REFERENCE SYSTEM BASED PERFORMANCE EXAMINATION OF PV POWER PLANT

Zoltán Kapros
Szent István University, Gödöllő – Hungary

Introduction

Our most significant renewable energy potential is the solar energy, the directly or indirectly usage of this is the basis of life. Al over the world they are strong attention today by the solar engineering and the connected researching areas. The ages of the low cost and high density energy sources will end in this century. This fundamental change also is reached by our answers of the global environmental problems, but today the intensive level of technological development is able to establish.

The current state of knowledge seems in Hungary that the best way of electricity production from solar energy is the photovoltaic energy technology. A study by the Hungarian Academy of Science shows the installation potential of PV systems in Hungary 4051.48 km2 area, which is means close to 484 974 GWh/a solar renewable electricity production potential (MTA, 2006).

In the top of the houses by the residential sector and the institutional buildings could be installed around 2500 MWP photovoltaic small power plans and these could produce about 2 846 GWh/a electricity. The technological potential at this level currently seems unattainable, but for example after 2021 by a European Union obligation as building renovations or new construction will have to reach the level of close to zero-energy buildings and the active solar energy equipments are essential part of these types of buildings.

The solar vision for the future must therefore prepare in Hungary too, where the "aggregators" will organize some smart producer and consumer groups with the small building integrated solar power plans. So these plans will be the huge elements of the electricity production structure, therefore the size of the installed solar electricity capacity and the capacity of the current domestic nuclear power plant (2000 MW) may be comparable.

The production of electricity from solar energy by a number of methods is known. The controllability and/or the possibility of the real-time forecasting of the energy production mean a growing importance by the technology evaluations.

The EPIA (European Photovoltaic Industry Association) examines the errors of the forecasting methods how it depends on the locations or the size of the systems. The inaccuracies of the forecasting cause more difficulty by the stabile and cost-effective operation of the electric grid. The size of the typical errors shows in the Figure 1. (EPIA, 2012).

The problems could be treatable technologically, but usually only with substantial additional costs (for example through the batteries, or purchasing reserve electricity). So eventually the restrictions of the establishing of the photovoltaic systems may be similar to that for wind energy

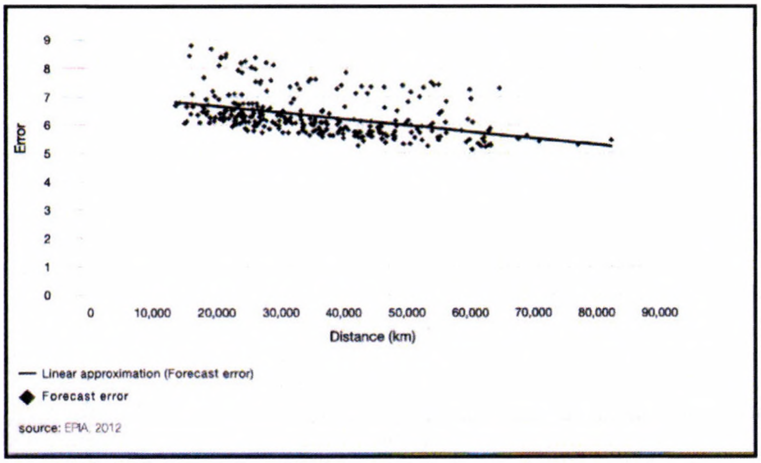

Figure 1. Forecasts errors example of the production of a PV portfolio (%).

The actually PhD research at the Szent István University in Gödöllő trying establish a real-time forecasting method with a new approach. The system can be suitable for the rapid and accurate prediction of the electricity production of some PV portfolios (which systems consist of many small PV power plants in top of the houses).

Methods of Evaluation

The comparison of different methods for sizing charts the Table 1 gives a good summary. It can be seen that a better approximation with numerical methods are available (Mellit et al, 2007).

Table 1. Various sizing models and test methods

Sizing methods	Typical relative errors	
Analytical	% (A_{PV})	% (C_U)
	9,1	2
Numerical	% (A_{PV})	% (C_U)
	8,3	1,2
Hybrid	% (A_{PV})	-
	7,14	
Special (Mellit) methods	% (A_{PV})	% (C_U)
	8,5	2,5

By the sizing and modeling of the photovoltaic systems the analytical models were the dominant software's for a long time. These are based on theoretical physical models and the limits of accuracy for today is already practically reached by them, The analytical formulas to solve, a large quantity of data to be provided to ensure an unrealistic expectation of the portfolios in the PV systems

The new model is only based on detailed investigation of a reference PV power plant. The reference error is the difference between the analytically modeled and measured production. This error is based on mainly the same physical effects, so the measured error. The measured errors are spreading, and these effects are could be similar by other PV systems. So this spreading of errors can be very useful if we will be able to modeling the directions and speeds.

This spreading can be difficult to describe analytically, but the necessary data would not be able to measure. However, some good approximations can be with numeric programming.

The method is thus:

- a database for future expected energy production;
- a specific measurement (by the reference PV station), which is based on the deviation as an error is determined;
- the numerical model structure, model training and testing

The definition of the errors

The error measurement is based on an examination of the difference between the actually measured and the expected (modeled) average power production. The actual mathematical error measurement and explicit formula for determining the appropriate required. The main aspects are as follows:

- to be relative numbers because of different rating systems in comparison with the performance goal
- to be a relative value, and whose denominator and the ratio values characterized by transparency the different conditions of the periods of the year and the different systems.

The equivalent peak load hour (Sharma, Tiwari, 2011) in a given time shows a value kind of performance. Thus, the actual performance of the system could be illustrated in relation to utilization. In the energetic the peak load hour is related to a time period and the energy production, but the equivalent peak load hour is characterized by energy-generating operating capacity in a given moment.

By sizing a PV system is the equivalent peak load hour defined as follows:

$$h_{ekv} = \frac{\zeta_{real}}{I_P} \qquad 1$$

Where hekv is the equivalent peak load hour, in h, Vreal is total specific amount of solar electricity in kWh/m^2, IP is current value of the global radiation intensity during in kW/m^2.

The model used for the relative error factor can be written as follows:

$$f = \frac{\left(h_{ekv} - h^{*}_{ekv}\right)}{h_{ekv}} \qquad 2$$

Where h_{ekv} is the analytically expected equivalent peak load hour, and h_{*ekv} is the measured expected equivalent peak load hour.

Neural network predictive modeling

The reference PV system must be located in right direction and distance from the PV portfolio so that the weather fronts typically one or two days to reach the region where the PV portfolio is operating. The numerical model for the PV portfolio with similar type of photovoltaic systems could reasonable accuracy. The outputs of model are the expected (predicted) values of the error factors. The meteorological conditions' nature (the weather front migration speed, direction) indicates the neural network requirements. The model system structure is shown in the Figure 2.

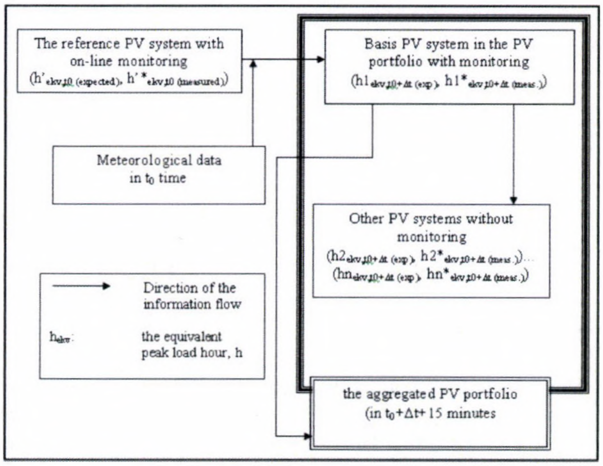

Figure 2. On-line scheduling flowchart.

The figure shows that the reference PV power plant and a one power plant in portfolios (bases PV systems) with on-line monitoring system may be suitable for the entire portfolio to a specific timetable.

The results of the measurements from monitoring systems are shown by Table 2 and Table 3.

Table 2. Reference system data table

t'_0	Δt	$h_{ekv,t0}$ (expected)	$h'^{*}_{ekv,t0}$ (measured)	f'_{t0}
t'_1	Δt	$h'_{ekv,t1}$	$h'^{*}_{ekv,t1}$	f_{t1}
t'_2	Δt	$h'_{ekv,t2}$	$h'^{*}_{ekv,t2}$	f_{t2}
t'_3	Δt	$h'_{ekv,t3}$	$h'^{*}_{ekv,t3}$	f_{t3}
...	...	...	...	...
t'_n	Δt	$h'_{ekv,tn}$	$h'^{*}_{ekv,tn}$	f_{tn}
...	...	...	...	...
t'_m	Δt	$h'_{ekv,tm}$	$h'^{*}_{ekv,tm}$	f_{tm}

Table 3. The basis system (in portfolio) data table

T_{0+k}	Δt	$h_{ekv,t0}$ (expected)	$h^{*}_{ekv,t0}$ (measured)	f_{t0}
T_{1+k}	Δt	$h_{ekv,t1+k}$	$h^{*}_{ekv,t1+k}$	f_{t1+k}
T_{2+k}	Δt	$h_{ekv,t2+k}$	$h^{*}_{ekv,t2+k}$	f_{t2+k}
T_3 +k	Δt	$h_{ekv,t3+k}$	$h^{*}_{ekv,t03+k}$	f_{t3+k}
...	...	...	...	...
t_{n+k}	Δt	$h_{ekv,tn+k}$	$h^{*}_{ekv,t04+k}$	f_{tn+k}
...	...	...	...	...
t_{m+k}	Δt	$h_{ekv,tn+k}$	$h^{*}_{ekv,t04+k}$	f_{tn+k}

The neural network method is shown in Figure 3.

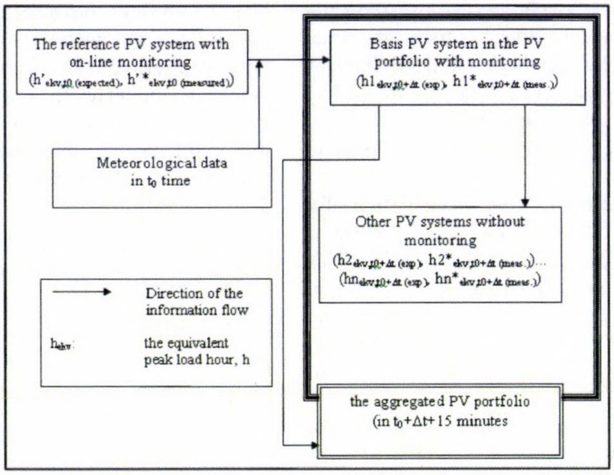

Figure 3. The neural network model block diagram.

Results and discussion

The research work aims the integration of autonomous or grid connected PV systems could be more safely and more cheaply, as presently possible. The obstacles to the spread of PV systems, which need for accurate 15-minute schedules, but the PV technology can not able to give these. The accurate knowledge of more several small systems' power production is not known for the system operators.

During the research, analyze and appreciate the opportunity to how can be produced information on the total average PV performances in a micro-region based on measurement and evaluation of a chosen reference photovoltaic system.

The research thesis is expected that the average performances of the systems can be modelled with reasonable accuracy with an on-line examination of a reference system.

Further expected result is the errors between the average performances according to analytical programs and the actual measurable values are able to make predictive forecasting.

The research with the new methods based on reference system could be long-term (day) forecast. The long-term forecasting using neural networks methods.

Conclusion

The forecast of electricity production of some PV portfolio with the knowledge of typical direction of weather fronts can be made more accurate.

This new method which only based on few pieces reference photovoltaic small power plans with on-line monitoring system and the analysis of errors could help to connect and integrate a large number of small PV systems to the grid,

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