Protection of Photoelectric Systems from Lightning

Khabibullo Sabirov[1], Tohir Axtamov[1], Sirojiddin Toshpulatov[2], Boysori Yuldoshov[2], Gayrat Raimov[2] and Tulkin Buzrukov[3]

[1]*Physical-Technical Institute, Chingiz Aytmatov Str. 2B, Tashkent, Uzbekistan*
[2]*Termez State University, Barkamol Avlod Str. 43, Termez, Uzbekistan*
[3]*Termiz University of Economics and Service, Farovon Str. 4B, Termez, Uzbekistan*
sabirovhabibullo47@gmail.com, tohiraxtamov@gmail.com, sirojiddin6870@gmail.com, b.yuldoshov10@mail.ru, raimov.gayrat@mail.ru, tolqinbuzrukov@gmail.com

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Abstract: The global PV market has grown extensively for small- to large-scale systems. Inevitably, this leads to the increased development of PV technology. PV systems are intrinsically exposed to weather phenomena. One such phenomenon is lightning. Direct and indirect effects of lightning can cause damage to PV systems. However, lightning protection for PV systems is often neglected and existing standards for protection are underdeveloped. In this paper, previous work is analysed to understand the interaction between lightning and PV systems and to ascertain gaps in current knowledge thereof. Investigation of these aspects will ultimately assist in understanding lightning risk, protection system design and aid in the development of lightning protection standards for PV in the renewable energy industry. The article also presents a specific case study, outlining the lightning protection system of a 3200W photovoltaic plant on a farm. The work includes a thorough description of the lightning protection system, addresses issues related to the contamination of PV surfaces, and proposes practical measures to ensure the safe and reliable operation of photovoltaic systems under adverse weather conditions. The experimental results affirm the significance of implementing lightning protection systems to ensure the robust performance of solar power plants.

1 INTRODUCTION

Nowadays photovoltaics is becoming more widespread due to the reduction in installation costs of photovoltaic (PV) systems and the incentives offered in many countries. Not only private households installing PV systems on their roofs, but private companies, educational institutions, business organizations or farms are also increasingly investing in PV systems to develop unused land. The judicious use of photoelectric batteries (PEB) will give the intended effect when the system is sufficiently focused on dustiness, extremely hot temperatures, and external protection. Factors such as hailstorms, strong winds, and lightning from changing natural phenomena seriously affect the stable operation of the photoelectric stations (PES). Because PEBs cover a large surface area, they are at increased risk of being struck by lightning during thunderstorms [1, 2, 3].

A lightning or lightning protection system consists of external and internal lightning protection measures. It protects people from injury, damage to structures, and electrical equipment from overvoltage.

The installation of photoelectric (PE) modules does not itself increase the risk of lightning strikes to buildings, but in the event of a lightning strike, there may be increased damage to the building's electrical installations. This is based on the fact that due to the wiring of FE systems inside the building (in existing inverters and cable systems), high voltage lightning currents can result in strong conduction voltages and high radiation luminances of lightning. The purpose of the installer is to protect the building and PE systems from damage caused by lightning. Namely, due to a direct lightning strike, electrical and electronic systems (inverters, remote monitoring systems, the main line of the photoelectric system) must be protected against the effects of lightning electromagnetic impulses (LEMI). Lightning and surge protection of photoelectric devices (PEDs) is actually an understudied topic. The problem of protecting PEDs has been studied from the point of view of preventing direct lightning strikes by constructing conventional external lightning protection systems [4, 5].

However, the problem is more complex; in fact. If a lightning strike occurs in the vicinity of an FE system, the devices may be damaged and fail due to voltage surges and excessive current flows. Previous studies have shown that overvoltages can reach significant values [6] and therefore it is essential to install surge protectors on both sides of power electronic devices (such as charge controllers and inverters) [7].

2 METHODS AND MATERIALS

This article describes the lightning protection system of a 3200W photoelectric plant (PES) installed on a farm in the Tomdi district, Navoi region and the passport parameters of the solar panel used in FES are listed in Table 1.

Table 1: Geometric size and physical parameters of photoelectric battery.

Parameters	
Geometric dimensions	Size
The surface of PEB, S_{PV}	1,018m^2
The frame width of FEB, d	3,5sm
Physical and technical characteristics	
Maximum power of PEB, P_{MAX}	200W
The efficiency factor of PEB, η	19,5%
Open circuit voltage of PEB, U_{OC}	45,48V
Short circuit current of PEB, I_{SC}	7,89A
PEB fill factor of the volt-ampere characteristic, FF	0,74

Tomdi district is one of the districts of Navoi region. It was established on July 3, 1927. It borders Konimekh and Nurota districts in the south, Kyzylorda in Kazakhstan in the north, South Kazakhstan regions in the east, the Jizzakh region in the southeast, and the Uchkuduk district in the west. The center of the district is the village of Tomdibulok. The territory of the district is located in the Kyzylkum desert, the geographical coordinates are latitude 42° 13' 30" North, longitude 65° 14' 5" East, and the height of the land above sea level is 220 m (Figure 1 and Figure 2).

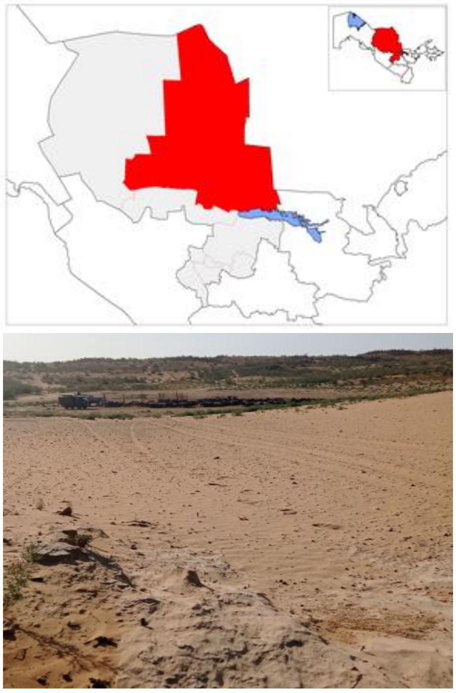

Figure 1: Geographical map of the area.

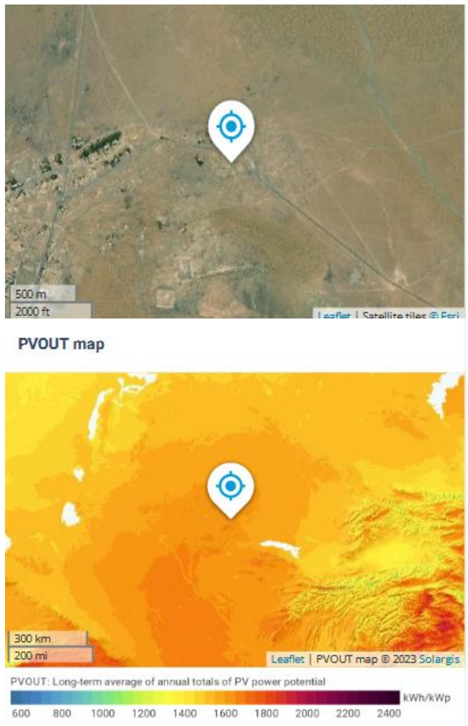

Figure 2: Solar Atlas data of the region.

The total area of Tomdi district is 4248.5 thousand km^2, of which 30.3 thousand km^2 are pastures (71%) and 12.2 thousand km^2 (29%) are non-agricultural lands. There are no irrigated lands. The climate is strictly continental. The average temperature in January is -4.1°, and the lowest temperature is -31°. The average temperature in July is +30°, the highest temperature is +48°. The average annual precipitation is 108 mm. There are no rivers or lakes. The soils are red, sandy soils.

The photoelectric plant installed in this area was fixed to the structure fixed to the ground, and before the installation work, information related to the area was collected and analyzed through the [8].

According to it, the azimuth angle for the solar panels was 180 ° clockwise from the north, and the optimal value of the installation angle of the solar panels with respect to the ground was 36°. It was determined that the total annual energy produced by PES is 5,140 MW•h and the annual total solar radiation is 2,002.2 kW/m^2.

Annual solar radiation values for the area are given below; direct normal radiation - 1772.2kWh/m^2, total horizontal radiation - 1708kWh/m^2, diffuse horizontal radiation - 654.6kWh/m^2, total radiation falling at an optimal angle – 2010.4 kWh/m^2 was found to be. Figure 3 shows the graphs of solar radiation and power that PES can produce per month and hours.

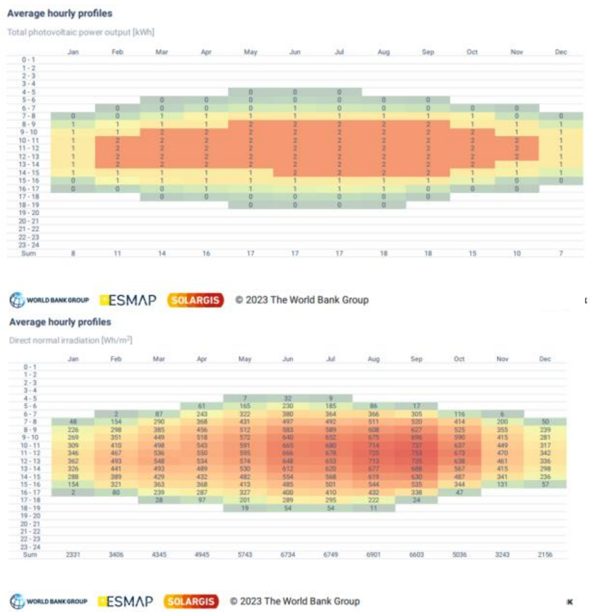

Figure 3: Power and Solar radiation data of the installed station.

3 RESULTS AND DISCUSSION

The farm is located in a desert area 352 km from the center of the district. This cattle breeding farm mainly uses PES to water its animal husbandry twice a day. For watering works, water is filled 3 times a day from a 65 m deep well into a cistern with a capacity of 8m^3 [9]. This year, some changes were made to the installation work of PES, which was installed on the farm last year. Accumulators of autonomous PES cannot justify themselves due to the sharp increase in climate in desert zones for the summer season. Therefore, the battery system was changed to a system that works only during the day with the help of a frequency inverter, which is shown in Figure 4.

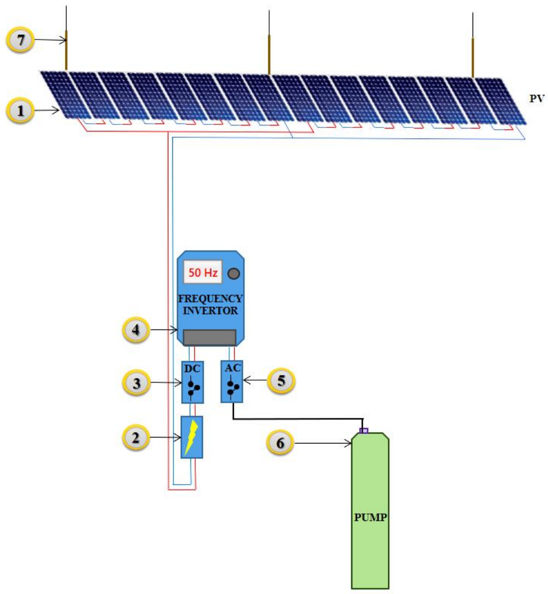

Figure 4: Drawing of a photoelectric plant for pumping water from a well through a frequency inverter installed on a farm: 1) mono silicon photoelectric battery, 2) lightning protection for electronic equipment (KYV-PS,1000DC/32A), 3) constant current connector, 4) frequency inverter (USFULL, 2,2kWt), 5) alternating current connector, 6) well pump (ZEN, 750 Wt), 7) protection of photoelectric station through the ground.

The changes made to the mounting work are as follows: for the external lightning protection system of the FES in the border area, vertical metal poles with an interval of 4 m each were installed on the ground at a distance of 1.5 m from the system. These poles protect photovoltaic cells on the surface, photovoltaic cell profiles, and structural parts from lightning strikes. Kayal KYV-PS (1000DC/32A) brand and IEC (EN) 60269-6 series European standard lightning protection device was used to protect the electronic components before the constant current from the panels enters the inverter (Figure 5).

Figure 5: Overview of lightning-protected PES and electronic devices.

It is known that during the PEB operation, the surface is polluted due to dust in the air, and the dust settles on the surface in certain microns. Due to the variability of the weather, especially during the rainy season, the sky is covered with clouds and it rains, which washes away the dust on the surface of the PEBs and cleans the panels. Naturally, in this case, the electrical efficiency of photoelectric batteries increases, and in addition, the value of the induced voltage associated with the magnetic fields of lightning flashes increases, and voltage loads are observed in electronic devices. This situation causes several problems in the operation mode of electronic devices and equipment. Our experience shows that it is necessary to complete the stage of lightning protection before the full operation of any PES installed on the premises. In addition, it is important that the panel frames of PEBs are painted in black to protect against lightning [10].

This work of photoelectric module protection systems was performed with the intention of contributing to providing experimental data for improved cases and this work is part of ongoing research.

4 CONCLUSIONS

During the works carried out in the area, the necessary installation works for optimal operation of the autonomous photoelectric plant for raising water from a well with a depth of 65 m were performed. The problems of providing the farm with electricity and water necessary for the whole year and especially for the summer season in livestock farms during the extreme months, which are the most unfavorable in terms of climate, were studied and solved. In addition, special attention was paid to the protection of the photoelectric station from adverse weather conditions. To protect against unexpected overloads, PES and consumer devices were protected according to world standards. The head of the farm acknowledged that the system was justified after a quarter of the work process of the station. Based on the results of the experiment, the following can be concluded:

1) Lightning strikes can seriously damage solar panels, inverters, electrical systems and monitoring equipment.
2) Introduction of lightning protection systems allows solar power plants to deliver clean and reliable energy to the network even in adverse weather conditions and ensures continuous operation.
3) In addition to extensive grounding measures, it is important to consider an isolated location on high ground from a high lightning zone, dry, rocky or otherwise poorly conductive soil layers, and the radius of the grounding connection.

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