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Sizing and Analysis of an Off-Grid Photovoltaic Power Supply for Drip Irrigation System

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GOAL OF THE STUDY

This study aims to demonstrate a methodology and provide practical guidelines for preliminary sizing and optimization of PV-hybrid system with battery storage that should provide stand-alone operation of irrigation systems.

PRELIMINARY ANALYZIS AND SIZING OF THE INSTALLATION

The object of the investigation is a drip irrigation system of an apple orchard with an area of 20 decares and a total of 960 trees. The irrigation system is divided into several sections, selectively controlled by electromagnetic valves. The main electrical energy consumer of the system is the hydraulic pump, responsible for pumping water from a nearby river or well.

To power the irrigation system, enough PV modules should be used. For performing preliminary estimation of the efficiency of a PV system, the "European Efficiency" factor is taken as a basis. It represents the average operating efficiency of the inverters as a function of their annual power distribution, corresponding to the climate in Central Europe. The value of this weighted efficiency is obtained by determining the percentage of time the inverter remains in a given operating range. Based on the specific calculations the photovoltaic panels should have twice the peak power of the total consumption of the system, if the required power of the electric load of the drip irrigation system should be guaranteed at all time.

LiFePO4 batteries have been chosen for the system as they have the longest life with relatively long pauses between charge/discharge cycles and in a charge-following mode. Furthermore, LiFePO4 batteries have a wider operating temperature range from -20°C to +60°C and are safer than lithium-ion batteries due to the strong covalent bonds between the iron, phosphorus and oxygen atoms in the cathode.

SIMULATION RESULTS

To investigate the performance of the proposed system and to obtain its optimal configuration, simulations have been performed in the PVSyst ver. 8 software. Initially, a simulation is implemented with 2 PV modules in series. The results show that during the summer months the unused energy is practically zero, which indicates that all available energy was delivered to the consumer. This indicates that two PV panels are not enough to power the irrigation pump, therefore additional simulations were performed with 3 PV panels connected in series. It can be seen that during the summer months there's approximately 10% of unused power, which indicates that in theory the system will be able to ensure the necessary power to the water pump during most of the irrigation season. The normalized parameters of the PV system with 2 and 3 PV panels are shown in Fig. 1 and Fig. 2.

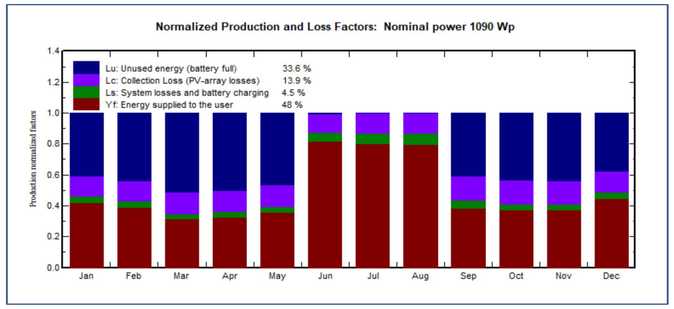

Fig. 1. Normalized parameters of the photovoltaic system with 2x540Wp

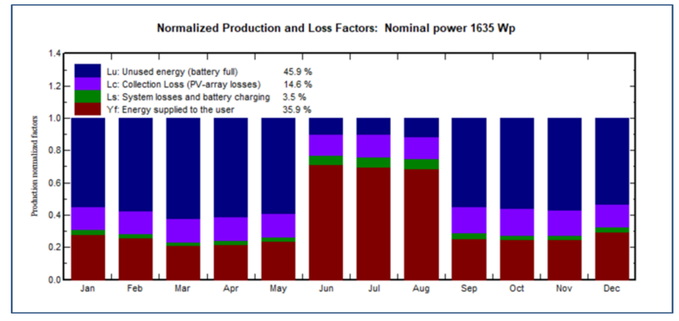

Fig. 2. Normalized parameters of the photovoltaic system with 3x540Wp

CONCLUSIONS

Two sizing methods were applied in this study – using the "European Efficiency" factor and through simulation with PVSyst software. The obtained results showed that the available peak PV power should be oversized with at least 80% compared to the power required to power the installation.

ACKNOWLEDGMENT

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