Evaluation of predicted and operated parameters of photovoltaic power - station

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This report is concerned with comparison of amount of power produced by photovoltaic power-station determined before construction by simulation of the given system with actually measured values during the full operation of the power-station. Our objective was to compare and evaluate the results of prediction against actual situation. The solution result is the justification of deviations measured.

Key words: *photovoltaic, solar power-station, electric energy, solar radiation, meteorological data, prediction, simulation, power delivery to the network, energetic audit*

Introduction

Recently, we are oriented to technologies increasingly which are able to use accessible energy suitably namely not only on the base of use of renewable energy sources. Increasing energy prices force us to increase the effectiveness of technological equipment. However, those are very often on their very peak. So it is necessary to search for solutions even in the technology designing stage and to be addicted to it comprehensively.

By this report, we have wanted to show that the correct understanding of technologies is important part of technology improvements primarily. However, it does not mean that it is the question of theoretical level, but also knowledge related to input data and principle of their function. Because the world exceedingly comprises small, maybe individually non-important things, they, as an entirety, create together unique harmony of feedbacks.

In the report, date and calculations based on input data provided by the company Solarit, s.r.o. are mentioned and used.

Prediction and expected yearly production

As a model pattern, photovoltaic power-station (hereinafter referred to as "FVE" only) located on Eastern Slovakia with installed power capacity of 999 kW. The Investor has selected a technology with mono-crystalline panels type EOPLLY EPTECH 125M with output per unit of 185 Wp (5400 pieces) with the orientation to the south and inclination of 35°, and 159 decentralized invertors type Solutronic GmbH Solplus to invert DC into AC.

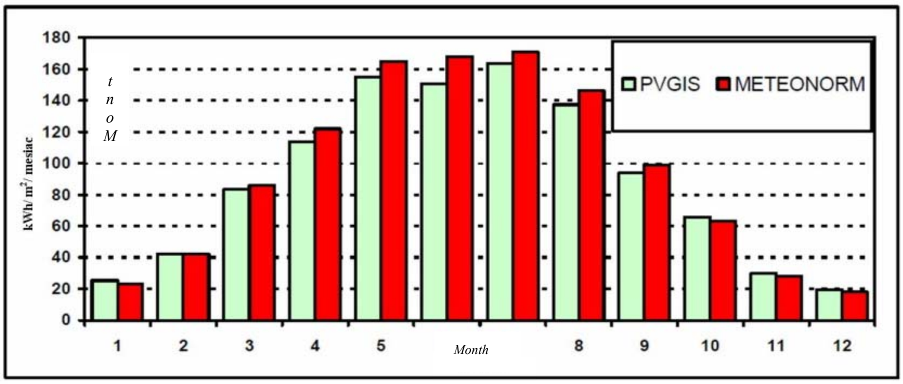

Fig. 1. Comparison of global radiation from various sources for the FVE locality.

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Thorough prediction of power production was based on several calculations. We have used data from Meteorological databases of Meteonorm and PVGIS (Fig. 1). Afterwards, these were applied to PV*SOL and PVSYST simulation processes, and, based on input data, analyses of power production from the given FVE were performed. Based on results of individual model calculations, we have prepared the following diagram (Fig. 2). The blue curved line is the energy delivered to the network when re-calculating from the Meteonorm database. Other two represent more conservative data of the PVGIS application.

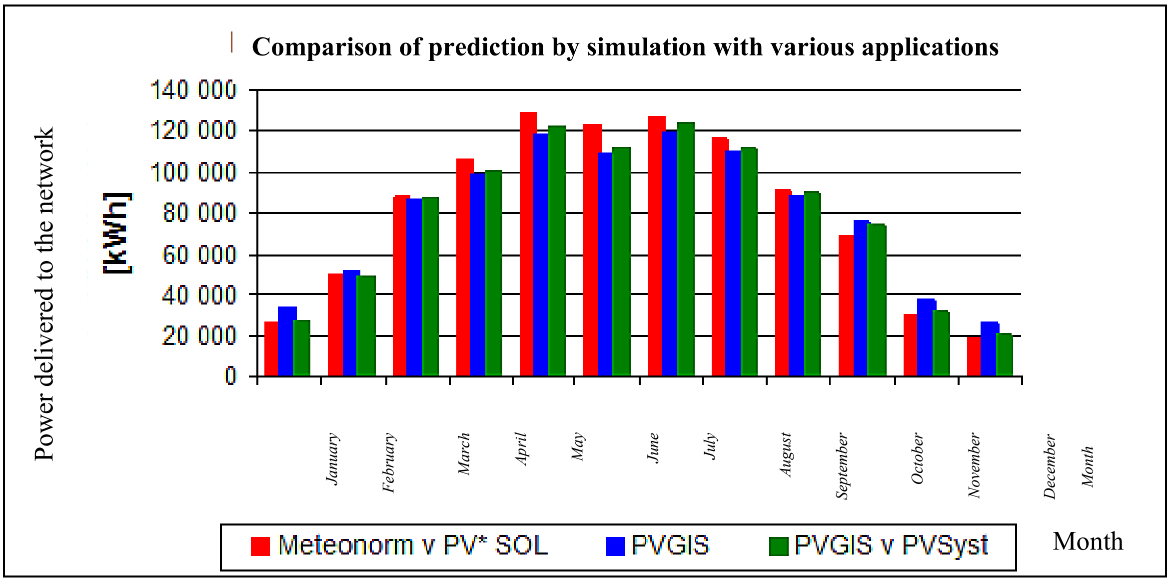

Fig. 2. Prediction of power quantity delivered to the network by means of various simulations.

Actually measured values

Construction of objective power-station was accomplished in 2010 and the commissioning was finished in June of the same year.

Fig. 3. Solar power-station in the Eastern Slovakia with the power output of 999 kW [13].

Tab. 1. Comparison of power quantity delivered to the network [13].

Month	Power quantity delivered to the network [kWh/month]	
	2010	**2011**
I	-	24 710
II	-	47 708
III	-	101 585
IV	-	118 233
V	-	144 228
VI	114 323	130 023
VII	127 133	106 673
VIII	126 078	149 388
IX	81 143	129 368
X	93 280	86 775
XI	40 213	54 315
XII	10 058	12 438
Year	-	1105 444
VI.-XII	592 228	668 980

Simultaneously, from the above mentioned month, data not only related to the power quantity produced, Tab. 1, but also other parameters such as per cent fulfilment against the plan, effectiveness, incomes, etc. started to be recorded. In this report, power quantity delivered to the network will be discussed only. Other parameters are omitted because connections and scope of comparison would be very extensive.

The following table illustrates measured values of power delivered to the network in 2010 a 2011. The year-to-year increase is the difference plus 76 752 kWh/month in comparable periods of Month June to December. Here, it is necessary to emphasize, that permanent rainy weather was in the area of Slovakia in 2010, which, beside reduction of sunny days, caused several floods and, as a consequence of it, the FVE was put out of operation from safety reasons for several times.

Evaluation

When comparing recorded quantity and actually produced power with simulation, various models were considered. Input data is applied into software directed to dimensioning of photovoltaic systems. Finally, we have decided to use balance, see Table 2, in which the comparison not only of use of various software, but also considering of two meteorological data types being the most precise for the conditions of Middle Europe from historical context.

When evaluating results, we were more conservative, because losses originating in configuration of various software types are not identical completely. We were focused on input data from meteorological databases and deviations of their prediction against the data measured during full operation.

Tab. 2. Comparison of prediction with actually measured production values of FVE.

Year 2010	PREDICTION IN 1st year [kWh/month]			
	According to EA (Meteonorm) in PV * SOL	According to PVGIS	According to PVGIS in PVASyst	Delivery to network
June	121 955	108 000	110 771	114 323
July	125 832	119 000	122 822	127 133
August	115 509	109 000	111 430	126 078
September	90 080	87 700	90 025	81 143
October	68 265	75 300	73 441	93 280
November	30 101	37 200	31 720	40 213
December	18 762	26 300	20 342	10 058
Sum (June—December	**570 504**	**562 500**	**560 551**	**592 228**
Year 2011	PREDICTION IN 2nd year [kWh/month]			Delivery to network
January	26 172	33 700	27 291	24 710
February	49 716	51 100	48 818	47 708
March	87 973	85 900	86 937	101 585
April	105 930	97 800	100 314	118 233
May	127 566	118 000	121 394	144 228
June	121 955	108 000	110 771	130 023
July	125 832	119 000	122 822	106 673
August	115 509	109 000	111 430	149 388
September	90 080	87 700	90 025	129 368
October	68 265	75 300	73 441	86 775
November	30 101	37 200	31 720	54 315
December	18 762	26 300	20 342	12 438
Sum (2011)	**967 861**	**949 000**	**945 305**	**1 105 444**
Sum (June—December)	**570 504**	**562 500**	**560 551**	**668 980**
	% difference in the given period against the prediction			Delivery to network
June—December 2010	3,67	5,02	5,35	592 228
June—December 2010	14,72	15,92	16,21	668 980
Year (2011)	12,45	14,15	14,49	1 105 444

In the table, prediction reaching higher values for given month are colour-marked with actual operational values exceeding predicted parameters during the overall year. From the simulation used, data generated from the Meteonorm database calculating the reduction of global radiation caused by high horizon and using the digital terrain model were the closest one to the actuality. When developing the database and its updates, experience in the area of development for energetic use were used more than 25 years, speak nothing of method of data application into computers by means of interpolation from more than 1700 stations on monthly basis and systematic generating on hourly basis [5]

Accuracy of 20 year long term averages of global radiation data in the conditions of Middle Europe is to be expected in the range of approximately ± 3-3,5 %. [7]

Model prediction showed per cent difference against the actuality in amount of 3,67 % in the period from June up to December for 2010 (rainy summer with floods) and comparable period of 2011 in amount of 14,72 % (too hot and too dry summer).

This difference may be caused not only by defining observed magnitudes and omitting certain parameters, but also by weather development in global criterion and time, so called change of climate or warming.

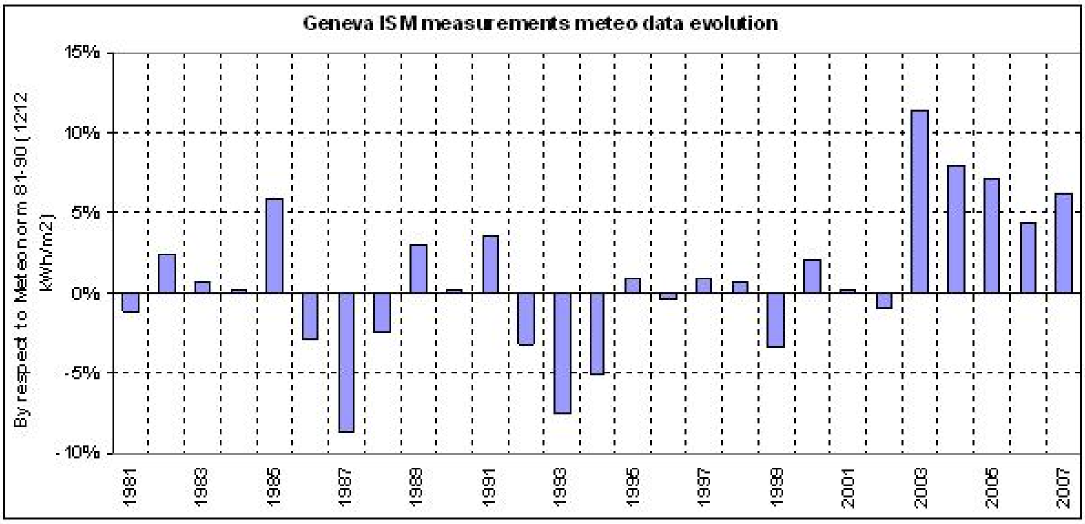

Fig. 4. Development of climatic changes during the period from1981up to 2007 measured in Geneva (homogenous samples of continuous measurement from the same source).

The most often used climatic models say that doubling of CO_2 will have the same effects as the sun power output increase by 2 % causing the increase of average temperatures by approximately 3°C.“ 0

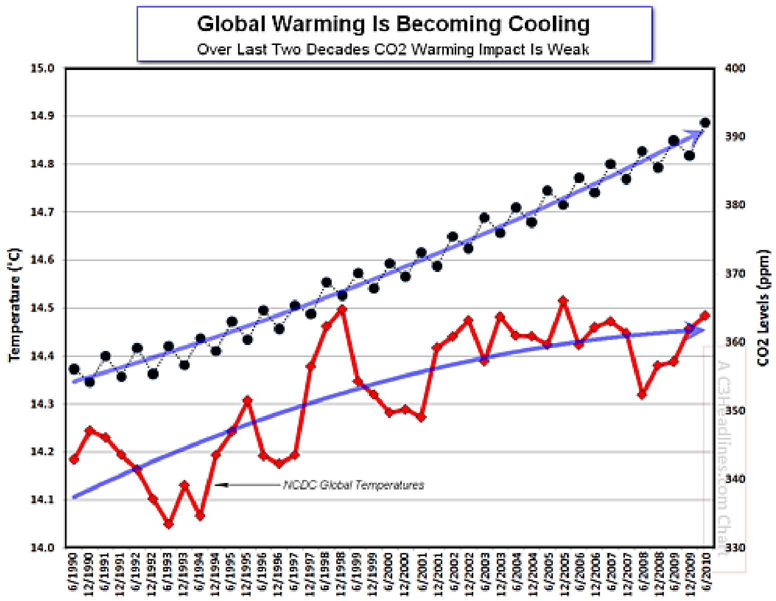

Fig. 5. Temperature anomalies and increase during the period from 1990 up to 2010 [10].

Conclusion

Finally, it is possible to say based on the above mentioned facts that the Meteonorm meteorological database and its use for calculation of predictions, especially for construction of solar power-stations (and equipment) represent the most accurate results and expectations of solar energy production to be delivered to the network. It, however, does not consider the fact of year-to-year increase of temperatures, global radiation and other meteorological parameters for next years so as any other meteorological databases. The reason is that this fact is not to be influenced and defined.

All simulations applications are operated on the ground of past data principle based on which they predict the weather character for individual months and days prospectively. It is to say shortly that they mentioned valued based on "experience".

So, it is important to be focused on selection of suitable meteorological data and, when predicting power quantity to be produced, concentrated on technology to be used primarily, its correct dimensioning and connection for each installation independently because each of them is unique by its geographical location, installed power capacity and other characteristics.

Implementation of results of operation parameters of existing FV facilities is unavoidable for correct function of simulation applications. This may help to predict further results with significantly lower inaccuracy rate. This may be proved by the fact that existing FV power-stations are operated with higher operation production of power which is in the range from 4 up to 22 % when comparing it with the analyses of their theoretical production performed in preparation stages of their projecting.

Acknowledgements: *„This report originated thanks support of the operation program Research and Development for the project: Research centre for efficient integration of the renewable energy sources with the code ITMS: 26220220064, co-financed resources of European Fund of Regional Development.*

„We support research activities in Slovakia co-financed by resources of EU."

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