YIELD COMPARISON OF NORTH- AND SOUTH-FACING PHOTOVOLTAIC PANELS

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Abstract

The paper summarizes the results of a several-month experiment carried out on the roof of one of the objects of the Faculty of Engineering. The aim of the experiment was to ascertain how many percent of energy is a north-oriented panel capable to deliver to an off-grid solar system in comparison to a south-oriented one. The point is to determine the effectiveness of deployment of a northern panel in case that it is not possible to install another panel to the south from space, aesthetical, or other reasons. During a three-month observation it has been reckoned up that with the north-oriented panel added, only 26 % more energy can be generated totally, but in the poorest days the benefit can make up to 99.8 %.

Key words: energy, solar, renewable, power, performance, sun, earth.

INTRODUCTION

Energy shortage appears in off-grid solar systems, especially in winter. Many such facilities need to assure at least a certain minimum energy to fulfil its objective, e.g. data acquisition and transmission. For these systems it is desirable to produce at least this minimum daily duty, so as to the number of missed days be minimised – MAREŠ (2013), GORDON (1987). For space and financial reasons it may not be possible to provide an accumulator for such device that would supply the system by surplus summer energy during winter months. One is also often met with instances where it's not possible to add another photovoltaic panel to the south side. For this reason, we consider interesting to find how many percent of energy a northern panel can produce during winter season. Winter period in Czech basin is generally characterized, besides the low sun path, by frequent inversions and low clouds that prevent direct sun visibility; various reflections and scattering can, on the other hand, occur from these atmospheric layers. It isn't easy to assess theoretically how intense any of the effects would be and what percentage of the winter period it would take– e.g. GOH, TAN (1977). For this reason, we have proceeded to do an experiment that compares the outputs of north- and south-facing photovoltaic panels in the conditions of central-Bohemia region.

MATERIALS AND METHODS

Two photovoltaic panels by SHANDONG LINUO PHOTOVOLTAIC HI-TECH CO., LTD., with 72 “125*125-C”mono-crystalline cells each have been used for the measurements, their peak power being 170 W and open-circuit voltage 42.7 V. The panels were mounted to a steel frame. The whole construction was placed on the roof of a faculty object at geographical coordinates 50.1287331 N, 14.3741250 E. A 0.7 Ω resistor was connected to the output of each panel. Voltage over the resistors has been sensed by a two-channel data logger Comet S5021. Data had been acquired with 14-bit resolution at the frequency of 1 sample per 10 seconds, from January to April 2016. Only values higher than 7 mV had been recorded. That would correspond to a minimum logged output power of 13 mW at optimal load – i.e. still a negligible value. Contingent snow had been removed regularly from the panels. Overall situation after the installation can be seen in Fig. 1.

Fig. 1. – Frame with panels installed on the roof – situation

RESULTS AND DISCUSSION

From the experiment, 92 winter days have been recorded and evaluated in all. In the following chart (Fig. 2) we can see daily amounts of energy supplied by the north-facing panel in comparison to the south-oriented one. Histogram is added in the chart that indicates how often particular daily solar radiation amounts occurred in the watched period. Solar irradiation data from a nearby meteostation METEO (2016) are available online. For typical yearly waveforms of solar irradiation and possible panel tilt adjustment see e.g. LIBRA (2010).

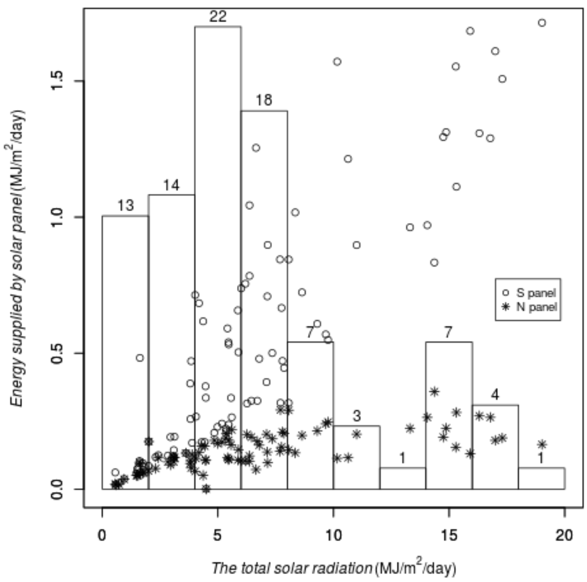

Fig. 2. – Daily energy output totals for both panels and distribution of daily solar radiation

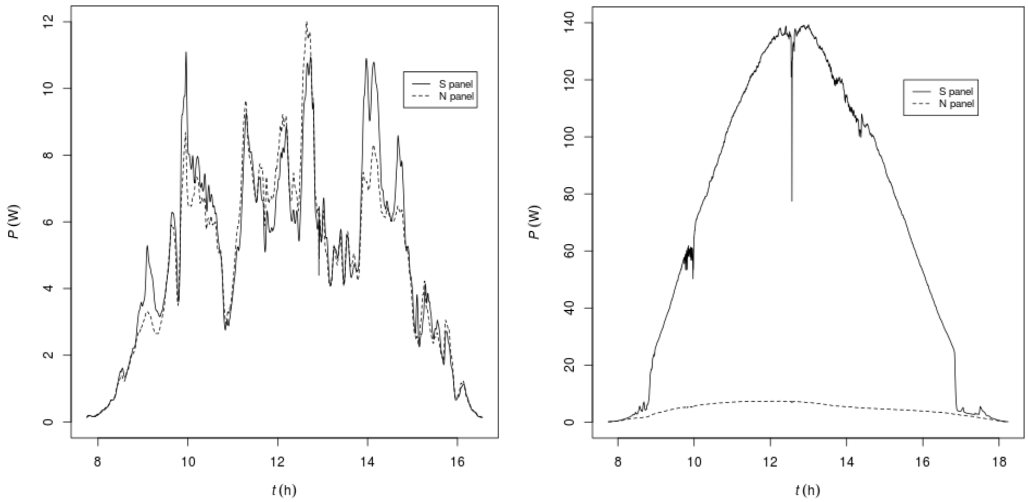

Fig. 3. and 4. – Typical daily runs of generated power in the north- and south-facing panels on an overcast (left) and a sunny (right) days (note the different vertical scales)

It is clearly visible in these charts that in cloudy days, energy supplied by the north-facing panel is equal and in some moments even higher than the energy supplied by the south-facing one, while in clear days the energy of the north panel stays between 8–15 % of the south one. The effectiveness of deployment of a north-oriented panel is thus indirectly proportional to the actual yield of the south panel, as shows the next chart.

Histogram of the daily share of the north panel on the total (both panels) energy production distribution can be seen in Fig. 5.

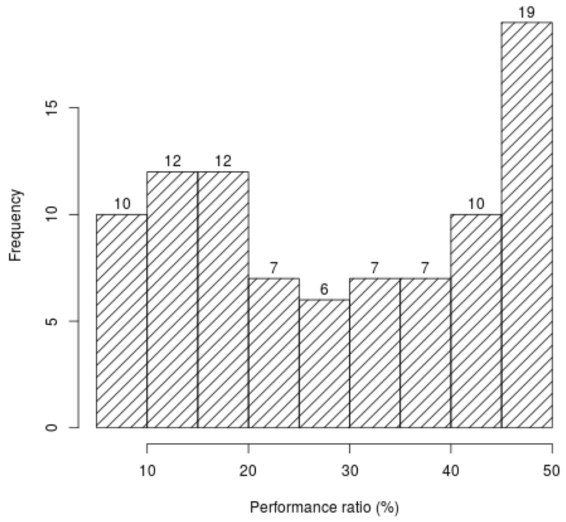

Fig. 5. – Daily shares of the north panel on the total performance

Basic descriptive statistics for the whole measured period are as follows: Total energy produced by the north-facing panel amounts 17440 kJ. Likewise, electric energy supplied by the south panel during researched period totals 66410 kJ. It works out thus that it is possible to supply 26.3 % in all, i.e. roughly one quarter, of electric power from north panel, compared to the south one. Minimum daily ratio of energy supplied by the north panel over the south one amounts 5.74 %, maximum daily ratio amounts 99.8 % by contrast. Mean amount of energy generated by the north panel over the south one makes 47±31 %.

This result is worth a little commentary. According to a strongly non-Gaussian distribution of the ratios visible in Fig. 5, there's a considerable difference between the mean value of the ratios at particular days on one side, the median (which amounts 41±29 %) and all the more so the total ratio of energies produced in the course of the whole period. It actually follows from the chart in Fig. 5 that the majority of the winter season consists of days that are favourable for the deployment of a north-facing photovoltaic panel, as the fraction of clear days, when the effect of its deployment lies below 20 %, is only 20 %.

CONCLUSIONS

The study has demonstrated appropriateness of north-facing panel deployment for the cases where there isn't possible to use a second south-facing panel. During winter season, that is the critical one for off-grid systems, there has been generated 26 % more energy than there would be without the use of north panel, in the case of past winter. In this sense, deployment of a north-facing panel is five times less effective than using a second south-oriented one; though especially during long runs of days without direct sun visibility, that are the most critical moments of the operation– see e.g. KOUŘÍM (2015), the effectiveness of the north panel deployment is identical to the south one. It turned out for the past winter that the sum of the time when the sun could not be seen directly during the days is equal to 82 % of the total time, so one can say that in 82 % of the time the effectiveness of north-facing panel deployment equals the effectiveness of the south orientation.

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