COMPOSITION OF ALTERNATIVE ENERGY BATTERY CHARGING STATION

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Abstract. The paper focuses on the composition of a battery charging station. The proposed charging station can be used for charging batteries of electric bicycles, using solar radiation as the main source of energy. The station contains 10 photovoltaic panels with total maximal power up to 2000 Watts. The harvested energy is accumulated in local batteries (24 V 300 Ah). During a regular summer day it is possible to charge up to 19 (12 Ah 36 V) electrical bicycle batteries. The key features of the proposed battery charging station are an adjustable photovoltaic panel angle for efficient use of solar energy and protection of parked bicycles against precipitation. The paper contains detailed information about the already built prototype of the proposed charging station. The constructed alternative energy battery charging station is completely autonomous.

Key word: photovoltaic modules, alternative energy, power station, battery charging station.

Introduction

The photovoltaic panel optimal operating mode is dependent on the position to the sun. Optimal position of photovoltaic panels to the sun is when their surface is perpendicular to the sunrays. In order to make the panel surface perpendicular to the sunrays, an adjustable photovoltaic panel angle is needed, which varies depending on the season [1]. In summer time, when the sun is higher above the horizon, the photovoltaic panels need to be adjusted in 45º angle, but in winter time, when the sun position is lower above the horizon, the photovoltaic panels need to be adjusted from 45º to 90º angle. Generally in the autumn and springtime the photovoltaic panel pitch angle matches with the latitude, in our case 57º. We need to add 10-15 degrees (67-72º) in wintertime, but take 10-15 degrees (42-47º) in summer. In order to locate the photovoltaic panels perpendicular to the sun rays, the panel alignment should also be changed in the course of the day, to compensate variation of the height of the sun to the horizon.

The solar charging station construction is used in two ways.

- Stations those are intended for the cities. These stations are mostly set as an architectural object to align in urban areas. Urban area is highly dense and it is very complicated to equip photovoltaic panels with a system which follows the sun. In general these photovoltaic panels are equipped with a system where only the pitch angle can be changed when the seasons change.
- Stations that are created to produce electricity effectively. These solar stations are equipped with a system that follows the sun. In general, these stations are created in areas with low building density and other objects that cast shadows.

From the description above, it can be concluded that for the optimum solar energy production, the construction should be with moving parts, to which attach photovoltaic panels, and it must be sufficiently strong and stable to withstand the local climatic conditions. The key features of the proposed battery charging station are an adjustable photovoltaic panel angle for efficient use of solar energy and protection of parked bicycles against precipitation.

Materials and methods

The alternative energy charging station had to be placed in the yard of the Faculty of Engineering of the Latvia University of Agriculture. It was necessary to determine the optimal placement of the station within limited area. Conformity to the existing infrastructure and potential shadowing by the buildings and trees had to be evaluated.

There were carried out experiments in March of 2012 about the shadowed areas of the faculty yard green area. It is important for determination of the alternative energy battery charging station position on the green area, to receive as much possible radiation from the sun during the whole year, thereby improving the efficiency of the station.

The lengths of the shadows are shown in Fig. 1. In March of 2012 at 9 o'clock the shadows from the buildings 1, 2 and 4 reach the center of the green area 5. In March of 2012 at 12 o'clock the shadows from the building 4 and trees do not reach the center of the green area 5.

To consider the sun height changes and increase of daytime, lengths of the shadows from the west in the afternoon are shown in Fig. 2. In March of 2012 afternoon the shadow lengths from buildings 1 and 4 and trees do not reach the centre of the green area 5.

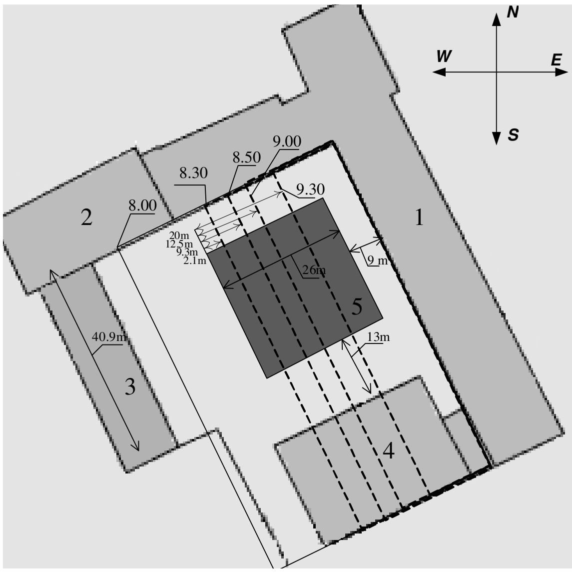

Fig. 1. **Shadow measurement on March 23 (in the morning):** 1 – old building, 2 –new building, 3 – garages, 4 – workrooms, 5 – green area

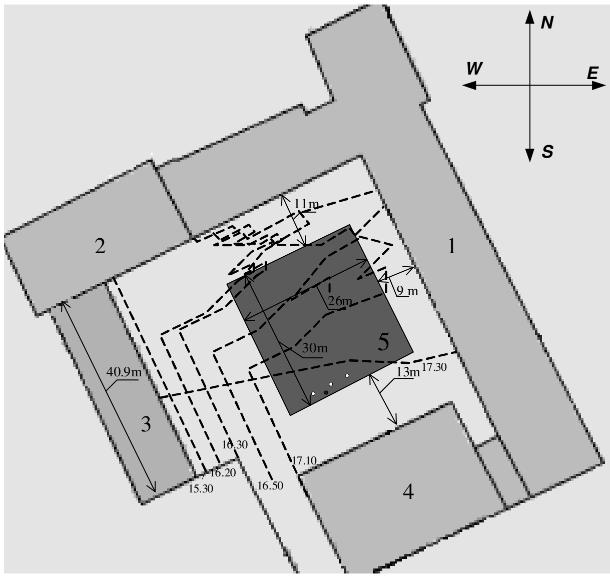

Fig. 2. **Shadow measurement on March 23 (afternoon)**

Earth is doing 1 rotation around the sun in a year, and its axis direction remains fixed in universe by 23.45 degrees at normal against the rotation plate [2]. The degree between the direction towards the sun and equatorial plate is called declination δ and is a seasonal change measure [3].

In the northern hemisphere δ changes from + 23.45° on July 21 (summer solstice period), to – 23.45° on December 21 (winter solstice period) [2].

The highest point of the sun at midday can be determinated using the following equation:

$$\alpha_n = 90° - \varphi + \delta \quad , \tag{1}$$

where α_n – degree of sun position at midday;
φ – degree of latitude (Jelgava 56.39 lat. degrees);
δ – declination.

Using the equation (1), it is possible to determine the sun altitude at midday for every season:

- in summer (on June 21) $\alpha_n = 90° - \varphi + \delta = 90 - 56.39 + 23.45 = 57.06$;
- in winter (on December 21) $\alpha_n = 90° - \varphi - \delta = 90 - 56.39 - 23.45 = 10.16$;
- in spring (21.03), in the autumn (21.09) $\alpha_n = 90° - \varphi + \delta = 90 - 56.39 + 0 = 33.61$.

Fig. 3, a schematically shows the movement of the sun and the station location, Fig. 3, b shows the solar height of the summer solstice (at midday). Choosing the location of charging stations should take into account the fact that the time of the so-called solar time does not coincide with the local time zone respectively, standard time (recorded clock) is different from solar time [4]. This difference is defined as the time equation.

The time equation value is constantly changing because the sun motion is not constant during the year. These irregularities are due to the Earth motion in the orbit with variable speed, and solar motion characteristics. Because of these two reasons, the time equation value can reach 16 minutes [5]. Therefore, several authors allow displacement of solar photovoltaic from the south a few degrees.

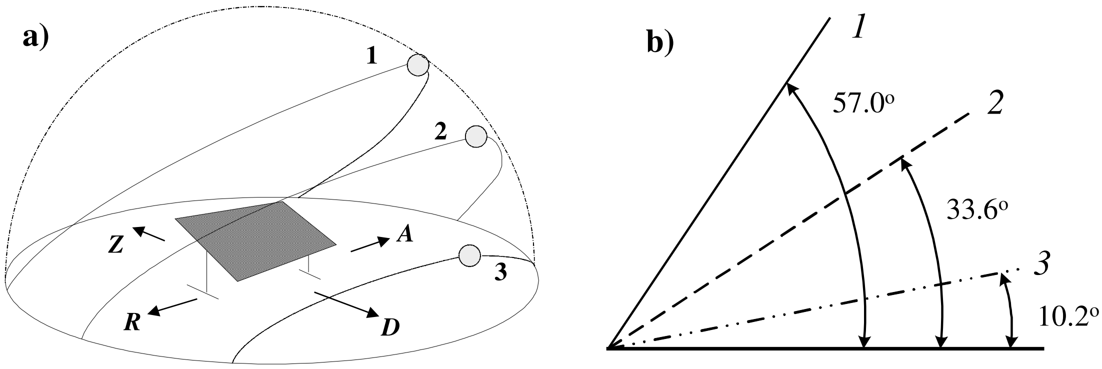

Fig. 3. **Position of the sun:** *a* – position of the sun during the solstice; *b* – highest point of the sun at midday; 1 – summer solstice; 2 – autumn solstice; 3 – winter solstice

The recommended position of the alternative energy battery charging station is shown in Fig. 4. Because the alternative energy battery charging station was designed as canopy and only one plane is regulated, the station is located 10-15 degrees to the west, to absorb the sun radiation more effectively during summer time.

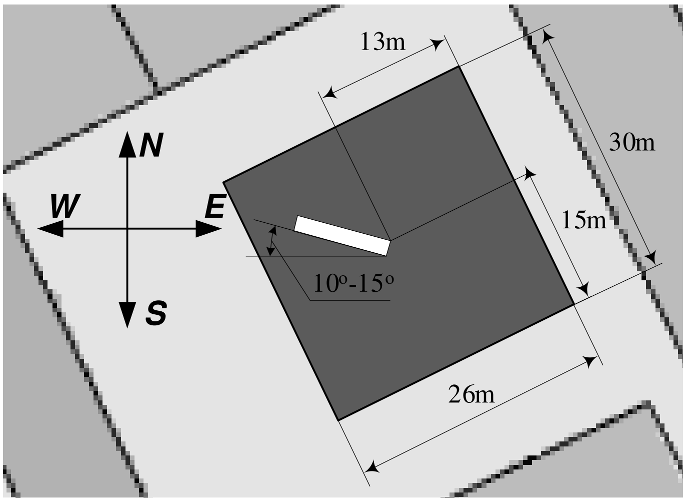

Fig. 4. **Position of alternative energy battery charging station**

Results and discussion

The prototype of the photovoltaic energy battery charging station contains 10 photovoltaic panels. The total area of the panels is 15 m^2. The construction weight without solar panels (photovoltaic panels) is about 380 kg. The frame is fixed to the central beam, which is hinged on two vertical stands. The vertical stands are secured by bolts to the concrete foundation. The solar station frame is shown in Fig. 5.

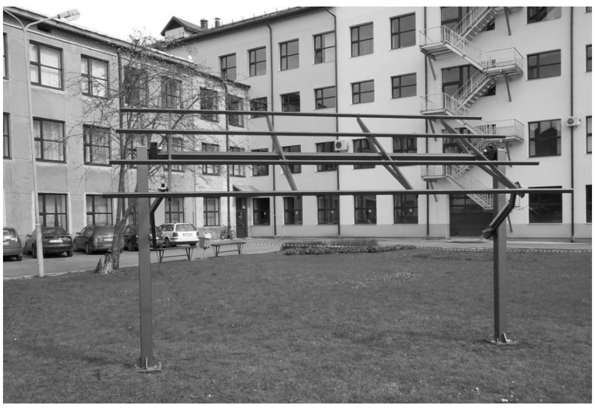

Fig. 5. **Frame of alternative energy charging station**

The frame and the central beam are made from square profile steel tubes, sized accordingly 50x30x3 mm and 120x80x4 mm, steel standard S235JR. The vertical stands are made from square profile steel tube, size 120x120x6 mm, steel standard S355J2H.

The dimensions of the solar station are the following:

- width – 5.02 m;
- height – 3.04-3.60 m (depending on frame positioning angle);
- depth – 0.97-2.02 m (depending on frame positioning angle).

The angle adjustment mechanism (Fig. 6) contains two square profile levers, which are hinged to the frame and fixed to the vertical stands. The angle is being adjusted using threaded rods and the desired position secured by bolts.

Fig. 6. **Angle adjustment mechanism of the solar station**

The panels are fixed on the frame by metallic clamps (Fig. 7). The charging station is designed to adjust from 27-63 degrees. If necessary, the adjustment mechanism can be equipped with an automatic angle adjustment mechanism.

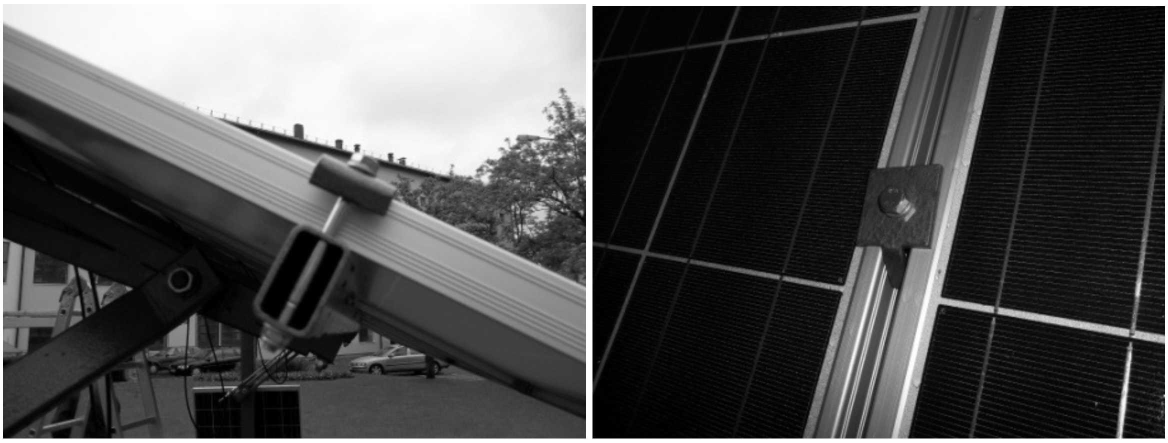

Fig. 7. **Photovoltaic module attachments**

The solar station design was guided by the following criteria:

- Ability to withstand wind and snow loads;
- Allowing simple adjustment of the inclination angle for photovoltaic panels;
- Architectonically fit for the location.

The constructed battery charging station is made with adjustable photovoltaic panel angle for efficient use of solar energy and protection of parked bicycles against precipitation.

Conclusions

1. The alternative energy battery charging station prototype can be used for efficient use of solar energy and protection of parked bicycles against precipitation.

2. It is important for stations located in city yards to be constructed in places where there is less shadowing from buildings and trees.
3. The charging station turning angle depends largely on the season and location latitude, in summer time when the sun is higher above the horizon the photovoltaic panels need to be adjusted in the angle 45º, but in winter time when the sun position is lower above the horizon – in 45º to 90º angle.
4. Because the alternative energy battery charging station was designed as the frame and only one plane is regulated, the station is located 10-15 degrees to the west to absorb the sun radiation more effectively during summer time.

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