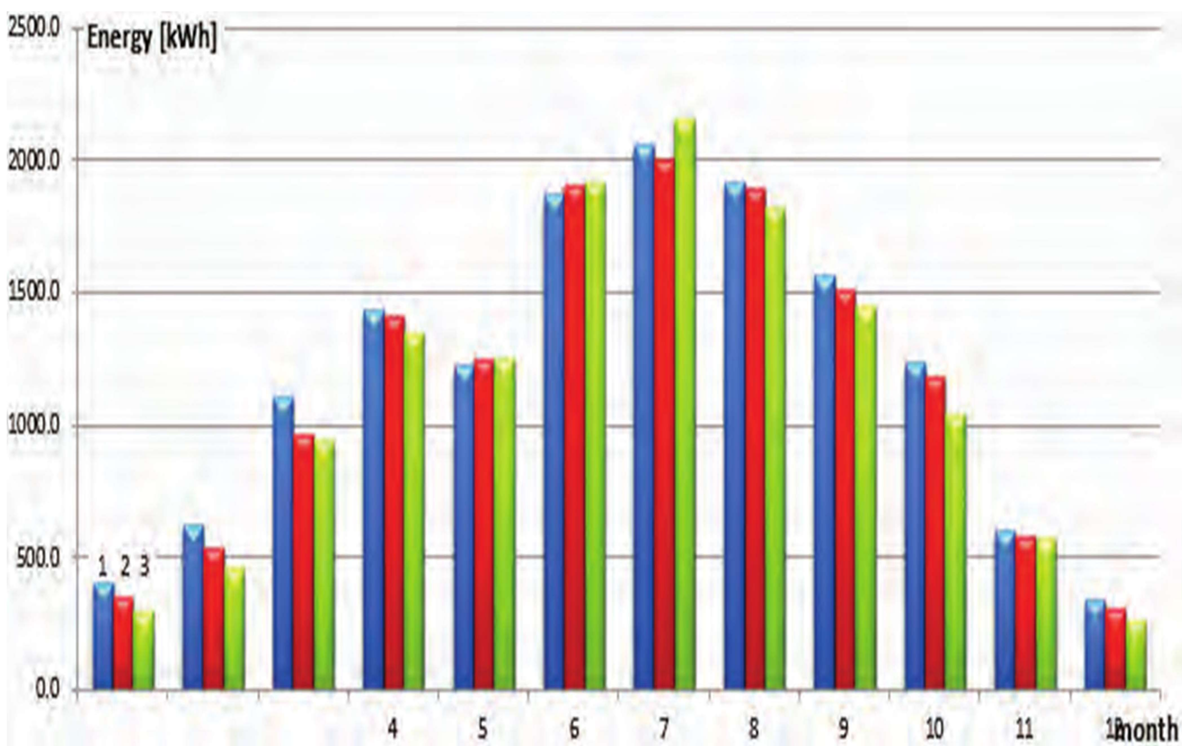

Figure 3. Comparative analysis of a PV generator, realized with Suntech STP180S-24/AC (Monocrystalline type) modules.
1 – Inverter data; 2 – Model data 2; 3 – Model data 1

	Inverter data	Model data 1	Model data 2 Factors kWh, %				All factors
	kWh		Albedo	NOCT	Ohmic Losses	Module quality – Mismatch	kWh
January							
HIP	330.1	280.5	290.2 13,7%	280.6 17,6%	280.6 17,6%	290.2 13,7%	300.4 9,9%
MONO	408.2	300.0	310 31,7%	304 34,3%	304 34,3%	310 31,7%	350.06 16,6%
June							
HIP	1890.3	1930.4	1930.5 -2,1%	1950.0 -3,1%	1930.4 -2,1%	1930.0 -2,1%	1920.4 -1,6%
MONO	1868.2	1914.0	1920 -2,7%	1940 -3,7%	1928 -3,1%	1924 -2,9%	1900.1 -1,7%

Table 3. Influance of the considered factors on the error during the correction of the model

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