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EnerSHelF

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Policy Brief

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Enhancing Energy Supply for Healthcare Facilities in Ghana Requires Interdisciplinary Perspectives

Many remote health facilities in Ghana experience insufficient access to energy, posing a severe challenge for adequate healthcare service. The EnerSHelF project aims to enhance the reliability and sustainability of energy supply through photovoltaic-solar hybrid systems while applying an interdisciplinary research approach. Based on the findings of the technical disciplines involved in the project, this policy brief provides recommendations for system design, meteorological considerations, and planning of photovoltaic-solar hybrid systems.

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Access to electricity continues to be a challenge for healthcare facilities in Sub-Saharan Africa (SSA) and in rural areas specifically. Comprehensive data on the scope of the issue is scarce. A survey[1] in 2013 across 13 SSA countries revealed that only 34% of health facilities had reliable access to electricity. For Ghana, a recent study[2] published in 2020 indicates that while urban areas are regularly connected to the grid, rural communities often lack access to reliable electricity – showing numbers as high as 46% for rural health facilities. Furthermore, blackouts in Ghana, so called "dumsor", lead to interruptions of energy supply with severe challenges for the provision of adequate healthcare services. This includes disrupted cooling cycles for medication and vaccines, halted sterilization of medical instruments, no light during the night, and reduced possibilities to use communication technology devices. Photovoltaic-solar systems are increasingly applied as off-grid or mini-grid solutions to bring electricity to rural health facilities in Ghana. This calls for a holistic analysis of chances, barriers, and challenges from an interdisciplinary perspective.

In 2019, the EnerSHelF project started to work on the analysis with combined effort of partners from academia and industry. This policy brief provides recommendations based on the findings of the technical disciplines to stakeholders and decision-makers in the energy-health-nexus.

EnerSHelF Quick Facts

Project: EnerSHelF – Energy Supply for Healthcare Facilities in Ghana

Location: Ghana

Type of funding: Public, CLIENT II

Sponsor: German Federal Ministry of Education and Research (BMBF)

Funding period: 01.06.2019 – 31.03.2023

Project partners: International Center of Sustainable Development (IZNE) at the University of Applied Sciences Bonn-Rhein-Sieg, Cologne Institute for Renewable Energy (CIRE) at the University of Applied Sciences of Cologne, Institute of Geography (IGUA) at the University of Augsburg, Reiner Lemoine Institute (RLI), West African Science Service Center on Climate Change and Adapted Land Use (WASCAL), The Brew-Hammond Energy Centre (TBHEC) at the Kwame Nkrumah University of Science and Technology (KNUST), WestfalenWIND Beyond, European Association of Development Research and Training Institutes (EADI)

Mini-Grid and Off-Grid Quick Facts

- A mini-grid system comprises a set of electricity generators as well as possibly storage systems, which are used to deliver electricity to a defined group of customers.
- A mini-grid can be off-grid without connection to existing electricity infrastructure or interconnected as an on-grid system.
- A mini-grid can use renewable energy such as photovoltaic solar energy as well as fossil-fuel based generation sources.

[1] https://www.ghspjournal.org/content/ghsp/1/2/249.full.pdf
[2] https://academic.oup.com/heapol/article/35/Supplement_2/ii124/5959266

Identification of Health Facilities in Off- or Weak Grid Areas

By analysing geospatial data based on night light[3] and grid line[4] data, we were able to reveal that in rural and semi-urban areas of Ghana, many health facilities lack reliable access to electricity even though they got a grid connection. This tendency is stronger in the North of Ghana and mostly applies to the smaller types of healthcare facilities (e.g. CHPS, maternity homes and health centres). Therefore, many health facilities do not have sufficient electricity supply to provide the medical services they should provide according to the Health Facilities Regulatory Agency Ghana (HEFRA)[5]. People living in catchment areas of those not sufficiently electrified health facilities are required to travel larger distances to sufficiently electrified health facilities to access quality health care that requires reliable electricity access.

Estimating Energy Demand of Health Facilities and Surrounding Communities

Based on requirements outlined by HEFRA, we estimated the electricity demand[6] of four different health care facility types (CHPS, Maternity Homes/Reproductive and Child Health, Health Centers and Clinics). The electricity demand of communities surrounding the not sufficiently electrified health facilities are acquired based on previous studies conducted in different regions of Ghana. We found out that health facilities have no standardised load profile, with electricity demand heavily depending on the facility type and the provided services. Furthermore, the usage of some appliances (e.g. x-ray) lead to high demand peaks which are only visible in fine resolutions of load profiles (e.g. minutely). We also identified varying electricity demand of households in different regions of Ghana with strong variations between rural and urban areas. In most analysed cases, peak loads of health facilities are lower than the ones of the surrounding households, which helps to balance the base and peak loads and may lead to more reliable, and economic electricity provision. In cases where the peak loads of health facilities are exceeding the base load of the surrounding communities, it is helpful to increase the radius of the considered households around the health facility (in our analysis 1 km was taken as threshold).

Messages for policy and stakeholders

- Solar mini-grid systems could play a significant role to ensure high quality health services and meet healthcare service requirements as outlined by the Ghanaian government.
- The expected electricity demand of health facilities needs to be assessed carefully based on context-specific characteristics to design solar mini-systems based on their base and peak loads.
- It is important to consider and apply electricity demands for households that are specific for the area or region that is analysed.
- To balance the energy flow and stabilise the energy system, it is promising to combine the electricity loads of health facilities and surrounding communities when designing solar mini-grid systems.
- A transfer of findings between different types of health facilities is not recommended.
- For the analysis of load patterns, a high temporal frequency is recommended.

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[3] Provided by Visible Infrared Imaging Radiometer Suite (VIIRS)
[4] Provided by Global Predictive Mapping Project
[5] http://hefra.gov.gh/index.php/requirements/
[6] Based on the RAMP electricity demand modelling tool

Planning of PV-solar Hybrid Systems

When PV Systems are planned and later installed, they must be included in the existing overall electricity network in place. Besides the estimation of the energy demand of Ghanaian health facilities, load measurements at a specific site were conducted. Over the course of the project, we collected load data at the St. Dominic Hospital in Akwatia. The data was used to develop an improved load model for the Ghanaian health sector, containing a list of electric equipment on department level and its load pattern.

Based on the collected information, we developed the Micro Grid User Energy Planning Tool Library (MiGUEL) modelling tool. MiGUEL can be used to model and simulate the hospital's energy system considering information on load pattern, energy generation and energy storage. MiGUEL specifies different operating strategies, which are supplemented by own operating strategies to obtain a broad operating spectrum. In addition to the simulation over a given period, the Levelized Cost of Energy [€/kWh] of the energy system is provided as an output variable. With this tool EnerSHelF provides an improved planning software for PV systems to be implemented in the Ghanaian Health sector.

Additionally, by utilizing forecast of load demand and solar radiation, our analysis shows that fuel consumption of PV-Diesel-Hybrid systems can be reduced. When adapting a battery to the system, the forecast can lead to an even higher reliability of the system and lower the dependency on the diesel generators. Blackouts can be handled by the battery, rather than the diesel generator. This also results to lowered emissions and an increased wellbeing of the population.

Messages for policy and stakeholders

- Using an advanced planning tool can improve the implementation of micro- or off-grid solar systems.
- Adapting battery storage to PV-Diesel-Hybrid systems can lower the fuel consumption and strengthen the reliability of the system towards blackouts.
- It is recommended to adapt batteries to PV-Diesel-Hybrid systems to lower emissions.

Providing Electricity through Off-grid System

Jointly with our partners from Ghana and Germany we were able to install a 5 kWp solar power system that supports the energy supply of the Kologo Health Centre (KHC) in the Kassena Nankana Municipality, Navrongo, Upper East Region, Ghana. The site selection and installation of the system has strengthened the collaborative efforts between KHC, the Municipal Health Directorate and Regional Health Director of Ghana Health Service as well as the Chief and leaders of the Community and the project implementing partners. The installed facility has been accepted widely by stakeholders across the management and use of the facility. Currently, the installed facility serves as a source of electricity for the cold chain and fridges at the KHC for storage of essential vaccines and medications. Initially, power/electricity outages affected storage systems of the KHC as well as health delivery activities in the night, but this has been greatly improved with the 5 kWp solar system. The cost associated with payment for the national grid electricity was also observed to reduce over the period.

By installing the system on site, a lot of helpful experience was gained for future projects. For example, the power requirements of the healthcare facility had been estimated based on images of the on-site equipment. No load measurements have been available during the planning phase. It turns out that the installed battery capacity had been undersized, especially for conditions during the rainy season and during the Harmattan. Accordingly, capacity had to be upgraded during the project. It was also observed that power demand increased during the project due to additional loads. It is therefore recommended that scaling of capacities should generally be considered. In addition, uncertainties concerning the grid integration occurred during the project. The initial single-phase grid required an adjustment of the inverter, and the three-phase grid expansion during the project required additional readjustment of the inverter technology used. The adjustments were only possible due to close cooperation with the partners on site. Further challenges that emerged consisted of an unstable grid, difficult weather conditions and interruptions in the mobile network, together with unforeseen conditions on site. However, these challenges have led to close cooperation between the various partners in Ghana and Germany. By demonstrating the necessary spontaneity and pragmatism, in combination with intense communication, trust has been built up. This allows a fruitful cooperation beyond borders It is therefore essential for the success that appropriate personnel are involved on site.

Messages for policy and stakeholders

- Appropriate site-specific data regarding load, solar resources and grid are crucial for system planning.
- The potential need of an up-scaling of generation and storage capacities after installation should be considered right from the beginning.
- Close cooperation and trust between the various partners as well as well-trained personnel in place is crucial for successful project implementation.

Solar resources in Ghana

Knowing the climatology or forecast of solar irradiance is paramount in optimizing solar energy at any site. Data measured on-site is the best source of data for solar energy assessment and prediction. With this in mind, the researchers have installed three Automatic Weather Stations at three Health Facilities in Ghana (Kologo, Kumasi and Akwatia) to record various meteorological parameters such as solar radiation, air temperature, relative humidity and so on. These recorded data are useful to validate both climatological data on solar resources based on satellites or reanalysis and forecasts based on numerical weather predictions.

Numerical weather predictions (NWPs) can be used for solar power forecasts needed for PV-system operation and PV-system optimization. Within the EnerSHelF project, we used the latest version of the most advanced NWP, the WRF (Weather Research and Forecasting) Solar model with a resolution of 3 km. Though, before a local forecast for the three EnerSHelF measurement sites at Kologo, Akwatia and Kumasi can be provided, the NWP must be calibrated. This means, that sensitivity studies have been conducted comparing five different radiation physics schemes over Ghana compared to ground- based measurements. In the end, the WRF version called RRMTG coupled with aerosol inputs performs better over the country. The EnerSHelF researchers forecast irradiance for 3-day ahead every day and upload the forecast data to the WASCAL Data Infrastructure where project partners can retrieve the data. Regular forecasts are provided for all three health facilities.

Solar energy assessments including PV system planning require information on the solar resources available at the location investigated. In the absence of available in-situ data, mainly satellite-based solar irradiance data or reanalyses were used. For the first time in the region, researchers from the EnerSHelF team have investigated a quality assessment of hourly solar irradiance data from two satellite-based (SARAH -2 and CAMS) and two reanalyses (ERA5 and MERRA-2) with 51 automatic weather stations in Ghana and Burkina Faso.

Messages for policy and stakeholders

- The shortwave radiation scheme RRMTG coupled with aerosol inputs is recommended for forecasting solar irradiance in Ghana.
- The WRF model performs better in forecasting GHI under clear skies than under cloudy skies for the 3 days ahead.
- SARAH -2 could be used as an alternative data source in the absence of in situ data for solar energy assessment in Ghana and Burkina Faso.

Further readings

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Energy Supply for Healthcare Facilities in Ghana

EnerSHelF is an interdisciplinary German-Ghanaian project of political economists, engineers, and partners from the private renewable energies sector. The project deals with the sustainable and reliable energy supply for healthcare facilities in Ghana.

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