SophiA

Implementation, analysis and simulations of off-grid systems and storage technologies in Africa

Graduate

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Introduction: In many African countries, healthcare facilities face challenges due to unreliable energy supply, frequent power outages, and high energy costs. This affects essential medical infrastructure, including refrigeration for medications, sterilization of medical tools, and access to clean water. The SophiA project, supported by the EU, aims to provide a sustainable solution by developing a decentralized, containerized energy system tailored for healthcare facilities. Using renewable energy, it ensures a reliable supply of electricity for refrigeration, steam generation, and water purification. The modular design allows for rapid deployment and adaptation to different site conditions, making it a flexible and scalable solution for regions with limited energy access. This master's thesis supports the SophiA project by contributing to the implementation, monitoring, and optimization of its solar energy systems. The work encompasses three key areas: remote support for first-generation containers in Burkina Faso, pre-commissioning of second-generation containers in South Africa for deployment in Malawi and Uganda, and participation in a Capacity Building event in Cameroon for knowledge transfer.

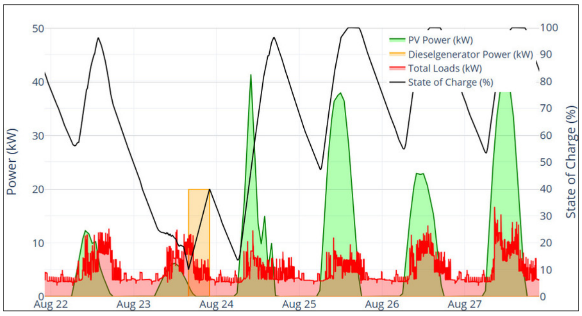
Approach: In a first step, the reliability of the overall system, as well as the communication with various subsystems, was analyzed in detail and subsequently improved. To further optimize the existing system, all data from the SophiA system are evaluated and analyzed. Based on the insights gained, a semi-empirical model is developed. This includes various analysis tools as well as the ability to import different generation and load profiles to simulate various scenarios. Additionally, the State of Charge (SoC) is modeled, and the behavior of the diesel generator is simulated. This model serves to verify the system's performance and provides recommendations on how it can be further improved. Additionally, the performance of the battery is thoroughly analyzed using advanced simulation tools like Open Sesame, and measures to extend their lifespan are defined.

Conclusion: The simulations confirmed that the energy system is well-dimensioned and operates reliably. One key objective was to reduce the runtime of the diesel generator, which was successfully achieved by lowering the generator's switch-off limit to 30% State of Charge (SoC) of the battery. This adjustment significantly limited diesel usage under normal conditions. Battery simulations revealed that calendar aging is the primary factor affecting battery health, while cyclic aging plays a minor role. To further extend battery lifespan, it is recommended to regulate the temperature inside the container, as this could slow down calendar aging. Despite the system's overall reliability, the first-generation containers in Burkina Faso still exhibit challenges and optimization potential, particularly within some subsystems. These issues need to be addressed before the project concludes. The adjustments to the communication protocols of the SteamCube and battery system have already improved overall system reliability. The pre-commissioning of second-generation containers for Malawi and Uganda was successfully completed in South Africa. Moving forward, continued data analysis will be essential to refine the semi-empirical model and further optimize system performance. Additionally, the final commissioning in Uganda and Malawi must be successfully executed.

SophiA - Project
https://sophia4africa.eu/summary-of-the-project/

SOPHIA
Sustainable Off-grid solutions for Pharmacies and Hospitals In Africa

System simulations with modeled SoC and behavior of the diesel generator
Own presentment



Implemented solar system for 2nd Generation Container while pre-commissioning in Cape Town
Own presentment

Advisor
Evelyn Bamberger

Co-Examiner
Dr. Daniel Zenhäusern, Anex Ingenieure AG, Zürich

Subject Area
Energy and Environment