

Features of designing of the grid connected photovoltaic station with a capacity of 10 kW

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Abstract

*Photovoltaic power station (PPS) operating function (without redundancy) with a nominal capacity of 10 kW connected to the low voltage electrical network established by "Zhejiang Chint Electrics Co Ltd" (PRC) under Tashkent conditions is defined. Analytical methods of calculation and design of PPS taking into account optimal distance between rows of photovoltaic batteries (PVB) are considered. The analysis of the results of the evaluation of the power generation of the PPS for the conditions of clear weather and clear cloudiness was carried out. According to the monitoring data for the winter period is 2211,5 kW*h.*

Keywords: solar cell, photovoltaic battery, low-voltage grid, grid photovoltaic station, design, optimal distance

1. Introduction

Energy shortages can be partially filled in many countries, including Uzbekistan, by using renewable sources of energy which are environmentally sustainable and affordable to consumers. In this regard it is advisable to use solar energy to produce electricity on an industrial scale, considering the substantial potential of solar energy in Uzbekistan. This is verified by the development and prospective photovoltaic solar station (PPS) programs, both abroad and in Uzbekistan [1-3].

The advancement of solar energy in Uzbekistan will undoubtedly contribute to addressing the country's energy security, social problems, environmental stability and improving the quality of life of the population. Unfortunately, the share of electricity generated in Uzbekistan using solar energy does not exceed 1 percent. The main obstacle to the wide introduction of solar energy is the lack of incentive measures for the population and industrial consumers, typical for China, Germany, Japan, Spain and the United States, and as a result, high capital investments, which fully fall on the shoulders of the consumer. Another significant problem is the lack of enterprises for serial production of photovoltaic converters, panels and component equipment based on modern technologies [4].

Currently, the situation in Uzbekistan is becoming different - the government has already adopted legislative documents encouraging the use of renewable energy sources, as well as the Ministry of Higher and Secondary Special Education is training students on specialties "Alternative energy sources", "Hydroelectricity and renewable energy sources", "Heliophysics and solar energy use", "Renewable energy sources and clean environment physics". [5-7].

2. Methodology

The development of technical profiles for solar photovoltaic stations based on higher education institutions creates opportunity for students and researchers to collect experimental data on the functioning of stations, evaluating potential technological solutions. Using analytical measurement methods with the aid of programs, monitoring and control of photovoltaic battery (PB) development parameters, elimination of photovoltaic characteristics, their study according to meteorological parameters.

3. Result and discussion

A 10 kW power plant was constructed at the Heliopolygon of the Power Engineering Faculty of Tashkent State Technical University on the initiative of "Zhejiang Chint Electrics Co Ltd" and small enterprise "Chint Distribution Uzbekistan" (Fig. 1), and a scientific and educational laboratory "Inspection of electrical devices and creative control of their control and measuring mode" was developed.



FIGURE 1. Solar photovoltaic station with capacity of 10 kW connected to low voltage network of the Faculty of Power Engineering

PPS consists of 40 PVB with seasonal orientation supporting structures to the south, three-phase network inverter with a capacity of 10 kW, the panel inside which is located: three-phase electrical meter, automatic input-output switches, electrical cables.

PVB with a rated power of 270 W is 60 solar cells (SC) connected in series on the basis of polycrystalline silicon. The main parameters of PVB are presented at the website [8].

PPS consists of 2 parallel groups of PVBs electrically connected to each other, each containing 20 batteries connected in series. PPS is placed at an angle of 46° in the south direction. However, it is also worth considering the seasonal change in the angle of incidence of solar radiation. For each latitude, in which the region is located, there is an optimal angle of inclination of the PVB installation. The PVB rises above the Earth's level to create space for free air circulation. The distance between the horizontal plane and the PVB is greater than ≥ 100 cm.

The distance between the two rows when mounting the PPS is of great importance for a PPS which is not fitted with a tracking system and which maintains a static location throughout the year. The greater the distance between the rows, the less likely it is that the first row will be shaded above the horizon at a low altitude of the Sun, thereby ensuring reliable electricity generation and transmission to the grid. At the same time, an increase in this distance leads to an increase in the area occupied by the PPS; therefore, finding the maximum and minimum values of this distance contributes to an increase in the average annual value of the PPS efficiency.

Calculations have been made to find the optimal distance between the rows of PVB.

$$d = S_1 + S_2 = \frac{L \sin(\alpha + \beta)}{\sin \beta} \quad (1)$$

where α is the angle of the Sun's height above the horizon; β is the angle of inclination of the PVB to the horizon; d is the optimal distance between the PVB rows; L is the length of the PVB; S_1 is the projection of the PVB length; S_2 is the projection of the line of the solar radiation angle of incidence.

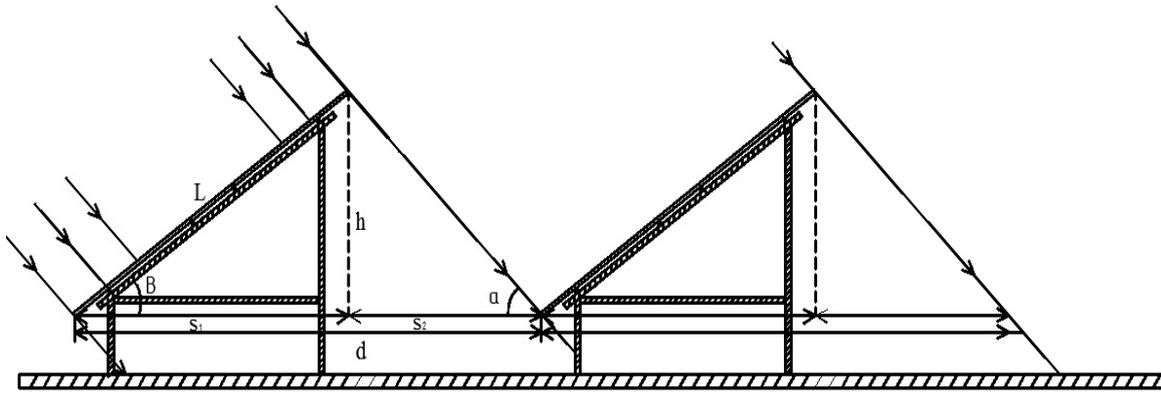


FIGURE 2. Determining the optimal distance between the rows of PVB

Using formula (2) and the Sun Facts program (Fig.3), we will determine the duration of sunny days per day and the value of the Sun's elevation angle above the horizon (α) on June 22 and December 22, 2019 at 12:22 hours. According to the calculation results for June 22, the angle of the Sun's altitude above the horizon was $\alpha \sim 72,1^0$ and the duration of sunny days per day was the maximum of 15 hours, 10 minutes. 10 sec. The minimum values of the angle of the Sun's altitude above the horizon and the duration of solar days per day on 22 December 2019 were $\alpha = 25,2^0$ and the day's length was 9 hours, 11 minutes and 12 seconds.

$$T_{c.c} = \frac{2}{15} \arccos(-\tan \varphi^0 \tan \delta^0) \quad (2)$$

were φ^0 - is the northern latitude of the terrain; δ^0 - δ^0 - the declination angle of the Sun for a given day.

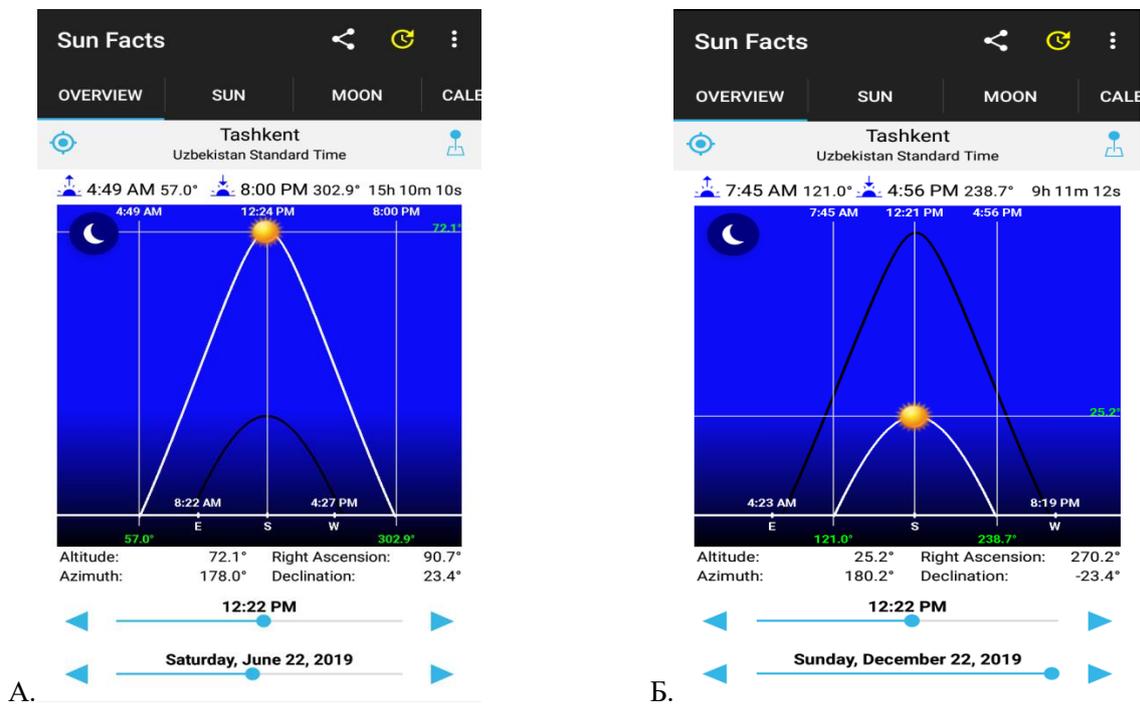


FIGURE 3. Interfaces Sun Facts program

Let the raw data be:

If $L = 165\text{cm}$; $\alpha_{min} = 25,2^0$; $\alpha_{max} = 72,1^0$; $\beta = 46^0$, we have still conducted experimental studies to measure the length of the PVB shadow on June 22 nd and December 22 nd 2019 at 12:22 hours. The values

of the minimum and maximum distance between the rows of PVB with a fixed location on the support structure are given in Table 1.

Date	Time	Lift height, m	d (m)	
			Calculation	Shadow length, Expert.
22 December	12:22	2,03	3,66	3,72
22 June	12:22	2,03	1,52	1,55

TABLE 1: The values of the minimum and maximum distance between the rows of PVB with a fixed location on the support structure

4. Conclusion

Therefore, Table 1 shows that the value of the optimal distance between the PVB rows, measured and calculated using the formula (1), differ slightly ~2-2,5%. According to the obtained results, it can be concluded that the proposed measurement technique and calculation of the optimal distance provide high accuracy.

It is possible to draw a conclusion that at stationary placing of PVB, when an angle of slope is equal to value of northern latitude of the terrain, it is necessary to consider distance between rows of PVB. If at designing not to consider optimum distance between rows of PVB, then increase of distance form shading of the bottom sites of the following rows, accordingly leads to decrease of efficiency of PVB and the occupied superfluous area of the Earth. In the first case, the maximum power point of the shaded PPS is shifted to the negative voltage zone and opens a bypass diode, which is connected in parallel to each battery to prevent the shift of the operating point of the battery in the energy consumption zone and, as a consequence, failure of the PVB.

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