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pvpumpingsystem: A Python package for modeling and sizing photovoltaic water pumping systems

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Summary

According to the World Health Organization, one tenth of the world population still lacks access to basic water supply. One of the reasons for this is the remoteness of these populations from modern water collection and distribution technologies, often coupled with an unfavorable socio-economic situation. Photovoltaic (PV) pumping technology makes it possible to respond both to this problem and to the criteria of sustainable development. However, these pumping systems must be carefully modeled and sized in order to make the water supply cost efficient and reliable.

Pvpumpingsystem was conceived in order to tackle this issue. It is an open source package providing various tools aimed at facilitating the modeling and the sizing of photovoltaic powered water pumping systems. Even though the package is originally targeted at researchers and engineers, three practical examples are provided in order to help anyone to use pvpumpingsystem.

Python is the programming language used in the software, and the code is structured with an object-oriented approach. Continuous integration services allow for lint checking and to test automation. Each class and function are documented with reference to the literature when applicable. Pvpumpingsystem is released under a GPL-v3 license.

Pvpumpingsystem relies on already existing packages for photovoltaic and fluid mechanics modeling, namely "pvlib-python" (Holmgren, Hansen, & Mikofski, 2018) and "fluids" (Bell, 2020). pvpumpingsystem's originality lies in the implementation of various motor-pump models for finite power sources and in the coupling of the distinct component models. In order to increase the understandability of the code, each physical component of the PV pumping system corresponds to a class, like for example the classes `Pump()`, `MPPT()`, `PipeNetwork()`, `Reservoir()`, and `PVGeneration()`. The previous objects are then gathered in the class `PVPumpSystem()` which allows running a comprehensive model of the pumping system.

The main inputs to the simulation are an hourly weather file, water source characteristics, expected water consumption profile, and specifications of the photovoltaic array, motor-pump and water reservoir. Typical outputs are hourly flow rates, unused electric power, efficiency of components, life cycle cost and loss of load probability. The sizing module then builds on the modeling tools, and uses them to provides functions to help choose the best combination of components in order to minimize the total life cycle cost. Nevertheless, sizing such complex systems is still an active field of research, and this module is subsequently expected to be expanded with time.

Two software packages with similar scope already exist: PVsyst and online tool SISIFO, developed by the MASLOWATEN consortium. Nevertheless, both are closed source, with restricted information on models used internally, and no API is made accessible. Pvpumpingsystem also

has the advantage of providing ways to size PV pumping systems thanks to automation of pump and PV array choices.

Pvpumpingsystem is the second academic contribution of a broader research program on photovoltaic water pumping launched in the Technologies of Energy and Energy Efficiency research group at Ecole de Technologie Supérieure Montreal, and is expected to grow with new features and accuracy assessment provided by experimental studies. The authors also want to give full access and help to anyone else interested in the use of the software.

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Reference

Bell, C. (2020). fluids: Fluid dynamics component of Chemical Engineering Design Library (ChEDL). *GitHub repository*. GitHub. Retrieved from https://github.com/CalebBell/fluids

Holmgren, W. F., Hansen, C. W., & Mikofski, M. A. (2018). Pvlib python: A python package for modeling solar energy systems. *Journal of Open Source Software*, *3*, 884. doi:10.21105/joss.00884