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New Photovoltaic System with Higher Effectivity

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Abstract: We increase the amount of produced energy from photovoltaic (PV) panels by the new construction of the solar PV system. The usage of our tracking stand TRAXLE™ was appropriate. The passive solar tracker TRAXLE™ and the tracking soft ridge concentrator were developed in co-operation of the CULS Prague and fa. Poulek Solar, Ltd. The small on-grid solar PV system 2 x 2 kW_p was constructed and installed at the Czech University of Life Sciences Prague. Similar PV systems can be used as off-grid or on-grid power supplying device in agriculture. The identical PV panels are compared. PV panels (2 kW_p) were fixed and PV panels (2 kW_p) were located on the tracking stand TRAXLE™ with the soft ridge concentrator. The produced energy amount is equal to the integral $E = \int_{\Delta t} P.dt$, where P is the instantaneous power and t is the daytime. The solar tracking system with the soft ridge concentrator yields the energy surplus up to 100% during sunny days in sunny countries. We expect the energy surplus up to 60% in the Czech Republic (50° of north latitude) during summer sunny days. The energy surplus corresponds with the lower price of the solar energy. Economic calculation shows, that the solar system with tracking stand and soft ridge concentrator is cheaper, when we compare two systems which produce the some amount of the energy. The tracking stand is more expensive than the fixed, but we can save some PV panels, and the price of the PV panels is the most significant part of the price of the whole solar PV system. At the present time, the data from our new PV system are collected. The results correspond with our above mentioned presumption.

Key words: Photovoltaics, solar tracker, solar energy

INTRODUCTION

Recently, we have frequently published our new results in the field of photovoltaics [1,2] and we have described also the unique and patented construction of an automatic tracking stand TRAXLE™ [2,3] with photovoltaic (PV) panels, tracking the Sun's movement on the sky and orientating the panels all

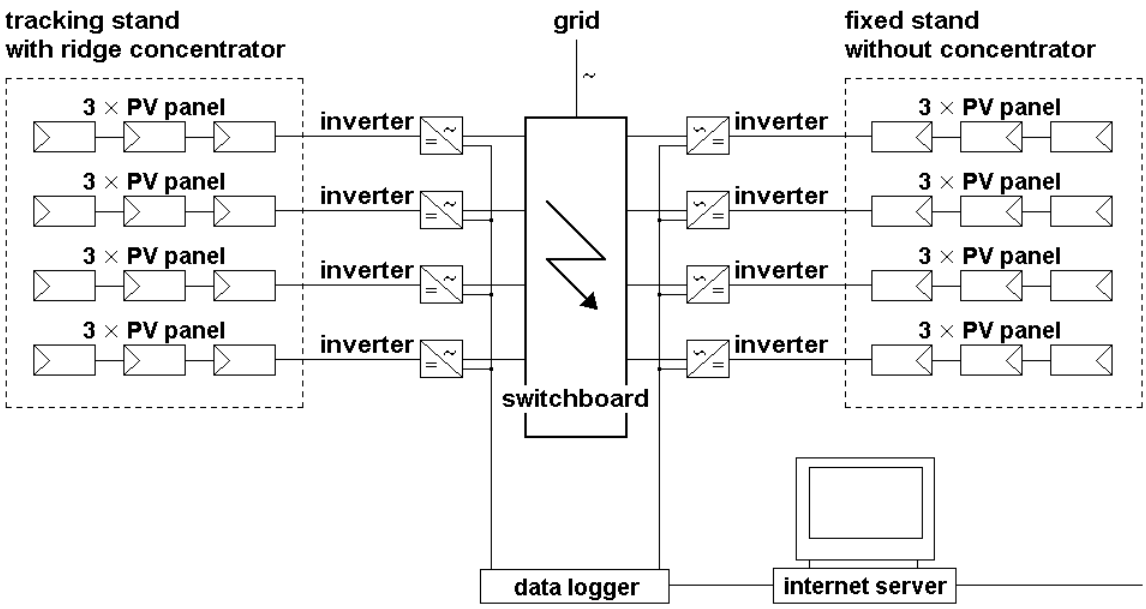

Figure 1. Schema of the PV system.

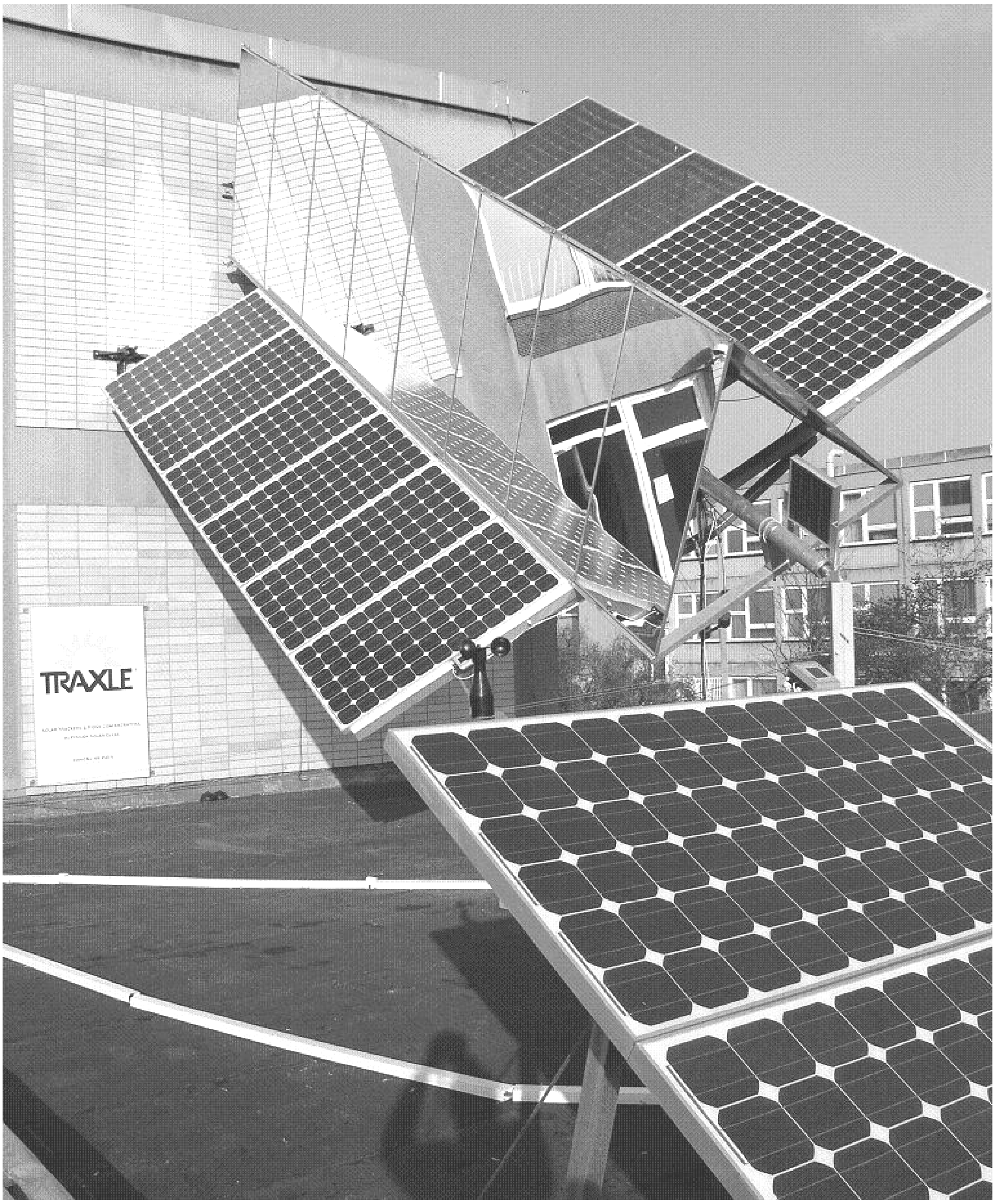

Figure 2. The PV system.

the time perpendicularly to the direction of the solar radiation. We have described the construction of the ridge radiation concentrator as well [2,4].

At the Faculty of Engineering of CULS Prague we have already tested various solar PV systems and we have build step by step larger and larger PV systems with respect to the acquired financial means. In the year 2007, we were able to design and build an already large PV system combining the automatic tracking stand, equipped with the ridge concentrator

Figure 3. Data logger, switchboard and Sunny Boy inverters placed in the laboratory.

of radiation, with PV panels of the total rated output power of 2 kW_p as well as a stationary system with identical panels, of the same rated output power of 2 kW_p.

CONSTRUCTION OF THE PV SYSTEM

The project was aimed to designing and constructing of a new photovoltaic solar system with higher effectivity, directly connected to the grid. The ridge concentrators of radiation with planar mirrors, in combination with the tracking stand and with bifacial PV panels, increase the produced energy amount of solar photovoltaic systems by up to 90 per cent under ideal conditions. The energy surplus should be up to 60 per cent under the conditions of the Czech Republic.

A photovoltaic system with the tracking stand TRAXLE™ and with the ridge radiation concentrator has been designed and constructed together with a comparative system with fixed panels without any radiation concentrator. The system is directly connected to the grid by means of the Sunny Boy inverters. Fig. 1 shows the schema of the PV system. It demonstrates the fact that always three identical PV panels (P_{max}= 170 W_p) connected in series are attached to one inverter (fa. Sunny Boy, P_{max}= 700 W). Four various types of PV panels, connected in series of three panels and located on the tracking stand with a ridge concentrator and on the fixed stand without the concentrator have been compared. Both stands have been equipped with sensors for the measurement and data collection of the incident radiation intensity. The anemometer for the measurement of the wind speed was attached to the fixed stand.

The PV system was accomplished in the year 2007. In spring the system had been designed and all the components were ordered. The system was gradually installed during the summer months and it was completed at the beginning of autumn. Fig. 2

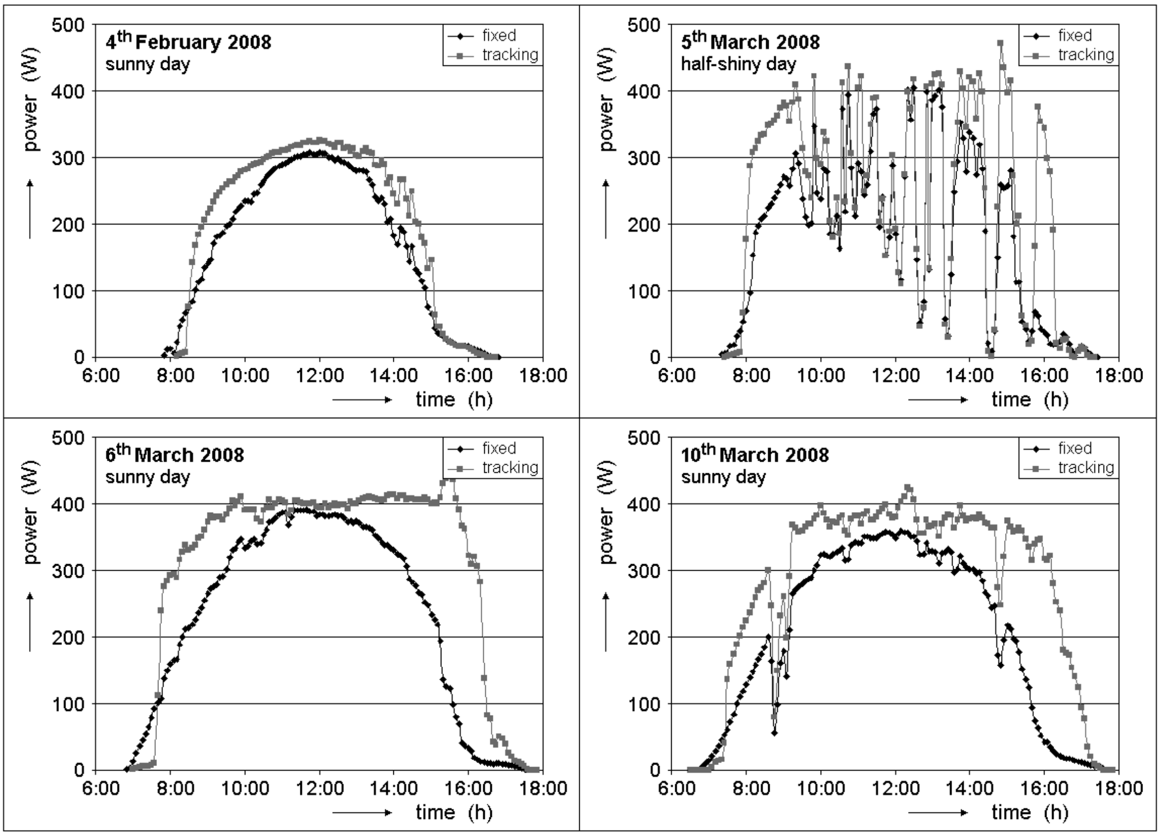

Figure 4. Time dependences of the instantaneous power for the PV panels located on the tracking stand with ridge concentrator and on the fixed stand during the selected winter days.

shows the PV system, the sensor for the measurement of the incident radiation intensity and the anemometer for the measurement of the wind speed are seen as well. All data of the instantaneous output power, wind speed and radiation intensity were stored in a data logger. Fig. 3 shows the data logger, switchboard and the Sunny Boy inverters placed in the laboratory.

RESULTS and DISCUSSION

A systematic study of the time dependence of the instantaneous output power, of the produced electric energy, and of the weather parameters started in autumn 2007. Measurements recorded during selected sunny winter days are shown in Fig. 4 as an example. The time dependences of the instantaneous output power for two sets of three identical PV panels of an advanced Chinese provenience, connected in series, are compared. The amount of the produced electric energy is given by the above mentioned integral of the output power over a given time $E = \int_{\Delta t} P.dt$, where *P* is the instantaneous output power and *t* is time. The area under the graph corresponds with the amount of produced energy. It can be seen that during the winter sunny days the increasing of the produced energy amount is up to 40 per cent in the case of PV system with the tracking stand and with the ridge concentrator.

However, during the winter days the Sun moves rather low over the horizon, the radiation dispersion is high and the PV panels on the tracking stand under comparison are only partly illuminated by the mirror. The non-illuminated PV cells of the PV panel acts partly as a load, the power is limited by the minimally illuminated PV cells. Moreover, the day becomes

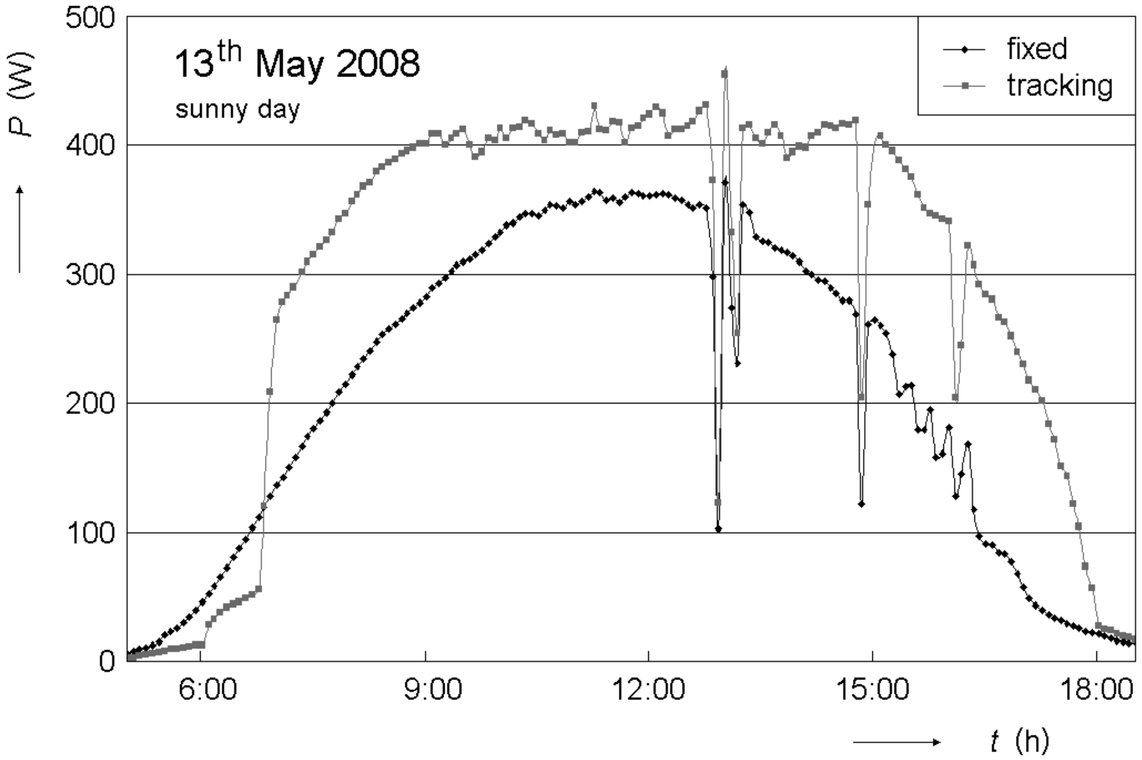

Figure 5. Time dependence of the instantaneous power for the PV panels located on the tracking stand with ridge concentrator and on the fixed stand during the selected spring day.

shorter and the Sun tracking angle is small. Fig. 5 shows an example of the similar graph corresponding with a sunny spring day. In this case the energy surplus is approximately 50 per cent. It can be therefore assumed that the energy surplus will be up to expected 60 per cent during the spring and summer sunny days.

There was few days windstorm in Prague during March 2008. The wind speed was up to 120 km.h^{-1}. The construcrion of the PV system persisted the wind, the system was not damaged. The operation is reliable after this windstorm. Few years ago we tested similar PV system in the wind tunnel in the Aeronautical Research and Test Institute in Prague-Letnany and the tests correspond with operation in real conditions.

CONCLUSION

The project program is accomplished in the Czech University of Life Sciences, Prague, during the years 2007-2008. The PV solar system with higher effectivity was designed and constructed, the comparison of the produced electric energy amount is now studied under the local conditions of Prague 6 – Suchdol for both standard and advanced photovoltaic panels located on the automatic tracking stand with the ridge radiation concentrator and on a fixed stand without any concentrator. It has been measured that the energy surplus is about 40 per cent in the case of PV panels of the advanced design, fixed on the tracking stand with the ridge radiation concentrator in comparison with the same PV panels located on a fixed stand during the winter sunny days under the local conditions of Prague 6. The energy surplus was up to 50 per cent during the sunny spring days till 15th May 2008. It is assumed that with respect to the effects discussed above the energy surplus will be up to 60 per cent during the spring and summer sunny days. From the point of view of the year-round effectiveness the spring and summer values are more decisive as the amount of the incident energy has then the highest value.

The construction of the PV system persisted the windstorm in the March 2008, the PV system was not damaged.

The system is simultaneously used as a demonstration system for students and interested public and for consultations in the field of renewable energy sources. Long-term measurements and monitoring of parameters will follow in the forthcoming years and the results will be thereafter published. More information and illustrations of our equipment are available, for instance, on the web address http://www.solar-trackers.com.

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