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A study of a hybrid type stand-alone 3 kW photovoltaic system of Karakalpak state university

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Abstract. This article examines the analysis of a 3 kW solar photovoltaic plant installed at the Karakalpak State University. It studied the location of the station and the analysis of sunny days on it. The efficiency of the generating capacity of this photovoltaic plant was also determined during the day, month and all year in comparison with its location.

1 Introduction

It is well known that Uzbekistan is geographically located in favorable climatic conditions for the development of solar energy. The summer climate is cloudless with a sufficiently large number of sunny days, such as more than 300 days, which leads to the use of all types of solar installations [1-6, 11]. On the other hand, despite abundant natural energy sources such as gas, oil, and coal, electrical energy is insufficient in Uzbekistan. It is also known to cause massive power loss due to the aging of power plants and transmission and distribution power facilities. For these reasons, the government has recently decided to increase the renewable energy ratio to 25% by 2030 and build three 100 MW solar power plants by 2021 [7-10, 12].

Currently, photovoltaic power plants' cost is drastically reduced due to technological developments such as modules and inverters. However, to maintain performance for many years as 20 years suitably, various technologies such as technical verification of modules and inverters, optimal design of power plants using such as PVsyst, Solarius PV, and EasyPower, and installation technologies are required [13-20, 8, 7].

For this study, the authors reviewed the installed 3 kW photovoltaic system and analyzed the server's data. In addition, using the Solarius - PV software, the authors simulated the 3 kW system and compared recorded generated electric energy yields with simulation results.

2 Review the 3 kW photovoltaic system

The 3 kW hybrid-type photovoltaic system was installed in January 2020 and currently in operation at Karakalpak state University in Nukus city (42° 45' 32" N, 59 ° 62' 68" E) such as photo 1. The module is a ground-mounted type with a 35° tilt but a 20° azimuth south-west for harmony with the university's main building.

Fig.1. 3 kW photovoltaic system

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The system consists of a hybrid type inverter, polysilicon type modules, and batteries, as shown in Table 1, such as the following. The modules consist of three strings with three parallels, a total of nine modules, and four batteries were series-connected [21-26, 9, 14].

Table 1. Technical specifications of the 3 kW system components

Hybrid Inverter	Module	Battery
Manufacturer: WE Energy Model: WI-3000(48VDC) Hybrid Max. PV Array DC Input: 145V	Manufacturer: Trina Solar Co., Ltd Model: TSM-350PE-15H	Manufacturer: Guangzhou Jalon PowerCo., Ltd Model: NP200-12
AC Input/Output: 1 Phase 220V	Rating: 350W	Rating: 12V 200AH
Capacity: 3 kW	Vmp: 37,9V	
	Imp: 9,23A	

Figure 2 is the main screen of the monitoring system, which is operated through the Internet. The data server is located in Korea and periodically stores data related to the inverter, modules, and batteries. Operators can analyze present and past periods using the monitoring program's functions or save data sets in Excel format to use various software to interpret them.

Fig.2. Main monitoring interface screen

Figure 3 shows two representative daily power patterns. Left is a sunny day without clouds, but the right is a clean day with passing clouds fast.

Fig. 3. Samples of daily electric power patterns

The authors use the Solarius - PV simulation software of the ACCA Company to simulate the 3 kW photovoltaic system [4]. Figure 4 shows the database of used inverter and module and modules' tile and azimuth.

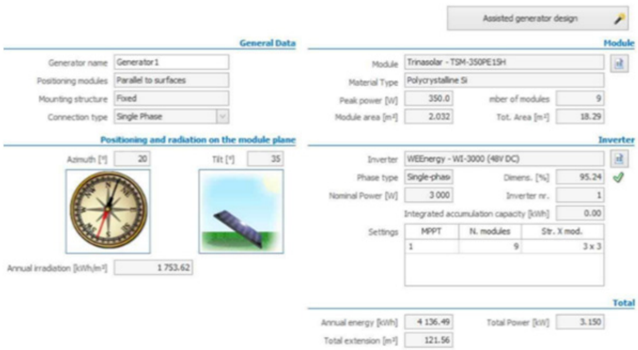

Fig.4. An interface screen of the Solarius - PV design and simulation software Simulation and Analysis

As a result, the software configured three strings and three parallel circuits automatically. Also, it showed some simulation results, such as annual solar radiation 1753.62 kWh/m2 for the modules for given tilt and azimuth, and yearly 4136.49 kWh generated electric energy.

The software shows more detailed monthly energy generation, such as the following graph 1. It indicated that July produces the most 450.12 kWh, and December generated the least 186.93 kWh.

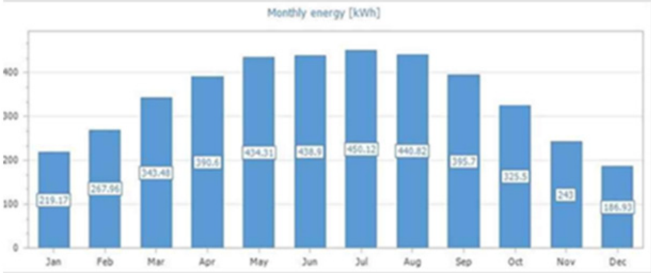

Fig.5. Simulation results for monthly generated electric energy

Figure 6 below compares the Solarius - PV simulation based on real input data and recorded server computer data from February to October 2020. From February to June, simulated and generated energy results are similar, but the difference was slightly larger in other months. According to the recorded data, the generated energy is zero for two days in February and March, thirteen days in August, and four days in September. The authors have a plan to analyze some reasons in detail.

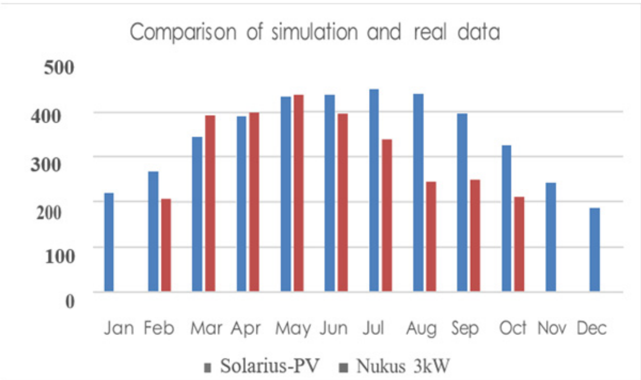

Fig.6. Simulated and real generated electric energy

3 Conclusion

The results of the installation and operation of the 3 kW on-grid hybrid type photovoltaic system (storage system: GEL type 12V 200AH 4ea) installed in Nukus city, Karapalpakstan Republic of Uzbekistan, are as follows.

1. After nine months of operation of the 3kW photovoltaic system, it was confirmed that it

Operates well in the climate and power system environment.

2. Through the real-time remote monitoring system, the authors confirmed that the operating conditions (power generation, the status of each part, environmental temperature, etc.) of the system installed at a distance could be usefully utilized anywhere the Internet is connected.

3. As a result of comparing the power generation record and the simulation result of Solarrius- PV software, four months were similar. But the remaining five months showed a little deviation. The authors will analyze the different reasons in a future thesis.

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References

1. Abdullaev D.A. Operational processing of measurement information in automated control systems. - Tashkent, Sub, 1985, 128 p.
2. Venikov V.A., Venikov G.V. The theory of similarity and modeling (in relation to the problems of the electric power industry). - M.: Higher school, 1984, 439 pp.
3. Nikiforov G.V., Oleinikov V.K., Zaslavets B.I. Energy saving and energy management in metallurgical production. M: Energoatomizdat, 2003.- 480 p.
4. Novikov SS Methods of operational planning and control of power consumption of large-capacity electric steel-smelting furnaces when operating on the wholesale electricity market: Avtorefer. dis. ... Cand. those. sciences. - M., 2008.- 18 p.
5. Resolution of the Cabinet of Ministers of the Republic of Uzbekistan dated January 12, 2018 N 22 "On additional measures to improve the procedure for the use of electrical energy and natural gas."
6. Decree of the President of the Republic of Uzbekistan no. PP-4477 of April 10, 2019 “On approval of the strategy for the transition of the Republic of Uzbekistan to the green economy for the period 2019—2030”. http://www.1ex.uz/docs/4539506.
7. https://www.accasoftware.com/en/solar-design-software/ photovoltaic software (Solarius-PV) site Accessed a Rakhmonov I.U., Najimova A.M., and Reymov K.M. AIP Conference Proceedings **2647.** 030010. (2022). https://doi.org/10.1063/5.0104788
8. Rakhmonov I.U., Najimova A.M. AIP Conference Proceedings **2647.** 030011. (2022). https://doi.org/10.1063/5.0104791
9. Rakhmonov I.U., Najimova, A.M., Esemuratova Sh.M., Koptileuov T.T. AIP Conference Proceedings **2647.** 070024. (2022). https://doi.org/10.1063/5.0104793
10. Hoshimov F.A., Rakhmonov I.U., Niyozov N.N., Omonov F.B. AIP Conference Proceedings **2647.** 030025. (2023). https://doi.org/10.1063/5.0112388
11. Rakhmonov I.U., Hoshimov F.A., Kurbonov N.N., Jalilova D.A. AIP Conference Proceedings **2647.** 050022. (2023). https://doi.org/10.1063/5.0112391
12. Rakhmonov I.U., Ushakov V.Ya., Niyozov N.N., Kurbonov N.N., Mamutov M. E3S Web of Conferences **289.** 07014. (2021). https://doi.org/10.1051/e3sconf/202128907014

13. Rakhmonov I.U., Ushakov V.Ya., Najimova A.M., Jalilova D.A., Omonov F.B. E3S Web of Conferences **289.** 07013. (2021). https://doi.org/10.1051/e3sconf/202128907013s of Oct. 2019

14. Rakhmonov, I.U., Reymov, K.M. E3S Web of Conferences **216**. 01167. (2020). DOI: 10.1051/e3sconf/202021601167

15. Rakhmonov, I.U., Hoshimov, F. E3S Web of Conferences **209**. 07018. (2020). DOI: 10.1051/e3sconf/202020907018

16. Rakhmonov, I., Berdishev, A., Niyozov, N., Muratov, A., Khaliknazarov, U. IOP Conference Series: Materials Science and Engineering, 2020. 883(1). 012103. DOI: 10.1088/1757-899X/883/1/012103

17. Rakhmonov, I.U., Niyozov, N.N. E3S Web of Conferences, 2019. **139.** 01077. DOI: 10.1051/e3sconf/201913901077

18. Rakhmonov, I.U., Reymov, K.M. Journal of Physics: Conference Series, 2019. 1399(5). 055038. DOI: 10.1088/1742-6596/1399/5/055038

19. A.D.Taslimov, A.S.Berdishev, F.M.Rakhimov, Melikuziev M.V. E3S Web Conf. **Vol. 139**. 2019. https://doi.org/10.1051/e3sconf/201913901081.

20. A.D.Taslimov, A.S.Berdishev, F.M.Rakhimov, Melikuziev M.V. E3S Web Conf. **Vol.139**. 2019. https://doi.org/10.1051/e3sconf/201913901082

21. Taslimov A.D., Melikuziev M.V., Najimova A.M., Alimov A.A. E3S Web of Conferences **216**. 01159 (2020). https://doi.org/10.1051/e3sconf/202021601159

22. Saidkhodjaev A.G., Nuriddinova Kh.R. AIP Conference Proceedings **2552.** 050037. (2023). https://doi.org/10.1063/5.0133486

23. Saidkhodjaev A.G. AIP Conference Proceedings **2552**. 050026. (2023). https://doi.org/10.1063/5.0111540

24. Usmonov E.G. AIP Conference Proceedings **2552.** 050020. (2023). https://doi.org/10.1063/5.0111537

25. Rakhmonov,I., Berdishev,A., Khusanov, B.M, Khaliknazarov, U., Utegenov, U. IOP Conference Series: Materials Science and Engineering **883(1)**. 012104. (2020). DOI 10.1088/1757-899X/883/1/012104

26. I.U. Rakhmonov, T.H. Khakimov, I.I. Bakhadirov, B.M. Khusanov. International Journal of Advanced Science and Technology **Vol. 29**. (2020). pp. 1525-1533.