AUTOMATIC TRACKIG STANDS OF PV PANELS ARE GAINING IMPORTANCE AGAIN DUE TO ADVANVED PV SYSTEM DESIGN

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Abstract
During the past 15 years, the price of photovoltaic panels has fallen significantly. The importance of automatic movable stands of PV panels with solar trackers has temporarily decreased, because due to mutual shading of movable stands with a polar axis, the area of the PV power plant is used less efficiently. Movable stands with a horizontal axis are the most effective, because they minimize the effect of mutual shading of the stands. Thanks to this, the importance of movable stands is growing again. Such stands are most effective in low latitudes, where they can increase the annual energy harvest by up to 30%. In Central Europe, they can increase the annual energy harvest by about 10%, but even that is significant for investors.

Key words: *Photovoltaics; PV panel; solar tracker; solar energy.*

INTRODUCTION

We intensively studied the issue of movable stands of solar photovoltaic (PV) panels ten to twenty years ago (*Poulek & Libra, 1998; Poulek & Libra, 2000*). At that time, a solar boom was taking place in Central Europe. The prices of high-quality PV panels were around 3 Euros per 1 Wp of installed nominal output power. Such a price was relatively high. With a slightly increased investment in a movable stand, it is possible to obtain up to 40% more electricity during a sunny day compared to the same PV panels installed on a fixed stand (*de Simón-Martín et al., 2013*). The theoretical calculation of this increase is relatively simple and we performed this calculation, for example, in the work (*Poulek & Libra, 2010*). The amount of electricity produced W is given by the equation:

$$W = \int_{\Delta t} P \, dt \,, \qquad (1)$$

where P is the instantaneous power and t is the time.

Solar trackers work on different principles and we have presented their overview in more detail, for example, in the book (*Poulek & Libra, 2010*). Solar trackers TRAXLE were developed in our laboratory and they have been installed in a number of PV power plants. Fig. 1 shows an example of their installation in a PV power plant with a nominal power of 10 MWp. Movable stands with polar axis allow an annual increase in the energy harvest of up to 35% in areas with a high number of sunny days during the year (*Huang et al., 2011*). However, at higher latitudes, the inclination of the axis causes the individual racks to shade each other and they need to be placed further apart, as can be seen in Fig. 1. This reduces the utilization of the PV power plant area.

During the last 15 years, the price of PV panels has fallen about 15 times below 0.25 Euro per 1 Wp of nominal output power, and the economic consequences of this decline have been discussed, for example, in the article (*Libra et al., 2023; Barbose at al., 2015*). This decrease in the price of PV panels has led to investors, especially in Central Europe, preferring to install a larger number of PV panels on fixed stands and thus make more use of the power plant area, because land area is expensive, especially in developed countries. The importance of movable stands with solar trackers has temporarily decreased, but has not disappeared. At present, movable stands with solar trackers are currently experiencing a renaissance. Their importance is growing for installations, for example, in desert or sparsely populated areas, where the price of land is low and the number of sunny days is high. The shading effect is almost eliminated in the case of horizontal installation of the rotation axis. For comparison, Fig. 2 shows a graph of the dependence of annual relative losses caused by shading on the ratio of land coverage by PV panels in Central Europe for the polar and horizontal axes (*Gordon et al., 1991*).

The aim of the work is to assess the possibilities of renaissance and new installations of PV tracking systems and thus increase the electric energy harvest from photovoltaic panels.

Fig. 1 The PV power plant with tracking stands TRAXLE of PV panels

MATERIALS AND METHODS

Thanks to our monitoring system (*Beránek et al., 2018*), we have detailed data from many PV power plants. In this article, we present as an example the evaluation and comparison of data from two PV power plants of different designs. For better comparison, the values are recalculated to 1 kWp of nominal output power.

The first PV power plant is installed in Chile on 31° south latitude, where the number of sunny days per year is a high. The PV panels are installed on movable stands and the rotation axes are oriented horizontally in the north-south direction (Fig. 3). The nominal output power of the power plant is 3000 kWp.

The second PV power plant is installed in the Czech Republic at CULS in Prague at 50° north latitude. The PV panels are installed on fixed stands with the inclination of 35° to the south (Fig. 4). The nominal power of the power plant is 10 kWp. To compare the energy harvest in PV systems in Prague with a fixed stand and with a movable stand with polar axis, we used a small PV system with a movable stand with a polar axis inclined at 35°.

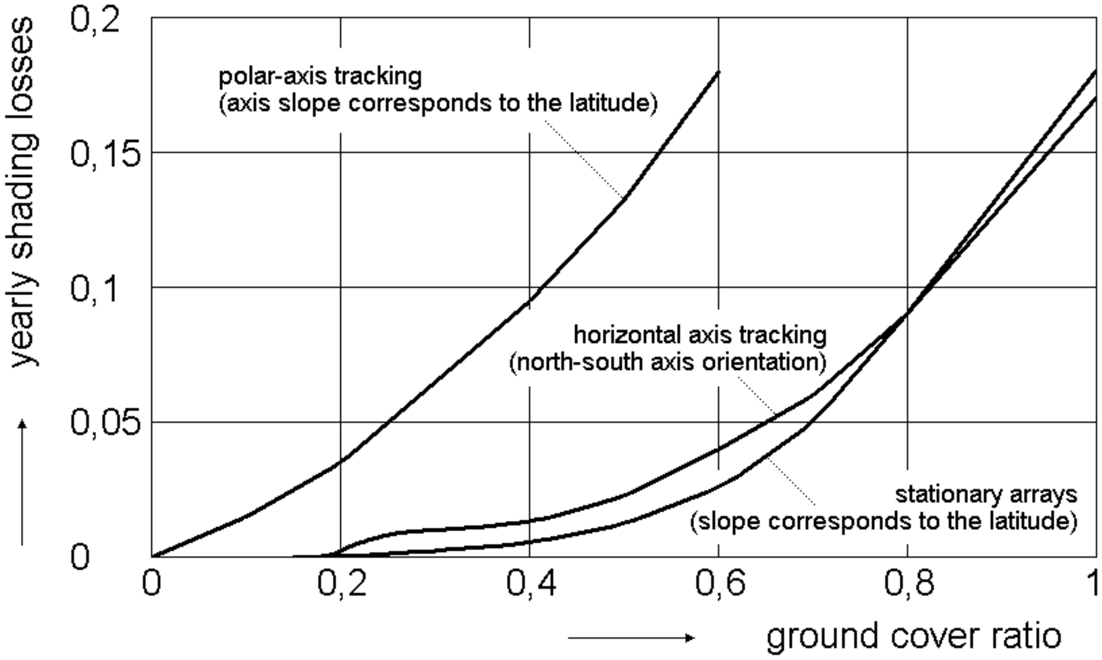

Fig. 2 The dependence of annual relative losses caused by shielding on the land coverage ratio in Central Europe

Fig. 3 The PV power plant in Chile with movable stands of PV panels with solar trackers and with horizontal axes

RESULTS AND DISCUSSION

Fig. 5 shows a comparison of the instantaneous power as a function of time for PV systems with the fixed stand and with the movable stand of PV panels in Prague at the CULS. It can be seen that during the sunny day of September 19 (near the equinox) the increase in the amount of energy harvest is around 40% in the case of movable stand with polar axis. The energy harvest is given by equation (1). In the afternoon, there is usually lower atmospheric humidity and therefore lower absorption of near-infrared radiation, which is most important for photovoltaic energy conversion in crystalline silicon-based PV panels. Therefore, in the afternoon, more electricity is usually produced than in the morning, which is also visible in our measurements. From the point of view of annual operation, we must understand that there is only a limited number of sunny days in Central Europe.

Fig. 4 The PV power plant in Prague at CULS with fixed stands of PV panels with inclination 35° to the south

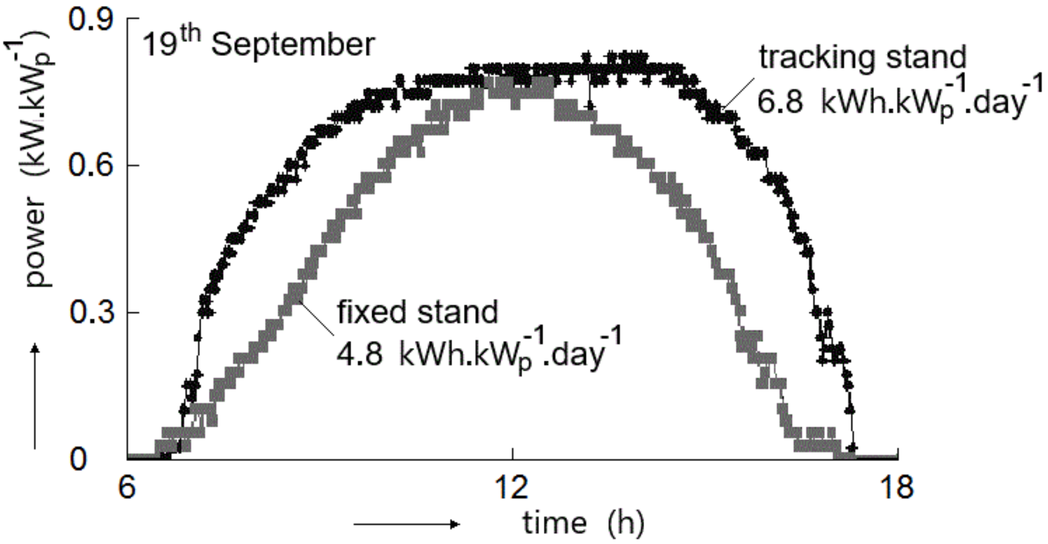

Fig. 5 Dependence of instantaneous power on time during the sunny day for a PV system with the fixed stand and with the moving stand with solar tracker and with polar axis

Fig. 6 shows the annual amount of electricity produced in both of the above-mentioned PV power plants. The reversal of summer and winter in the northern and southern hemispheres is noticeable, as well as the effect of higher value of the energy produced in the case of the movable PV panels stands.

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Installation with a horizontal rotation axis is most effective in the areas with low latitudes, where it allows an annual increase in electricity production of up to 35%. In Central Europe, this design allows an annual increase in electricity production of about 10%, but even that is already significant for investors. Fig. 7 shows a detail of such an installation.

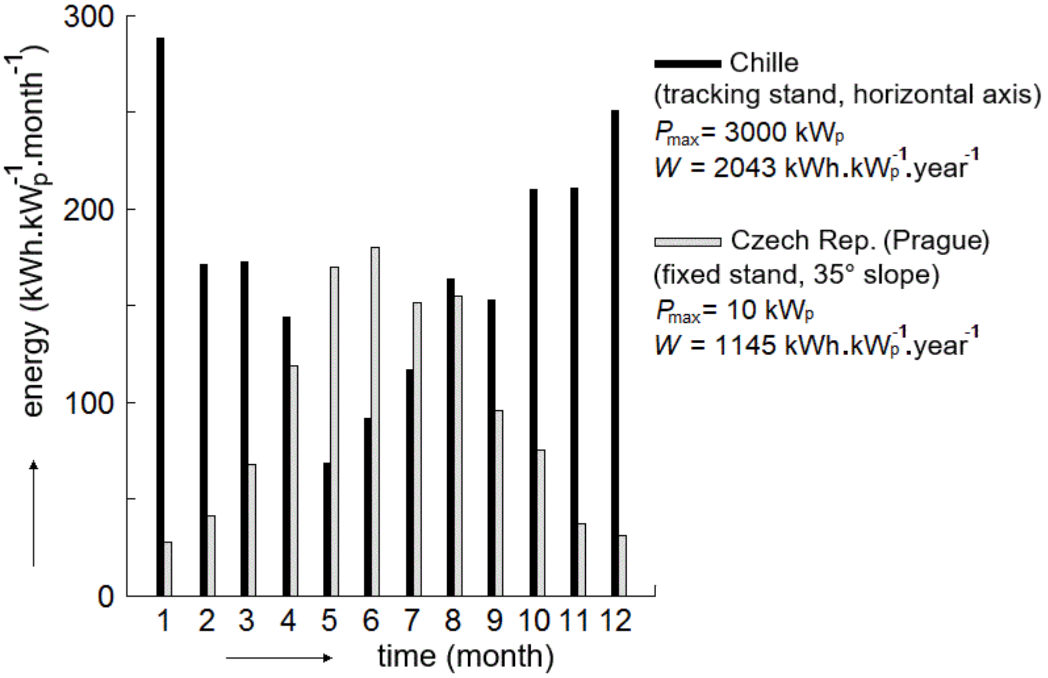

Fig. 6 Annual values of the elektricity produced in both mentioned PV power plants

Fig. 7 Detail of the movable stand of PV panels with solar tracker and with horizontal rotating axis

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CONCLUSIONS

Currently, a new solar boom is taking place mainly in Central Europe in connection with the increase in energy prices. Small PV systems are installed mainly on the ridge roofs or on facades of residential buildings. There are suitable structures with fixed PV panels. However, movable stands of PV panels with solar tracker and with a horizontal rotation axis can be used in open areas or on horizontal roofs. If the axis of rotation is oriented horizontally, the mutual shielding effect of the stands is minimized.

In the Czech Republic today (y. 2025), there are around 150,000 small PV power plants on residential buildings with a nominal output power of around 10 kWp. The number of all PV power plant installations is around 170,000. The total installed nominal output power of all PV power plants in the Czech Republic is around 3,600 MWp.

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