Sierra Leone Healthcare Electrification Project: Impact Assessment of Project Phase 1

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Acronyms

AC	Air Conditioning	**kWp**	Kilowatt peak
BESS	Battery Energy Storage System	**MoE**	Ministry of Energy
CAPEX	Capital Expenditure	**MoH**	Ministry of Health
CO_2	Carbon Dioxide	**MW**	Megawatt
CS	Caesarean Section	**MWp**	Megawatt peak
DAC	Development Assistance Committee	**O&M**	Operations and Maintenance
DiD	Difference-in-difference	**ODCH**	Ola During Children's Hospital
DoD	[Battery] Depth of discharge	**OECD**	Organisation for Economic Co-operation and Development
EPC	Engineering, Procurement, and Construction	**OPEX**	Operational Expenditure
GHI	Global Horizontal Irradiance	**PCMH**	Princess Christian Maternity Hospital
GoSL	Government of Sierra Leone	**PV**	Photovoltaic
GPB	British Pound Sterling	**RE**	Renewable Energy
GST	Goods and Service Tax	**RMS**	Remote Monitoring System
GY	Gender and Youth	**SCBU**	Special Care Baby Unit
IA	Impact Assessment	**SL-HEP**	Sierra Leone Healthcare Electrification Project
IE	Independent Evaluation	**SLA**	Service Level Agreement
IV	Intravenous	**SoC**	[Battery] State of charge
kVA	Kilo-volt-amperes	**TBA**	Traditional Birth Attendants
kW	Kilowatt	**UK**	United Kingdom
kWh	Kilowatt hour		

1. Executive Summary

Phase 1 of the Sierra Leone Healthcare Electrification Project (SL-HEP) aimed to address critical energy access challenges in six major hospitals by installing 627 kWp of solar PV capacity and 1,561 kWh of battery storage. The intervention was implemented by SEforALL and funded by the UK Foreign, Commonwealth & Development Office (FCDO), serving a population of over 8.5 million people, including 4.2 million women and children under five. This impact assessment evaluates the results of Phase 1 against OECD-DAC criteria and FCDO's Value for Money (VfM) framework using quantitative data from remote monitoring systems and hospital records, as well as qualitative stakeholder interviews.

Prior to SEforALL's intervention, four out of the six hospitals (Kambia, Kabala, Masanga, and Bonthe) predominantly relied on diesel gensets to power the services offered at the hospitals. This group of hospitals is not connected to the national electricity grid, and only Kabala, Masanga, and Kambia had existing solar PV systems. Nonetheless, the solar PV systems were installed to serve a specific purpose, such as powering a water pump or isolated units like laboratories or the Special Care Baby Unit (SCBU) and did not significantly improve the overall electricity access at the hospitals. Only the co-located Ola During Children's Hospital (ODCH) and Princess Christian Maternity Hospital (PCMH) are connected to the grid, yet they still relied heavily on diesel gensets due to the unreliability of the national grid.

Key Findings:

- **Relevance:** SL-HEP Phase 1 directly aligns with Sierra Leone's National Health Sector Strategic Plan (NHSSP) 2021–2025 and Energy Transition and Green Growth Plan 2024 - 2050. It supports national and global goals, including SDGs 3 (Health), 7 (Energy), and 13 (Climate), by improving access to clean, reliable energy in public health facilities. The intervention addressed long-standing energy deficiencies that previously undermined critical healthcare services, particularly maternal and neonatal care. Reliable electricity has increased hospital utilisation and enhanced patient trust.

- **Effectiveness:** SL-HEP has significantly improved the reliability and quality of hospital electricity, ensuring continuous operation of essential medical equipment such as oxygen concentrators and neonatal incubators, which previously suffered frequent outages. Several healthcare facilities have reported substantial increases in electricity uptime and notable reductions in disruptions during critical and emergency medical procedures, attributed directly to the newly installed solar systems. However, systematic data collection gaps limit the precise quantification of health impacts.

- **Efficiency:** The introduction of solar energy systems has effectively reduced hospital dependency on diesel generators, with some facilities achieving reductions of up to 68% in diesel consumption. However, inconsistent energy management practices, such as unauthorised electricity use and inadequate staff training, have partially offset cost savings, highlighting the need for stronger operational oversight and consistent training to realise full efficiency gains.

- **Impact:** Environmentally, the project has achieved a 38% reduction in CO_2 emissions through reduced diesel usage, significantly enhancing hospital sustainability and reducing air and noise pollution. Socially, the project has positively impacted healthcare delivery, improved staff working conditions, and increased community perceptions of hospital safety. Economic impacts included temporary employment during construction and valuable capacity-building through initiatives like the Women in STEM traineeship, although long-term job creation remained limited.

- **Sustainability:** While solar systems are currently operational and effective, their long-term sustainability faces challenges due to unclear ownership of maintenance responsibilities and the absence of a structured financial model for ongoing operations and maintenance (O&M). Ongoing dialogue with the Ministry of Health and Energy is essential to clearly delineate maintenance responsibilities, secure sustainable financing, and integrate systems into broader healthcare infrastructure and energy transition strategies.

- **Value for Money (VfM):** The project has demonstrated effectiveness and efficiency in reducing operational costs and enhancing healthcare services. However, incomplete financial data prevents a full cost-benefit analysis, and long-term financial sustainability remains a challenge.

Overall, Phase 1 of SL-HEP has significantly advanced healthcare service delivery in Sierra Leone, demonstrating clear environmental and socio-economic benefits. To sustain and amplify these achievements, future project phases must emphasise structured sustainability planning, robust operational management, and integrated workforce development, ensuring continued alignment with national priorities and long-term resilience of healthcare infrastructure.

2. Introduction

2.1. Project Background

Sierra Leone faces significant challenges in electricity access and reliability. It is among the countries with the lowest electricity access rates in the world, with service reaching only 5% of rural areas and 55% of urban areas as of 2022. The sector is afflicted by high technical and collection losses, poorly maintained infrastructure, and unreliable supply. As a result, there is an overreliance on diesel-powered gensets. These conditions not only affect citizens' day-to-day activities but also negatively affect the quality of basic social services, including healthcare and education.

The Sierra Leone Healthcare Electrification Project (SL-HEP) is a large-scale healthcare electrification initiative implemented by Sustainable Energy for All (SEforALL) and funded by the UK Government, with a total funding allocation of GBP 4.95 million for Phase 1 and GBP 19.95 million overall. The project was developed as a direct response to energy audits conducted under the Powering Healthcare Market Assessment and Roadmap, which was supported/funded by the Global Energy Alliance for People and Planet (GEAPP). These audits identified 20 healthcare facilities across Sierra Leone as a sample to validate existing data on energy demand. Sierra Leone's Ministry of Health (MoH) later identified an additional seven priority hospitals with critical energy access challenges. This project highlights the urgent need for sustainable, reliable, and clean power solutions to improve healthcare service delivery and aims to address the challenges of the 27 healthcare facilities over three phases.

This Impact Assessment (IA) focuses on Phase 1 of the project since one full year of post-commissioning data is available for analysis. Simultaneously, a Developmental Evaluation (DE) is being conducted to incorporate learnings from Phases 2 and 3, where solar PV systems have been recently installed or are still in the planning stage. Phase 1 aimed to electrify six major hospitals across Sierra Leone through the installation of solar photovoltaic (PV) systems, ensuring improved energy reliability, reducing dependence on diesel gensets, and ultimately enhancing healthcare service provision. The selected hospitals serve a catchment population of over 8.5 million people, including 4.2 million women and children under five years old, who are among the most vulnerable groups reliant on hospital-based maternal and child healthcare services. The six hospitals targeted in Phase 1 include:

1. Bonthe Government Hospital
2. Kabala Hospital
3. Kambia Government Hospital
4. Masanga Hospital

5. Ola During Children's Hospital (ODCH)[1]
6. Princess Christian Maternity Hospital (PCMH)[1]

Figure 1. Sierra Leone Healthcare Electrification Project Phase 1 Hospitals Map

The Sierra Leone Healthcare Electrification Project was structured to address critical energy gaps in healthcare facilities, focusing on hospitals with insufficient or unreliable electricity supply that hindered effective service delivery, especially for emergency care, maternal health services, and night-time medical procedures. The scope of the project included:

- Conducting detailed energy audits at target facilities to assess infrastructure and energy needs.
- Designing and deploying tailored energy solutions, including solar PV systems with over 600 kWp of installed capacity.

[1] ODCH and PCMH, co-located sister hospitals, jointly utilize the same solar PV system installation.

- Executing civil works and system installation to transition from unreliable power sources to solar energy.
- Commissioning and handing over fully operational solar PV systems to MoH.
- Enhancing local capacity through training and skills development in solar energy systems maintenance and operations.

Phase 1 of the SL-HEP kicked off in August 2022, with commissioning of systems by December 2023. Post-commissioning data from the installed Remote Monitoring Systems (RMS) was thus available for a full year, enabling an Impact Assessment covering the period from January to December 2024.

The Theory of Change (ToC) for Phase 1 of the SL-HEP was built on the premise that reliable, clean energy access in healthcare facilities leads to measurable improvements in healthcare service delivery, operational efficiency, and environmental sustainability. The anticipated outcomes of Phase 1 included:

1. **Enhanced Healthcare Service Delivery**: (i) Increased operational hours, increased services overall, increased quality of medical services, and the availability of more modern healthcare services thanks to uninterrupted power supply; (ii) Reduction in medical equipment failures caused by power outages; and (iii) Improved access to lifesaving maternal, neonatal, and emergency care services.
2. **Energy Independence and Reliability**: (i) Installation of 627 kWp solar PV capacity, significantly reducing reliance on diesel gensets; and (ii) Improved energy security for the hospitals, ensuring consistent access to power for critical medical equipment.
3. **Environmental and Economic Impact:** (i) Reduction in CO_2 emissions and hospital operating costs by cutting diesel fuel consumption; and (ii) Creation of a sustainable energy model that can be scaled and replicated across other healthcare facilities.
4. **Capacity Building and Workforce Development**: (i) Training of local hospital personnel in solar PV system maintenance to ensure long-term sustainability; and (i) Development of skilled professionals through the Gender and Youth (GY) STEM traineeship, contributing to gender inclusion and local workforce development.

2.2. Evaluation Purpose

The following IA of Phase 1 of the Sierra Leone Healthcare Electrification Project (SL-HEP) is being conducted to assess the effectiveness, efficiency, and sustainability of the hospital electrification initiative and to generate evidence-based insights that will inform future phases of the project and broader programming. This IA builds upon a prior utility- and process-focused evaluation of

Phase 1, which provided an initial assessment of project implementation, challenges, and early outcomes, which were integrated into the design and implementation of Phases 2 & 3 (which are out of scope for this IA but in scope for a parallel Developmental Evaluation).

The primary objectives of this IA are to:

1. Measure the extent to which Phase 1 achieved its intended health, energy, environmental, and socio-economic outcomes, as outlined in the project's Theory of Change (ToC), logframe, and key performance indicators (KPIs).
2. Identify unforeseen or additional effects not captured by existing monitoring and evaluation (M&E) frameworks.
3. Assess the sustainability of the interventions, particularly the operational and financial viability of the solar PV systems beyond the project's implementation period.
4. Evaluate the overall impact of the project using data from RMS and field visits and identify opportunities to leverage the emerging impact tool to project and quantify further impact, thereby informing enhancements to future MEL Frameworks and additional data collection in Phase 3.

This IA builds upon the process-oriented assessments conducted during Phase 1, which examined (i) project design and implementation processes; (ii) stakeholder engagement and coordination mechanisms; and (iii) challenges and risks encountered during execution. **While the previous Independent Evaluation provided insights into project execution, this IA shifts the focus towards measuring real-world outcomes, using pre- and post-intervention data to quantify impact and inform adaptive management for future phases.**

Figure 2 **shows** a complete overview of SL-HEP's reach.

Figure 2. Overview of solar PV systems capacity and commissioning status for all phases of the SL-HEP

Imp. Phase	Sites	Solar Capacity (kWp)	Battery Capacity (kWh)	Status	Solar Cap. Exp. (kWp)	Expansion Status	Scope
1	Bonthe Hospital	70.4	217	Commissioned	26.5	Commissioned	IA - field visit & RMS
1	PCMH	300.8	547	Commissioned	120[2]	On going	IA - field visit & RMS
1	ODCH						
1	Masanga Hospital	105.6	290	Commissioned	52.8	Commissioned	IA - field visit & RMS
1	Kabala Hospital	90.75	290	Commissioned	49.5	Commissioned	IA - field visit & RMS
1	Kambia Hospital	59.4	217	Commissioned	35.2	Commissioned	IA - field visit & RMS
2	Kailahun Government Hospital	114.4	290.3	Commissioned			DE
2	Jenner Wright CHC	13.2	20	Commissioned			DE - field visit
2	Cline Town CHC	13.2	20	Commissioned			DE - field visit
2	Bayama Lela CHP	6.6	10	Commissioned			DE
2	Ngelehun Govuhun CHC	6.6	10	Commissioned			DE
2	Bo School Clinic CHC	6.6	10	Commissioned			DE
2	Torwama MCHP	6.6	10	Commissioned			DE
2	Yele Community CHC	6.6	10	Commissioned			DE
2	Makali CHC	13.2	20	Commissioned			DE - field visit
2	Mamosasanka CHC	6.6	10	Commissioned			DE - field visit
2	Kameindor CHC	6.6	10	Commissioned			DE
2	Kindoya CHC	13.2	20	Commissioned			DE
2	Mokotawa CHP	6.6	10	Commissioned			DE
2	Moriba Town CHP	6.6	10	Commissioned			DE - field visit
2	Foya CHP	6.6	10	On going			DE
2	Taigbe CHP	6.6	10	Commissioned			DE
2	Bonthe Under Five MCHP	6.6	10	Commissioned			DE - field visit
2	Mindohun CHP	6.6	10	Commissioned			DE
2	York Island MCHP	6.6	10	Commissioned			DE
2	Torma Bum CHP	6.6	10	Commissioned			DE

[2] SEforALL is executing the expansion of the newly installed 300.8 kWp solar PV system by an additional 120 kWp, expected to be commissioned by March 31, 2025. In parallel, the components are being installed for a 150 kWp solar PV system with a 290 kWh battery capacity to supply the oxygen gas plant. Commissioning is subject to the installation of the oxygen plant. The project has an estimated completion date of December 2025.

Imp. Phase	Sites	Solar Capacity (kWp)	Battery Capacity (kWh)	Status	Solar Cap. Exp. (kWp)	Expansion Status	Scope
2	Taiama Trauma CHC	6.6	10	Commissioned			DE
2	York Peripheral Village CHC	6.6	10	Commissioned			DE - field visit
2	Newton CHC	6.6	10	Commissioned			DE
2	Kent CHP	6.6	10	Commissioned			DE
2	Tombi CHC	13.2	20	Commissioned			DE
2	Khalimat Shahed Hospital	6.6	10	Commissioned			DE - field visit
3	Connaught Hospital	759.9	1225	On going			DE
3	King Harman Road Hospital	94.6	190	On going			DE
3	Rokupa Hospital	94.6	292	On going			DE
3	Lakka Government Hospital	105.6	190	On going			DE - field visit
3	Port Loko Hospital	179.3	394	On going			DE - field visit
3	Makeni Hospital	250.8	496	On going			DE - field visit
3	Magburaka Hospital	190.3	350	On going			DE
3	Koidu Government Hospital	667.7	860	Not started			DE
3	Moyamba Government Hospital	233.2	262	On going			DE - field visit
3	Kenema Hospital	190.3	204	On going			DE
3	Pujehun Hospital	160.6	634	On going			DE

2.3. Scope of the Evaluation

This IA of Phase 1 of SL-HEP applies the Organisation for Economic Co-operation and Development – Development Assistance Committee (OECD–DAC) evaluation criteria—relevance, coherence, effectiveness, efficiency, impact, and sustainability—alongside FCDO evaluation standards, ensuring a rigorous and actionable assessment of the project's performance and long-term viability.

Relevance: Evaluates SL-HEP's alignment with Sierra Leone's national healthcare and energy priorities, assessing how effectively the project addresses the electricity needs of the six targeted hospitals and the communities they serve.

Effectiveness: Assesses the extent to which the SL-HEP has achieved its intended outcomes, particularly in improving healthcare service delivery by providing reliable and sustainable electricity to the hospitals.

Efficiency: Reviews the project's resource utilisation, considering cost-effectiveness, timeliness, and financial and operational management, ensuring that implementation maximises impact within the available budget and timeframe.

Impact: Measures the broader effects of the SL-HEP, including improvements in health outcomes, environmental sustainability (reduced reliance on diesel gensets), and socio-economic benefits for the hospitals and their surrounding communities.

Sustainability: Investigates the long-term viability of the installed solar PV systems, including operational maintenance, financial sustainability, and the capacity of local stakeholders to sustain project benefits beyond the donor funding period.

Beyond these OECD/DAC criteria, this evaluation follows FCDO's evaluation standards, ensuring that findings are proportional to the project's scale, uphold ethical standards in data collection and stakeholder engagement, and deliver utility-focused recommendations for SEforALL, FCDO, and other stakeholders involved in scaling and replicating healthcare electrification initiatives.

3. Evaluation Objectives and Questions

3.1. Evaluation Objectives

The primary objective of this impact evaluation is to assess the **relevance, effectiveness, efficiency, impact, and sustainability** of Phase 1 in achieving its intended outcomes as defined in the Logframe, Theory of Change (TOC), and Key Performance Indicators (KPIs).

The secondary objectives are to:

1. Assess **causal links** between project inputs and outcomes, including unforeseen positive and negative impacts;
2. Identify gaps in current indicators and propose enhancements to improve tracking of long-term impacts; and
3. Provide actionable recommendations to strengthen project design, implementation, and monitoring for subsequent phases/projects (replication/scale-up).

3.1. Key Evaluation Questions:

Q1: How well has the project aligned with national healthcare and renewable energy goals?

Q2: To what extent have the intended health and energy outcomes been achieved?

Q3: To what extent has the project delivered value for money across economy, efficiency, effectiveness, and equity dimensions?

Q4: What external factors influenced the project's effectiveness?

4. Evaluation Methodology

This impact assessment employed a mixed-methods approach, integrating quantitative and qualitative data collection and analysis to assess the outcomes of Phase 1 of SL-HEP. The IA measured changes in healthcare service delivery, energy access, operational efficiency, and sustainability, ensuring findings were both data-driven and contextually informed.

Quantitative Methods

Health outcome data were analysed using pre- and post-intervention records from the six hospitals, focusing on logframe indicators such as maternal and infant mortality rates, patient volume, and service availability. Energy usage and system performance data were extracted from the Remote Monitoring System (RMS) logs to assess electricity reliability, power quality, uptime of electricity services, the share of renewable energy used, and reductions in diesel consumption and CO_2 emissions. This was complemented by data collected through on-site fieldwork and surveying. Financial data were also reviewed to estimate operational cost savings and assess Value for Money (VfM), aligning with FCDO's VfM framework while incorporating broader sectoral considerations.

To establish causal links, the IA employed a difference-in-differences approach, comparing baseline and endline data to infer the impact of electrification on hospital operations and healthcare service delivery. Given the limited number of hospitals included in Phase 1, data collection encompassed all six facilities, ensuring a comprehensive assessment.

Qualitative Methods

Structured interviews were conducted with key stakeholders, including hospital facility managers, healthcare staff, SEforALL project team and management who were involved in the project, and government representatives, to understand the perceived benefits, challenges, and sustainability of the intervention. Additionally, discussions with patients and community members explored how electrification influenced perceptions of healthcare quality, security, and overall well-being.

Data Triangulation and Ethical Considerations

Findings from the quantitative analysis were validated through qualitative insights to understand the project's impact. Improvements in key health indicators were corroborated with reports from healthcare providers and patient experiences, while energy system performance data were compared with staff feedback on reliability and efficiency. The IA adhered to ethical standards, securing informed consent from participants and maintaining strict confidentiality measures. Special attention was given to cultural sensitivity, so that all stakeholder interactions and data collection processes were conducted respectfully and inclusively.

5. Findings and Analysis

5.1. Evaluation Dimensions

The following section is structured around key OECD-DAC evaluation criteria—relevance, coherence, effectiveness, efficiency, impact, and sustainability— and FCDO's Value for Money (VfM) framework to assess the SL-HEP's outcomes and long-term viability. These criteria provide a framework to determine how well SL-HEP is aligned with national priorities, the efficiency of resource use, the extent of its impact on healthcare service delivery, and the sustainability of the installed solar PV systems.

The findings presented in this section are based on quantitative data from the Remote Monitoring System (RMS), which tracks solar energy generation, diesel fuel consumption, power outages, and system uptime at the six hospitals. This is supplemented by hospital records on electricity usage, patient care statistics, and financial data, as well as qualitative insights from stakeholder

interviews and field observations. Later sections, including the Summary of Key Performance Indicators (KPIs) and Key Learnings, provide a consolidated analysis of SL-HEP's measurable outcomes and broader lessons for future implementation.

The overview of the results is detailed in the following sections.

5.1.1. Relevance

The SL-HEP Phase 1 has been **highly relevant to both Sierra Leone's national healthcare and energy priorities**, directly addressing critical electricity shortages in hospitals. The project aligns with national efforts to expand access to renewable energy, particularly in essential public services such as healthcare. The SL-HEP responded directly to Sierra Leone's urgent need for reliable healthcare infrastructure, particularly in maternal and neonatal health services, where access to stable electricity is essential for safe deliveries and emergency procedures. The project directly supports the National Health Sector Strategic Plan (NHSSP) 2021–2025, which prioritises health infrastructure, equitable access to quality healthcare services, and health system resilience. It also aligns with Sierra Leone's energy transformation goals, outlined in the Energy Transition and Green Growth Plan which was developed under SEforALL's Energy Transition & Investment Planning arm, which aim to increase renewable energy capacity from 160 MW (2023) to 850 MW (2030) and boost renewable energy generation from 35% to 80% by 2030, ultimately achieving universal electricity access by 2040. The Government has committed to expanding access to affordable, reliable, and clean energy to improve people's livelihoods and meet its Nationally Determined Contributions (NDCs) under the Paris Agreement.

The SL-HEP contributes directly to the advancement of Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), SDG 3 (Good Health and Wellbeing), and SDG 13 (Climate Action). By installing 627 kWp of solar PV capacity (by the end of Phase 1), the project has displaced fossil fuel dependency, reducing the carbon footprint of hospitals while strengthening health service delivery and resilience. Interviews with Ministry of Health (MoH) officials confirmed that hospital electrification remains a priority area.

Discussions with patients and hospital staff revealed that unreliable electricity discouraged some individuals from seeking care, particularly for critical services such as maternity and emergency care. The installation of solar PV systems has significantly improved power reliability, ensuring that hospitals can provide consistent and uninterrupted services, thereby enhancing patient trust and increasing hospital utilisation. These improvements align with community priorities for safer, more accessible, and higher-quality healthcare services, reinforcing the project's relevance to local health needs and expectations.

5.1.2. Effectiveness

The SL-HEP Phase 1 has been highly effective in improving hospital electricity reliability, directly enhancing healthcare service delivery, particularly in maternal and emergency care. The SL-HEP successfully improved hospital electricity reliability, leading to enhanced healthcare service delivery, particularly in neonatal and maternal care. However, the significant gaps present in MoH data limited the ability to quantify the direct health impacts of the project.

Post-intervention hospital records do indicate a reduction in electricity-related disruptions in critical care units. At ODCH, staff reported that incubators and oxygen concentrators that previously failed due to outages now operate continuously, leading to improved neonatal outcomes. At PCMH, emergency C-sections are no longer delayed due to power shortages, reducing risks to maternal health.

Data collection gaps prevent a full quantitative assessment of maternal and under-five mortality reductions. While qualitative feedback from doctors and nurses suggests that health outcomes have improved, systematic patient outcome tracking linked to energy access remains limited.

5.1.3. Efficiency

SL-HEP has demonstrated strong efficiency in reducing reliance on diesel fuel gensets and optimising hospital energy use, though inconsistencies in energy management practices have limited the full realisation of cost savings.

The analysis shows a significant reduction in diesel fuel genset usage at Masanga Hospital, where gensets were being used for about 11 hours/day. Solar power has replaced about 68% of previous diesel consumption, and now gensets are only being used for a few hours a day to ensure the batteries are fully charged. This transition has led to lower fuel costs and operational savings of about 21%. Bonthe and ODCH & PCMH show an increase in fuel consumption, which is likely due to imperfect data collection. Since RMS data was incomplete, the analysis for this indicator used data collected during on-site interviews, relying purely on human recollection. Interviewees at these hospitals estimate that the generators are being used slightly less after the installation of the solar PV systems, predominantly to charge the batteries, when necessary, similar to the situation at Masanga.

Field observations have also identified inefficiencies in energy use, including hospital staff leaving air conditioners and non-essential appliances running overnight, depleting battery reserves. At Kabala and PCMH Hospitals, maintenance officers reported that hospital power was used for personal appliances, such as refrigerators, requiring intervention from the EPC

contractor, EM-ONE, to disconnect unauthorised devices. While energy monitoring systems help mitigate these issues, ongoing staff training and supervision are needed to maximise efficiency.

Ensuring technical design efficiency is also a critical piece to optimising energy use and long-term sustainability. Proper system sizing plays a key role in balancing cost-effectiveness with hospital energy demand, preventing both underutilisation and system overloading. SL-HEP's design accounted for short- to medium-term electricity demand growth; however, as indicated, hospitals have already experienced higher-than-anticipated consumption increases. While the solar systems have effectively reduced reliance on diesel gensets, variability in energy management practices and fluctuations in hospital demand have shaped the degree of efficiency across different sites.

5.1.4. Impact

SL-HEP has demonstrated strong environmental and social benefits, but long-term economic sustainability remains uncertain.

5.1.4.1. Climate: Reduction in CO_2 emissions.

The transition to solar PV systems at the six hospitals has led to **a 38% reduction in diesel fuel consumption.** This change translates to **an annual CO_2 reduction of 72 metric tons from genset use—a 38% decrease.** Assuming the solar systems operate for 20 years, this translates to a potential reduction in CO_2 emissions from genset use of 1,439 tons. Additionally, the RMSs have reported decreased grid power consumption at ODCH and PCMH, which translates to an annual reduction of approximately 7 metric tons of CO_2 emissions per year, representing a 22% decrease.

The project's original target of a 75% reduction in diesel consumption was not fully met, likely due to several operational and contextual factors. Hospitals continue to rely on backup diesel generators during periods of low solar generation, particularly in cloudy or rainy conditions. The hospitals have also experienced increased electricity demand following solar installation, as new medical equipment and expanded service availability have contributed to higher overall power consumption.

Beyond carbon reductions, the shift to solar power is expected to contribute to lower levels of air and noise pollution within hospital compounds, potentially benefiting both patients and healthcare workers by reducing exposure to diesel exhaust and generator noise. While direct measurements of the co-benefits are not available, qualitative insights from hospital staff suggest that improvements in air quality and working conditions are perceived as secondary benefits of solar electrification.

5.1.4.2. Economic: Job creation

SL-HEP's economic impact was primarily observed in workforce development, improved working conditions for healthcare staff, and training opportunities in the renewable energy sector. While the installation of solar PV systems did not generate significant full-time employment opportunities at the health-facility level, it enhanced job quality and efficiency for hospital personnel, particularly those in surgical theatres, maternity wards, and neonatal care units. Before the intervention, healthcare workers frequently experienced power disruptions that forced them to rely on unreliable gensets or even phone flashlights, creating stressful and unsafe conditions during emergency procedures. The introduction of stable, renewable electricity has improved workflow efficiency, reduced workplace stress, and enhanced service delivery, particularly in high-demand departments. Hospital interviewees noted that, while no full-time jobs have been created to date, they see potential for employment growth as healthcare services expand, largely enabled by improved electricity supply.

Although part-time roles were created for basic solar maintenance tasks (e.g., cleaning PV panels and performing site inspections), these positions were limited in scope and typically required work only once a month or less. As a result, direct employment generation from SL-HEP remained limited, reflecting the project's primary objective of enhancing healthcare service delivery rather than driving large-scale job creation.

Beyond hospital operations, SL-HEP supported skills development in the renewable energy sector through the Women in STEM initiative, which trained 23 female technicians in solar PV installation and maintenance. The project successfully equipped participants with technical expertise and professional networking opportunities, expanding their career prospects within the renewable energy industry. According to interviews with two trainees, the training built their confidence and technical proficiency; one of them pursued further education, and the other one secured an internship in the field. Without clear career pathways, there is a risk that trained individuals may shift to other industries, reducing the long-term impact of the initiative. One of the interviewed trainees was invited to attend the Energizing Healthcare Conference in Nairobi, and both had access to job fairs in Sierra Leone. However, these insights are based on only two interviews and may not reflect the broader experience of all trainees—additional positive impacts may have occurred but were not captured in this assessment.

From a broader sectoral perspective, the project created significant high-skilled employment opportunities in engineering, procurement, commissioning, and operations and maintenance of the PV systems, primarily through the contractor EM-ONE.

5.1.4.3. Social: Changes in healthcare access and community perceptions

SL-HEP has significantly improved perceptions of hospital safety and service quality, particularly among pregnant women and mothers of young children. Before the intervention, unreliable electricity led to frequent service disruptions, forcing some patients to seek informal healthcare options or rely on home-based deliveries. Interviews with patients and healthcare staff revealed that the availability of reliable lighting and powered medical equipment has increased patient confidence in seeking care at hospitals, particularly for maternal and emergency services.

In addition to medical benefits, the availability of reliable lighting has also contributed to enhanced security within hospital compounds, addressing previous concerns about theft, attacks, and unsafe working conditions at night. Night-shift nurses and on-call staff, who once had to work in dimly lit environments, now feel safer moving between wards and responding to emergencies. Despite these improvements, gaps in outdoor lighting persist, particularly along pathways between staff quarters and hospital buildings, leaving some staff—especially female healthcare workers—feeling vulnerable when walking at night. Interviews conducted further reinforce these findings, with both patients and nurses reporting that brighter hospital surroundings deter theft and unauthorised entry. While these non-medical security benefits were not an explicit design objective of the HEP, they highlight an important secondary impact of hospital electrification that should be considered in future phases, including comprehensive outdoor lighting solutions to enhance overall facility security.

Beyond patient experiences, healthcare staff in all hospitals have also benefited from the improved energy infrastructure, leading to higher job satisfaction, motivation, and retention. Interviews across hospitals indicated that before the intervention, some doctors actively avoided postings in facilities with unreliable power, viewing these assignments as undesirable and isolating. At Masanga Hospital, one doctor refused a posting due to poor conditions, while at Bonthe Hospital, the facility was described as “a prison” before the installation of solar PV systems. The improved working and living conditions have reversed these perceptions, with staff now expressing pride and satisfaction in their assignments.

Reliable power has also led to operational improvements, particularly in maintenance and support staff engagement. Maintenance teams at all hospitals reported greater motivation and ability to focus on broader infrastructure maintenance, as they no longer had to constantly troubleshoot electricity failures. Reductions in electricity-related disruptions have also contributed to fewer staff delays, further improving hospital efficiency.

While extended electricity access has improved staff living conditions, challenges remain in some hospitals where staff quarters do not receive consistent night-time power, impacting comfort and

morale. Of the four hospitals with staff quarters, only one—Kabala—reported having 24-hour electricity. However, they noted that power rationing may soon be necessary. Addressing these disparities in energy distribution within hospital premises would further enhance job satisfaction and retention among healthcare workers.

Overall, SL-HEP has not only improved patient trust in healthcare services but also enhanced the well-being and engagement of hospital staff, making healthcare facilities more attractive workplaces and strengthening the overall quality of service delivery.

5.1.4.4. Equity and Inclusion: Gender and youth participation, equitable access to benefits

SL-HEP improved gender and youth inclusion through targeted training initiatives, but the project lacked systematic equity tracking in healthcare service delivery.

The Women in STEM programme was a stepping stone for its participants into Sierra Leone's renewable energy sector. The project provided key tools and skills necessary to enter this often male-dominated industry. In healthcare service delivery, the SL-HEP prioritised maternity wards for uninterrupted power supply, ensuring that women and newborns benefited significantly. However, no gender-disaggregated hospital data were available to assess whether improved energy access led to measurable changes in service utilisation across different demographics.

5.1.4.5. Sustainability: Long-term functionality of PV systems, integration into national policies

The SL-HEP's sustainability is uncertain due to unclear long-term ownership of system maintenance and financial constraints. While solar PV systems are currently functional, there is currently no dedicated O&M funding beyond the initial donor-supported period, though SEforALL has noted that a solution is being pursued. Interviews with Ministry of Health (MoH) and Ministry of Energy (MoE) officials revealed uncertainty over ownership of long-term maintenance responsibilities, with conflicting perspectives on whether hospitals, government agencies, or private contractors should manage system operations. This lack of clarity poses a significant risk to sustainability, particularly as batteries and inverters require periodic replacement to maintain system performance.

Despite these challenges, Sierra Leone's energy and health sector policies provide a potential pathway for integration. The NHSSP 2021–2025 highlights the importance of infrastructure

resilience and sustainable healthcare services, suggesting that long-term solar PV maintenance could be incorporated into broader health sector planning. Sierra Leone's renewable energy targets under the National Energy Policy, Implementation Strategy, Energy Transition and Green Growth Plan also indicate a commitment to increasing off-grid solar solutions, which could provide a framework for expanding and sustaining hospital electrification efforts.

5.1.4.6. Value for Money: Performance across the FCDO's VfM framework (economy, efficiency, effectiveness, equity)

Assessing Value for Money (VfM) for the SL-HEP presents several limitations due to gaps in financial data and cost tracking. While the project has clearly demonstrated efficiency and effectiveness in improving electricity reliability, reducing diesel consumption, and enhancing healthcare service delivery, a comprehensive VfM assessment requires a more granular cost-benefit analysis.

Specifically, there is limited financial data on procurement costs, hospital operating expenditures before and after electrification, and potential opportunities for reinvestment of diesel cost savings into healthcare services. The absence of a structured long-term financing mechanism for system maintenance presents a risk to economic sustainability, as hospitals may struggle to fund battery replacements and ongoing repairs once donor funding ends. However, as part of the overall SL-HEP, in the later phases, SEforALL has been working closely with FCDO and the Ministry of Health to develop a structured long-term sustainability model for system maintenance. This includes exploring potential financing mechanisms, such as government budget allocations, donor commitments, and public-private partnerships, to ensure the continued operation of the solar systems beyond the project's lifespan. A formalised mechanism will help mitigate financial risks by providing a sustainable funding pathway for ongoing maintenance, ensuring that hospitals can reliably operate their electrification systems without dependence on ad-hoc external support.

The figure below summarises the VfM assessment based on FCDO's four VfM criteria—economy, efficiency, effectiveness, and equity—while highlighting key findings and data gaps.

Figure 3. Value-for-money assessment

VfM Criterion	Findings from SL-HEP Impact Assessment	Key Evidence and Data Gaps
Economy (Cost-effectiveness of inputs)	The SL-HEP procured and installed solar PV systems at competitive costs, reducing reliance on diesel gensets, which had high operational costs. However, a full financial breakdown comparing solar vs. diesel costs is unavailable, limiting a precise assessment of procurement efficiency.	- 38% reduction in diesel fuel consumption across hospitals. - Estimated 72 metric tons of CO_2 reduction per year (38% decrease), translating to 1,439 tons over a 20-year project life. - Competitive procurement costs compared to similar projects, though a lack of comprehensive cost-benefit data limits a full assessment of financial efficiency. While the accelerated procurement and implementation timeline likely contributed to time efficiencies, the extent of any cost savings remains unclear due to the absence of detailed expenditure data.
Efficiency (Resource optimisation and cost savings)	The shift to solar energy has reduced diesel fuel dependency by about 38%, equating to saving roughly 22,500 litres/yr. This translates to an annual savings of about US$ 27,000, assuming an average cost of US$ 1.20 per litre. Ultimately, this leads to lower operational costs and fewer service disruptions. However, standardised financial tracking of cost savings and reinvestment opportunities in hospital operations remains limited. Unregulated power use (e.g., personal appliances) has also put additional strain on battery storage.	- Reduced genset runtime and fuel costs at all hospitals. - Unclear financial reinvestment of diesel cost savings. - Risk of accelerated battery depletion due to increased energy demand.
Effectiveness (Achievement of objectives)	The SL-HEP successfully delivered reliable electricity, improving maternal and emergency care services while enhancing staff efficiency. However, financial sustainability remains at risk due to the absence of structured long-term O&M funding.	- Consistent 24/7 electricity supply reported in maternity and surgical wards. - Reduction in service disruptions during critical procedures. - Lack of long-term financial planning for O&M costs.

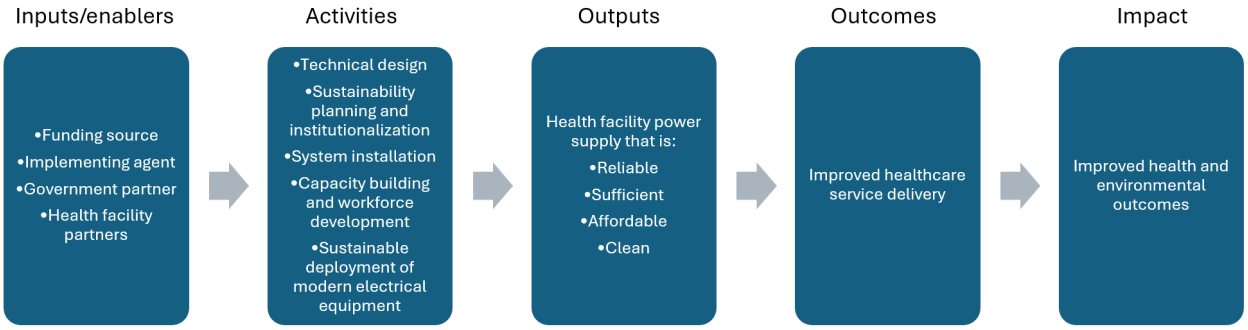
VfM Criterion	Findings from SL-HEP Impact Assessment	Key Evidence and Data Gaps
Equity (Fair distribution of benefits)	The SL-HEP ensured equitable access to clean energy in both urban and rural hospitals, benefiting patients, staff, and surrounding communities.	- Solar PV installations at 12 major hospitals and 25 CHCs throughout the 3 phases of the project serve over 8.5 million people. - 11 and 12 female STEM trainees per cohort (23 total trained in Phases 1 & 2)

5.2. Theory of Change

In the original project design, the Theory of Change (ToC) was based on the premise that reliable, clean energy access in healthcare facilities would lead directly to measurable improvements in healthcare service delivery, operational efficiency, and environmental sustainability. As initially envisioned, Phase 1 anticipated that installing solar PV capacity would enhance healthcare services through increased operational hours, reduced equipment failures, and improved access to critical maternal, neonatal, and emergency care. It also aimed to achieve energy independence, reduce CO_2 emissions and operating costs, and build local capacity through targeted training initiatives.

Building on this foundation, the Catalyst team has developed a revised and more robust Theory of Change (see Figure 4 below). This updated model not only reaffirms the original assumptions but also incorporates a broader, utility-focused perspective. It emphasises not only the direct benefits of reliable electricity but also the importance of a comprehensive suite of supporting activities, such as optimised system design, sustainability planning, and institutionalisation, that are essential for ensuring the long-term impact and scalability of the programme. By expanding its focus to include these critical dynamics, the new Theory of Change provides a more complete roadmap for driving sustainable improvements in healthcare delivery and environmental outcomes, both within Sierra Leone and in future replicable initiatives. Annexe VII depicts an alternative visualisation of the revised theory of change.

Figure 4. Revised Theory of Change



The Catalyst team has identified five distinct recommendations that are deemed critical to future project design at ToC stage.

1. **Technical design**. While an unavoidable activity, performing it well ensures that the solutions deployed are fit-for-purpose and scalable while preventing the under-sizing or over-sizing of systems, which impacts performance, cost-effectiveness, and long-term sustainability. Design activities should aim to future-proof systems by accommodating short- to medium-term evolution in electricity demand while enabling straightforward capacity expansions. Technical designs should include robust remote monitoring hardware that covers not just core system functionality but also that of other generation sources (e.g., gensets, grid connections) and critical circuits, when possible.
2. **Sustainability planning and institutionalisation**. Sustainability planning ensures that hospital electrification is not just a short-term intervention but a long-term transformation in healthcare infrastructure. Without clear institutionalisation, many electrification projects fail once donor funding ends, leading to system neglect. This activity establishes the governance structures, funding models, and regulatory frameworks needed to maintain and expand energy access for hospitals. By integrating operations and maintenance (O&M) planning, financial sustainability models, and policy alignment, hospitals and governments can take full ownership of the solar systems, reducing dependence on external donors and ensuring continuous, affordable, and reliable electricity.
3. **System deployment**. A well-executed installation ensures that solar PV and battery storage systems function as designed, providing uninterrupted and reliable power for hospital operations. Poor installation can lead to system failures, inefficiencies, or safety hazards, making this activity critical to success. Proper procurement, site preparation, and commissioning guarantee that the hospital's power infrastructure is secure and well-integrated with existing facilities. Ensuring a smooth handover process also empowers hospital staff with the knowledge needed to operate and maintain the system, ultimately maximising the project's impact.
4. **Capacity building and workforce development**. No electrification project can succeed without trained personnel to operate, maintain, and troubleshoot the system. Capacity building ensures that hospital staff, local technicians, and other stakeholders have the skills to manage renewable energy infrastructure. Investing in local workforce development reduces dependence on external contractors, ensuring that hospitals remain self-sufficient in maintaining their systems. Additionally, by incorporating Women in STEM initiatives, programmes can help to bridge gender gaps in the renewable energy sector, fostering a more inclusive workforce and expanding economic opportunities for women.

5. **Sustainable deployment of modern electrical equipment**. Reliable electricity alone is not enough—hospitals must also use modern, efficient electrical equipment to maximise the benefits of solar power systems. This requires close collaboration between the Ministry of Health, health facilities, and implementing partners to ensure the right equipment, such as oxygen concentrators, vaccine refrigerators, LED lighting, fans, and air-conditioning systems, is deployed and managed effectively. By prioritising low-power, high-efficiency equipment, hospitals can reduce energy demand, making solar power more sustainable and cost-effective. Coordinated efforts are also needed to establish maintenance and replacement plans, preventing equipment failures that could disrupt healthcare delivery.

Below, we highlight what the learnings from our fieldwork and data analysis say about the SL-HEP's outputs, outcomes, and impact to date. Later, in our key recommendations, we isolate specific activities that we believe need further attention to maximise project outputs, outcomes, and impact over the longer term.

5.3. Summary of key health, energy, and socio-economic outcomes to date.

This section provides a summary of all KPIs analysed in this IA; a detailed analysis of all the indicators can be found in the sections that follow.

Figure 5. Summary of climate-related indicators

CLIMATE				
GENSET EMISSIONS				
The transition to solar PV resulted in an overall reduction in diesel fuel consumption and related CO_2 emissions.				
Indicator		*Δ v Baseline*	*Units*	*% change*
Annual diesel fuel consumption across all Phase 1 hospitals	●	-22,492	litres/yr	-38%
Annual CO_2 emissions from diesel fuel consumption across all Phase 1 hospitals	●	-72	ton/yr	-38%
GRID EMISSIONS				
The transition to solar PV decreased electricity consumption from the national grid, reducing corresponding CO2 emissions.				
Indicator		*Δ v Baseline*	*Units*	*% change*
Annual CO_2 emissions from the electricity consumed from the grid at ODCH and PCMH	●	-7	ton/yr	-22%
GENSET USE				

CLIMATE				
Although hospitals have significantly reduced their reliance on generators following the installation of solar PV systems, they still depend on both gensets and the national grid (where available) to maintain a consistent electricity supply. Genset usage varies depending on solar system capacity, seasonal fluctuations in solar generation, and financial constraints.				
Indicator		*Δ v Baseline*	*Units*	*% change*
Average generator uptime across all Phase 1 hospitals	🟢	-2.0	hrs/day	-52%
Total daily electricity produced by generators across all Phase 1 hospitals	🟢	-38.8	kWh/day	-12%
ENERGY EFFICIENCY				
Retrofitting of existing electrical infrastructure has improved efficiency. Staff are actively managing energy use, though there is no systematic tracking of behavioural changes.				

Figure 6. Summary of energy-related indicators

ENERGY				
ELECTRICITY UPTIME				
Field reports confirm that the installation of solar PV systems improved electricity reliability, though RMS data display inconsistencies and require further refinement.				
Indicator		*Post Solarisation*	*Units*	*% Impr.*
Average daily electricity uptime	🟢	19.7	hrs/day	14%
QUALITY OF SERVICE				
The solarisation of hospitals has improved the quality and stability of electricity, ensuring that voltage remains within the acceptable range across all facilities.				
Indicator		*Post Solarisation*	*Units*	*% Impr.*
Average voltage across all Phase 1 hospitals	🟢	229.6	V	79%
Average frequency across all Phase 1 hospitals	🟢	50.0	Hz	68%
Average time outside the nominal voltage range across all Phase 1 hospitals	🟡	0.7	hrs/day	-25%
OUTAGES				
Four out of six hospitals experienced a reduction in daily outages, with three hospitals now averaging fewer than one outage per day. ODCH and PCMH reported an increase in daily outages, which may be due to manual switching delays when transitioning between grid and solar power.				
Indicator		*Δ v Baseline*	*Units*	*% change*

ENERGY				
Average number of daily outages across all Phase 1 hospitals	🟢	-0.3	outages	-21%
Average length of outages across all Phase 1 hospitals	🟡	0.2	hrs	4%
ON-SITE RENEWABLE ENERGY				
All hospitals display a significant increase in electricity generation from the new solar PV systems; however, in some cases, hospitals have focused on leveraging the new solar system to increase electricity uptime rather than constraining genset use.				
Indicator		*Δ v Baseline*	*Units*	*% change*
Total electricity generation from new solar PV systems across all Phase 1 hospitals	🟢	1,018	kWh/day	342%
Average share of electricity supplied by new solar PV systems across all Phase 1 hospitals	🟢	46%	-	200%
ELECTRICITY CONSUMPTION				
Total electricity consumption has increased across all Phase 1 hospitals, despite a 400 kWh/day reduction in grid usage at the ODCH and PCMH hospitals.				
Indicator		*Δ v Baseline*	*Units*	*% change*
Total daily electricity consumption across all Phase 1 hospitals	🟢	575	kWh/day	23%

Figure 7. Summary of solar PV system-related indicators

SOLAR PV SYSTEM		
INSTALLED CAPACITY		
The SL-HEP has successfully installed the proposed solar PV systems at all six Phase 1 hospitals. Additionally, expansions of the solar PV systems have already been commissioned in four hospitals, with the remaining two expected to be completed by March 31, 2025.		
Indicator	*Cap.*	*Units*
Total solar PV installed capacity across all Phase 1 hospitals	627	kWp
Total battery installed capacity across all Phase 1 hospitals	1,561	kWh
Total planned solar PV expansion capacity across all Phase 1 hospitals	284	kWp
BATTERY STORAGE CAPACITY		
While solar systems adequately meet energy demands during the day, battery storage capacity remains insufficient to sustain hospital operations throughout the night. As a result, hospitals must rely on diesel generators in the evening and strict energy rationing to prevent early battery depletion.		

SOLAR PV SYSTEM		
Indicator		*Post Solarisation*
Average share of time the battery spends at maximum SOC across all Phase 1 hospitals	●	18%
Average share of time the battery spends at or under restart SOC across all Phase 1 hospitals	●	6%
Average PV system performance ratio across all Phase 1 hospitals	●	51%
SECURITY LIGHTING		
Insufficient lighting around ground-mounted PV plants increases their vulnerability to theft, vandalism, and unauthorised access.		
STANDARDISED CONTAINERISED POWERHOUSE		
Inconsistent storage conditions for battery and inverter systems pose risks to equipment integrity and system reliability.		

Figure 8. Summary of economic outcomes

ECONOMIC				
COST SAVINGS				
Though overall electricity spending has increased across most hospitals, total average monthly spending has decreased. The increase in electricity spending in some hospitals reflects the implementation of more robust and reliable power systems that now effectively meet hospital energy demands.				
Indicator		*Δ v Baseline*	*Units*	*% change*
Average monthly power system costs across all Phase 1 hospitals	●	5,911	USD	31%
Average cost of electricity across all Phase 1 hospitals	●	-0.14	USD	-27%
ECONOMIC SPILLOVER				
The increase in patient numbers could have contributed to higher demand for local micro-businesses (e.g., food vendors or transport services). Nonetheless, no significant businesses were created due to improved electrification.				
SPENDING ON GENSET FUEL				
Hospitals that previously relied heavily on gensets now use less fuel, particularly in the dry season when solar production is high. Rainy season challenges remain, as hospitals still rely on gensets when solar generation and battery storage are insufficient.				

Figure 9. Summary of health outcomes

HEALTH

HEALTH OUTCOMES

The availability of reliable lighting and powered medical equipment has increased patient confidence in seeking care at hospitals. While qualitative feedback strongly suggests positive impacts on maternal and infant health, the lack of comprehensive quantitative data limits the ability to fully measure progress.

Indicator	*Δ v Baseline*	*Units*	*% change*
Total annual headcount across all Phase 1 hospitals	26,702	patients	57%
Total annual deliveries across all Phase 1 hospitals	-208	births	-2%
Annual maternal deaths across all Phase 1 hospitals	24	deaths	32%
Annual deaths of children <5 yrs across all Phase 1 hospitals	951	deaths	602%
Annual number of major surgeries across all Phase 1 hospitals	-402	surgeries	-7%
Annual number of minor surgeries across all Phase 1 hospitals	-547	surgeries	-41%

SERVICE AVAILABILITY

The solarisation of hospitals has significantly improved healthcare service delivery, ensuring more reliable emergency response, safer surgical conditions, and better patient monitoring. Power stability has led to improved maternal and neonatal care, enhanced laboratory capabilities, and expanded vaccine storage capacity.

USE OF MEDICAL EQUIPMENT

The installation of solar systems has significantly improved the functionality and utilisation of existing medical equipment, particularly in critical units. However, healthcare staff consistently report shortages of medical equipment and challenges in acquiring new equipment, limiting the full potential of the improved electricity supply.

Figure 10. Summary of healthcare staff outcomes

HEALTHCARE STAFF

MOTIVATION

Improved electricity access in hospitals has significantly enhanced staff motivation, creating a better working and living environment for healthcare professionals. Reliable power enables better work-life balance, increased job satisfaction, and improved efficiency, making hospitals more attractive workplaces.

LIVING CONDITIONS

HEALTHCARE STAFF
Improved electricity access has enhanced safety, comfort, and overall living conditions for healthcare workers, leading to higher motivation and job satisfaction. However, inconsistencies in power availability across staff quarters present challenges.
SAFETY
Hospital staff perceive the facilities as significantly safer than before due to improved night-time lighting, which has enhanced security, reduced risks of attacks and theft, and created a safer working environment for night-shift staff. However, outdoor lighting remains insufficient in some areas, particularly along pathways between staff quarters and hospital buildings, leaving staff feeling vulnerable when walking at night.
JOB CREATION
While the installation of solar systems did not generate significant new full-time employment opportunities, it greatly improved working conditions for existing hospital staff by ensuring a more stable and efficient work environment.
TURNOVER RATES
Staff in solar-powered hospitals report higher job satisfaction and better working conditions, which could contribute to lower turnover rates. However, no formal data exists to track turnover trends.
ELECTRIFICATION OF STAFF QUARTERS
Staff quarter electrification status varies across hospitals. All hospitals with staff quarters have some level of electricity access, although not always supplied by the HEP PV solar systems.

Figure 11. Summary of operation and maintenance outcomes

OPERATION & MAINTENANCE
HOSPITAL ENERGY MANAGEMENT & EFFICIENCY
While hospitals reported improved reliability in electricity supply, inefficient energy use, particularly overnight overconsumption, has affected system performance in some hospitals.
MAINTENANCE PROTOCOLS
Hospital staff effectively carry out routine maintenance tasks, but a weak maintenance culture poses a risk to long-term system performance.
O&M SERVICE PROVIDER
EM-ONE's responsive O&M support is praised for its timely and professional resolution, but further digitalisation of O&M services could improve transparency for all stakeholders and contribute to long-term sustainability.
LONGTERM O&M STRATEGY
Uncertainty over long-term O&M responsibilities and funding poses a major risk to the project's sustainability.
SPARE PART PROVISION OF ESSENTIAL COMPONENTS

OPERATION & MAINTENANCE
The limited provision of spare parts for essential components, such as light bulbs, tubes, and fans, poses a risk to system functionality and hospital operations.

Figure 12. Summary of training and capacity building outcomes

TRAINING AND CAPACITY BUILDING				
TRAINING & CAPACITY OF MAINTENANCE STAFF				
EM-ONE's hands-on commissioning training was highly valued for its practical approach, enabling maintenance officers and their teams to understand system functionality and troubleshooting better. However, skill gaps among maintenance staff, particularly in certain hospitals, pose a long-term sustainability risk.				
Indicator		**Post Solarisation**	*Units*	*% women*
Total number of trained technicians across all Phase 1 hospitals	●	29	persons	0%
STEM TRAINEES				
The Women in STEM training successfully equipped participants with technical skills and professional networking opportunities, empowering them to enter the renewable energy sector. However, strengthening post-training employment pathways is crucial to retaining female talent, sustaining engagement in the field, and maximising long-term impact.				
Indicator		*Post Solarisation*		
Number of female engineers trained through the project	●	23		

Figure 13. Summary of social outcomes

SOCIAL
LIVELIHOODS
While the project created temporary jobs during installation and improved working conditions for healthcare staff, long-term job creation remains limited. Some hospital workers (e.g., maintenance officers) have received training but remain unpaid volunteers, reducing the sustainability of livelihood improvements.
IMPROVEMENT OF HEALTH SERVICES
Staff in 6 of 6 hospitals report improved service availability, especially for emergency surgeries, maternal care, and neonatal services.

SOCIAL
Patients report feeling safer, more confident, and more willing to seek care at hospitals due to stable electricity. Improved lighting, reliable oxygen supply, and uninterrupted medical services have enhanced patient trust in healthcare facilities. However, in some hospitals, it was difficult to find patients who could directly compare pre- and post-solarisation conditions, limiting the ability to assess long-term perception shifts.
HEALTH & SAFETY
Retrofitting existing electrical installations has significantly improved safety in hospitals. Before solarisation, some facilities reported unsafe wiring, frequent voltage fluctuations, and sockets bursting, posing risks to staff and patients. However, solarisation introduces new safety challenges, particularly related to the maintenance of rooftop solar PV systems, which require proper training and safety protocols for maintenance staff.

5.4. Attribution Analysis

This section examines the extent to which the changes observed in healthcare service delivery, energy efficiency, and environmental impact can be directly attributed to SL-HEP. The analysis integrates quantitative and qualitative data, applying causal inference methods such as difference-in-differences (DiD) comparisons, stakeholder interviews, and system performance tracking.

Causal Contribution to Healthcare Service Delivery Improvements

The reliable electricity supply provided by SL-HEP-funded solar PV systems has had a demonstrable impact on hospital operations, staff performance, and patient trust.

Quantitative Evidence: Remote Monitoring System (RMS) data show that hospitals previously experiencing frequent power outages now have significantly higher uptime, with reductions in power disruptions to critical care units (e.g., maternity and neonatal wards).

Qualitative Evidence: Interviews with hospital administrators and medical staff confirm that solar power has eliminated delays in life-saving procedures (e.g., C-sections at Princess Christian Maternity Hospital). Doctors and nurses report improved morale and efficiency, as they no longer rely on unreliable backup gensets or manual lighting solutions (e.g., mobile phone flashlights).

Counterfactual Considerations: Without the SL-HEP intervention, hospitals would have continued relying on diesel gensets, which were subject to frequent breakdowns and fuel shortages, leading to service disruptions. Alternative donor-supported electrification efforts did not target these specific facilities, reinforcing SL-HEP's unique contribution. For instance, while the World

Bank's ongoing 'Enhancing Sierra Leone Energy Access' project aims to solarise approximately 200 health facilities, as of the latest update in August 2024, none had been successfully solarised, further underscoring the gap that SL-HEP has addressed.

Causal Contribution to Reduced Diesel Dependence and Environmental Impact

The SL-HEP played a direct role in reducing diesel fuel consumption and CO_2 emissions by installing 627 kWp of solar PV capacity in Phase 1, displacing fossil fuel reliance in hospitals.

Quantitative Evidence: Diesel consumption dropped by 38% at the six hospitals, translating into an estimated 38% annual CO_2 reduction of 72 metric tons per year across the six hospitals post-installation (based on pre/post-intervention diesel use and standard emissions factors).

Qualitative Evidence: Hospital staff no longer experience frequent fuel shortages, reducing disruptions in essential medical services. Additionally, healthcare workers noted improved air quality inside hospital compounds, as reduced diesel genset use has led to lower exposure to fumes and noise pollution.

Counterfactual Considerations: While Sierra Leone's national renewable energy goals promote hospital electrification, there were no alternative ongoing government or donor projects that could have achieved this level of diesel displacement within the same timeframe. Without SL-HEP, hospitals would have continued operating under high-cost, unreliable diesel dependency.

Causal Contribution to Economic and Workforce Outcomes

The SL-HEP's contribution to economic benefits and job creation is less direct but still observable through its training and workforce development initiatives.

Women in STEM Training: SL-HEP trained 23 female technicians in solar PV installation and maintenance across Phase 1 and Phase 2, demonstrating a direct impact on workforce capacity development in the renewable energy sector. Limited job placement post-training suggests, however, that while SL-HEP provided valuable skills development, it did not create sustained employment pathways, limiting its long-term economic impact.

Healthcare Workforce Motivation: Interviews with hospital staff indicate increased job satisfaction due to improved workplace conditions, particularly in critical care wards.

Reduced staff absenteeism and delays at hospitals like Masanga and Bonthe suggest a positive behavioural shift linked to better energy reliability, though this change is difficult to quantify.

Counterfactual Considerations: Without SL-HEP, it is unlikely that an alternative workforce development initiative focusing on women in solar energy would have been implemented at this scale. Economic benefits could, however, have been amplified if stronger employment placement mechanisms were built into the project.

Limitations and Alternative Explanations

While the SL-HEP's contribution to energy access, service delivery, and environmental impact is strongly supported by quantitative and qualitative evidence, certain limitations and external factors must be considered:

Health Outcome Attribution Challenges: While improved electricity reliability enables better maternal and neonatal care, the lack of systematic health data collection from the MoH impedes a robust analysis of the direct attribution of mortality reductions to the intervention. Other factors, such as staffing levels, medical supply chains, and broader healthcare investments, also influence patient outcomes.

Energy Management Variability: While SL-HEP provided solar PV systems, the behaviours of the hospital staff and the institutional energy management practices affect system efficiency. The persistence of inefficient energy use (e.g., personal appliance use, lack of night-time shutdown protocols) means that some hospitals have more consistent power availability (especially at night) and are likely to provide better services than others.

Policy and Funding Gaps: SL-HEP successfully demonstrated the feasibility of solar electrification in hospitals, but its long-term impact depends on integration into long-term national policies and sustained funding mechanisms. Without structured O&M planning, the benefits could diminish over time, making attribution of long-term sustainability more uncertain.

Summary/Conclusion

The attribution analysis confirms that the SL-HEP played a decisive role in improving energy reliability, reducing environmental impact, and enhancing workforce conditions within the targeted healthcare facilities. The project's solar PV installations directly contributed to greater electricity uptime, which in turn enhanced hospital operations and service delivery, particularly in

maternal and emergency care units. Additionally, the reduction in diesel consumption has led to lower CO_2 emissions, demonstrating clear environmental benefits.

Beyond energy access, the SL-HEP has positively influenced healthcare workforce motivation, with staff reporting improved working conditions and job satisfaction due to consistent electricity availability. The project's Women in STEM training initiative successfully provided technical skills to 23 female trainees, though its long-term employment impact remains limited, highlighting the need for stronger job placement mechanisms.

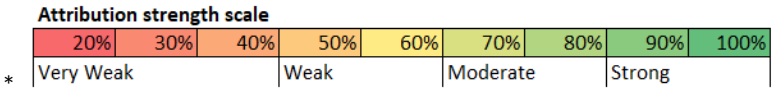
Despite these successes, the attribution strength for health outcomes, economic benefits, and long-term sustainability is lower, primarily due to gaps in systematic data collection and financial planning for ongoing system maintenance. The extent to which improved electricity access has directly contributed to patient outcomes is difficult to quantify without robust health impact monitoring, and uncertainties around O&M financing raise concerns about the project's long-term viability.

Figure 14 below presents an overview of SL-HEP's attribution strength across key impact areas, illustrating where the project had the most direct influence and where additional interventions may be needed to ensure sustained benefits and scalability.

Figure 14. SL-HEP's attribution strength across key impact areas

Outcome	Attribution Strength*	Justification
Electricity Reliability	95% (Strong)	Directly measured via RMS logs, the immediate and sustained effects. Attributed benefits extend to healthcare workers and patients who now have consistent access to lighting, refrigeration, and medical devices—enabling uninterrupted service delivery, especially during night shifts and emergencies.
Efficiency	70% (Moderate)	RMS and facility data show reductions in diesel consumption at several hospitals, contributing to operational savings and more efficient energy use. Inconsistent energy management practices increase the total load at some facilities, and the use of hospital power for non-essential appliances tempered the full efficiency gains.
Diesel Consumption Reduction	60% (Weak)	Genset usage is tracked exclusively by Prospect RMS logs; however, significant data gaps hinder precise analysis.
CO_2 Emissions Reduction	60% (Weak)	Estimates are derived using conversion factors, based on indirect measurements from incomplete Prospect RMS logs.

Outcome	Attribution Strength*	Justification
Healthcare Service Delivery Improvements	75% (Moderate)	Hospitals report improved maternal and emergency care, but lack of systematic health outcome tracking limits direct attribution.
Healthcare Workforce Motivation & Efficiency	80% (Moderate)	Staff interviews confirm improved morale, efficiency, and safety, but other factors (e.g., staffing levels, working conditions) contribute.
Women in STEM Training & Job Impact	70% (Moderate)	23 women trained, but limited employment pathways reduce long-term impact.
Long-term Sustainability (O&M & Financial Viability)	60% (Weak)	SL-HEP provided an initial system setup, but the lack of structured funding for maintenance limits sustained impact.



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5.5. External Influences

SL-HEP was implemented in a dynamic environment influenced by multiple external factors that shaped its outcomes. While the project was designed to improve healthcare service delivery through reliable electricity, several contextual elements played a role in either amplifying or moderating its impact.

- **Macroeconomic and Political Context:** Sierra Leone's economic volatility, characterised by inflationary pressures and budgetary constraints within the public health sector, affected hospitals' ability to fully leverage the benefits of electrification. Government funding for hospital operations remained limited, which in some cases constrained the ability of facilities to scale up medical services despite improved energy reliability.
- **Seasonal Variability and Climate Factors**: The effectiveness of the solar PV systems varied with seasonal shifts. During the last rainy season, hospitals experienced challenges in maintaining battery charge levels, which increased reliance on diesel gensets. This factor, beyond the control of the project, impacted hospitals' ability to fully transition away from fossil fuels, particularly in facilities with relatively smaller solar systems and/or lower battery storage capacity.

- **Ongoing energy crises:** Sierra Leone's energy sector is severely mismanaged and has proven to be increasingly volatile with time. Multiple prolonged blackouts impacted Freetown and other parts of the country in 2024, undermining the reliability of the national grid. Hospitals connected to the grid, such as ODCH and PCMH, must effectively utilise alternative electricity sources, such as backup gensets or solar power, to ensure uninterrupted services.
- **Healthcare System Constraints:** While the SL-HEP addressed the critical challenge of unreliable electricity, systemic healthcare issues, such as shortages of trained medical personnel, inconsistent supply chains for essential medicines, and limited financial resources, also influenced overall hospital performance. The availability of power alone did not immediately translate into improved health outcomes in all cases due to these underlying constraints.
- **Parallel Development Initiatives:** Other donor-funded healthcare interventions coincided with the implementation of the SL-HEP. Some hospitals benefited from additional support, such as improved medical equipment donations and infrastructure rehabilitation projects, which made it challenging to isolate the sole contribution of solar electrification to improved healthcare outcomes. These synergies did, however, reinforce the broader impact of the project by complementing its benefits.

5.6. Unexpected Impacts

The SL-HEP generated several unintended outcomes, some of which enhanced its impact beyond its initial objectives, while others introduced new challenges.

5.6.1. Positive Unintended Effects

- **Enhanced staff retention and workforce satisfaction**: Hospital staff widely reported greater motivation and improved working conditions due to stable electricity. In some cases, facilities that previously struggled to attract qualified personnel saw increased interest from healthcare professionals seeking assignments in hospitals with reliable power and improved living conditions.
- **Operational efficiency gains beyond energy access**: Maintenance teams and hospital administrators observed broader improvements in facility management as a result of the discipline introduced by structured energy management. Hospitals that previously lacked a culture of preventative maintenance demonstrated increased attentiveness to infrastructure upkeep beyond just the solar systems.
- **Boosted perceptions of government and development partners**: Patients and community members perceived the electrification of hospitals as a tangible improvement in public services, strengthening trust in both the healthcare system and the role of

development partners in delivering essential services. This was particularly evident in rural hospitals, where unreliable power was previously a major barrier to healthcare access.

- **Indirect economic benefits to local vendors**: While direct job creation from the installation of solar PV systems was limited, some hospitals observed increased economic activity around their facilities. Vendors selling food, medical supplies, and other goods reported higher customer traffic, possibly linked to improved hospital functionality and increased patient volume.

5.6.2. Negative Unintended Effects

Increased electricity demand beyond system capacity: Reliable electricity led to a surge in energy use, with some hospitals experiencing higher-than-expected demand. Staff sometimes connected personal appliances, such as refrigerators and fans, to the hospital power supply, creating strain on battery storage. While monitoring systems detect these issues, continued supervision and energy efficiency training are needed to sustain optimal system performance.

Security and theft risks for solar infrastructure: In at least one hospital, concerns were raised about the security of ground-mounted PV panels and battery storage units, particularly in facilities without proper fencing or security protocols. While no major incidents were reported during Phase 1, the risk of theft or vandalism remains a potential challenge that needs to be addressed in sustainability planning.

6. Recommendations

The recommendations below have been structured to align with the new Theory of Change, focusing first on the five groups of recommendations within SEforALL's sphere of influence that contribute directly to project outputs, outcomes, and impacts. Additional recommendations that relate to SEforALL activities follow and could be undertaken to improve its ability to monitor, evaluate, and learn from project outputs, actions, and impacts.

1. **Technical design**.
    a. **Increase battery storage capacity.** Current battery storage is insufficient to ensure uninterrupted overnight power, leading to continued reliance on diesel gensets in some hospitals. SEforALL should assess the feasibility of increasing battery capacity to reduce genset dependency, particularly during nighttime.
    b. **Optimise grid integration at ODCH/PCMH.** The hospitals still operate in bypass mode, meaning solar power is not being fully utilised for voltage stabilisation. A more efficient switching system is needed that allows the hospital to prioritise PV

power, complemented by the grid, and only switch to the genset to preserve the battery system's state of charge.

c. **Improve system monitoring and data integration.** There are inconsistencies in monitoring uptime and genset usage across hospitals due to missing or unreliable data from multiple remote monitoring platforms. To capture more accurate data will likely require deploying a more rigorous and unified monitoring system that 1) can Integrate data from multiple sensor platforms, 2) has sufficient local storage to maintain data integrity in the event of short- to medium-term network downtime, and 3) uses current transformers (CTs) upstream of power sockets (i.e., at the circuit breaker) to avoid human-induced sensor downtime.

d. **Standardise security measures for ground-mounted PV systems.** Lack of adequate lighting and security measures increases the risk of theft and vandalism in some locations.

e. **Assess the feasibility of electrifying staff quarters.** Some hospitals provide 24/7 power to staff quarters, while others do not, impacting staff comfort and retention. Electrifying staff quarters is likely to enhance retention rates and satisfaction among healthcare personnel.

f. **Standardise containerised powerhouses to store system components, including the batteries and inverter**. Storage conditions vary across hospitals, with some facilities using insecure or poorly ventilated rooms. A standardised solution is needed for better security and equipment longevity.

g. **Ensure PV system modularity and scalability** to accommodate future demand growth. The technical design should be adaptable, allowing for seamless expansion and integration of additional capacity as healthcare needs evolve.

2. **Sustainability, planning, and institutionalisation**

   a. **Develop a long-term O&M financial forecast**. SEforALL should work with the Ministry of Health (MoH) to budget for O&M and component replacement costs, ensuring sustainability beyond donor funding.

   b. **Develop a long-term O&M strategy with government partners**. There is uncertainty over long-term O&M responsibilities and financial sustainability. A comprehensive O&M strategy must be developed in collaboration with key stakeholders, including government ministries, donors, and implementing partners, to ensure sustainability, cost-effectiveness, and accountability. This should include:

      i. Clearly defining which entity is responsible for the ongoing maintenance, repairs, and monitoring of PV systems.

ii. Determining whether a public, private, or hybrid model will be used for O&M, with contractual obligations and service agreements where applicable. Different models might be necessary depending on specific factors, such as hospital type or system specifications.
iii. Carefully estimate the O&M costs at project inception so it can be properly funded. Having an initial cost strategy can motivate investors and can ensure the responsible entity fully understands the long-term O&M costs and component replacement cycles.
iv. Requiring formal sign-off from the responsible entity on system design before installation.
v. Ensuring the responsible entity is involved in all project stages, including site selection, system sizing, and supplier selection for future projects. For existing systems, the relevant Ministries (MoH and MoE) need to be involved in long-term O&M planning.

c. **Develop a short-term O&M strategy to ensure existing installations are served while the long-term national O&M strategy is being developed**. While a long-term strategy is necessary, a temporary solution to ensure these installations are serviced beyond the current O&M contracts is crucial to ensure system uptime.
d. **Develop robust O&M contracts** that include clear performance indicators and Service Level Agreements (SLAs). Regardless of the selected counterparty, contracts should establish accountability by tying service payments to the achievement of defined performance metrics and timely service delivery. This ensures that providers are incentivised to maintain high-quality, responsive support.
e. **Support the establishment of a multi-donor fund for O&M financing.** Sierra Leone's government lacks a sufficient budget to fund ongoing maintenance and component replacements. A dedicated O&M financing mechanism is needed.
f. **Clarify stakeholder responsibilities for O&M.** There is no consensus on whether the Ministry of Energy, the Ministry of Health, or a future Rural Electrification Agency should take full ownership of long-term system maintenance.
g. **Improve procurement planning for spare parts.** Hospitals report difficulties replacing essential components (e.g., light tubes and fans). More robust spare parts provision and stock management are required. Hospitals should be provided with an initial stock of critical spare parts, and a clear procurement pathway should be established for future needs.

h. **Training and maintenance manuals**. Ensure that the hospitals receive training or user manuals to help them manage the systems, troubleshoot issues, and conduct regular maintenance.
i. **Provide maintenance tools**. Provide site-specific maintenance tools to ensure proper system upkeep. Example: The hose provided to Kabala Hospital for PV panel cleaning is too short for rooftop installations.
j. **Implement a digital ticketing system for O&M requests**. Maintenance requests are currently tracked manually, leading to inefficiencies. A digital system would improve response times and better track service quality.

3. **System installation and operation**.
    a. **Ensure hospitals have hired maintenance officers before the installation of the solar system.** Some hospitals lack maintenance personnel, creating risks for long-term system sustainability. A maintenance officer should be a prerequisite for installation.
    b. **Display a toll-free service number for maintenance support**. A toll-free service number should be displayed on solar installations (e.g., on the powerhouse) to ensure hospital staff always know how to report technical issues.
    c. **Provide maintenance tools and installation diagrams**. Hospitals should be provided with proper tools for system upkeep. For example, Kabala Hospital received a PV panel cleaning hose that was too short for rooftop installations. Future projects should ensure that site-specific maintenance tools and installation diagrams are provided to each hospital.
    d. **Prompt maintenance officers to actively track genset diesel fuel consumption.** Hospitals should place a logbook next to each genset so maintenance officers can keep track of the volume of diesel fuel being consumed in real time. This practice will complement the RMS data collection and allow more accurate tracking of genset use.

4. **Capacity building and workforce development**.
    a. **Training manuals.** Ensure that the hospitals receive training or user manuals to help them manage the systems, troubleshoot issues, and conduct regular maintenance.
    b. **Establish a structured refresher training programme.** Maintenance personnel require refresher training six months post-installation to reinforce skills and prevent system mismanagement.

c. **Expand energy efficiency training for hospital staff**. Hospitals report wasteful energy use, such as leaving air conditioning units running overnight. Training should focus on sustainable energy management.
d. **Strengthen job placement pathways for Women in STEM trainees**. While training programmes have successfully equipped women with technical skills, many struggle to find employment in the energy sector. Stronger job placement and mentorship support are needed.
e. **Retain Women in STEM trainees as mentors**. Past trainees should be engaged as mentors or supervisors for new training cohorts, ensuring skill retention and continued engagement in the energy sector.
f. **Establish specialised training for AlphaESS systems** to build in-country expertise in installation, operation, and maintenance. Given the technical complexity of these systems and the limited local capacity, targeted training will be essential to ensure long-term sustainability and optimal performance.

5. **Sustainable deployment of modern electrical equipment**.
    a. **Ensure deployment of energy-efficient hospital equipment.** Some hospitals continue using outdated, high-energy-consuming medical and electrical devices. Collaboration with the MoH and donors is needed to ensure hospitals receive modern, efficient equipment that aligns with the capabilities of their solar PV systems, including oxygen concentrators, diagnostic machines, and neonatal care appliances.
    b. **Expand the power supply to support additional oxygen generation.** Many hospitals lack sufficient oxygen supply due to power limitations and inadequate on-site generation. PV systems and battery storage should be optimised to support continuous oxygen production, while collaboration with the MoH should facilitate deployment of additional oxygen plants to reduce reliance on external supply chains.
    c. **Integrate smart technology for energy management.** Hospitals face challenges with inefficient energy use, including unnecessary overnight air conditioning and unauthorised personal appliances. Deploying smart energy management systems, such as occupancy- or time-based controls for AC units and systems to detect unusual loads (e.g., from personal fridges), could help optimise electricity demand, extend battery life, and reduce unnecessary strain on hospital power systems.

6. **Improvement in economic impact.**
    a. **Conduct a study to understand economic spillover effects.** Preliminary insights from IA fieldwork suggest that micro-businesses, such as food vendors, may

experience increased customer traffic linked to improved hospital functionality and increased patient volumes. However, these effects were difficult to quantify through the existing fieldwork. A focused study could generate more robust evidence on the broader local economic impacts.

The below suggestions, if acted upon, could help SEforALL improve its ability to monitor, evaluate, and learn from the SL-HEP's outputs, actions, and impacts.

- **Improve health data tracking and reporting**. Support MoH to strengthen data collection and reporting. Implement standardised digital reporting tools to ensure consistent tracking of maternal and infant health outcomes across all healthcare facilities. As part of this, address facility-specific data gaps as detailed in Figure 56.
- **Enhance monitoring of electricity system performance**. As mentioned in the section on 'Technical design' recommendations, a more robust remote monitoring system will allow SEforALL to more confidently track the reliability, sufficiency, affordability, and cleanliness of health facility power systems and take action to maximise these elements, increasing the likelihood of greater project impacts. Future RMS shouldn't rely exclusively on one communication protocol, and it should integrate a memory system. A combination of cellular and WiFi protocols can reduce the risk of underreporting, while having a memory system can ensure collected data is not lost.

7. KPI Data Summary

This section summarises the baseline and post-solarisation data collection for all hospitals in Phase 1. In cases where there is more than one data source, an accent box or highlighted cells identify which source was used to calculate the improvements relative to the baseline.

The KPI quantitative analysis uses RMS data from three different platforms installed at each facility, each measuring different system components. Figure 15 describes the sensors employed at the SL-HEP sites; a complete list of sensors installed in facilities across the three phases of the project can be found in Annexe II: List of remote monitoring systems in place for all Phases.

Figure 15. Summary of RMS deployed at Phase 1 hospitals

Sensor	System Scope	Specific Indicators	Data Reliability
Alpha ESS	SEforALL solar PV installations	• Daily solar generation • Daily load • Battery SoC • PV system uptime • Number of outages (inferred)	High
nLine	Room-level quality of electricity service	• Daily duration of outages • Daily frequency of outages • Average length of outages • Voltage • Frequency • Time outside nominal voltage range	High[3]
Prospect	Electricity generation by source	• Electricity generation from gensets, solar PV systems, and the grid (where applicable)	Low

This section uses a **confidence level scale** for each indicator to illustrate the reliability of the data. The scale is comprised of the following levels:

- Low: The data is drawn from multiple sources with differing methodologies, often combining incomplete RMS data with information collected through on-site interviews reliant on human recollection. While this approach attempts to fill gaps using the most reliable information available, the resulting dataset has limited reliability.
- Medium: Similar to the "Low" level, the data originates from mixed sources with different collection methods. However, there is a slightly higher level of confidence in the quality and consistency of the data.
- High: The data comes directly from RMS sources that consistently provide complete, high-quality information.

[3] While nLine sensors provide reliable data, their system-level calculation methodology introduces complexities that may portray indicators as worse than they are in reality. Following the impact assessment of the first year of operations, nLine budget was not available and the remote monitoring systems became less reliable for longer term impact assessment using this source.

This section also summarises qualitative findings from the on-site visits that took place between January and February 2025. Annexe V: Interview Guide Phase 1 Health Facilities depicts the interview guide that was used at each facility.

7.1. Climate

7.1.1. List of Gensets at each facility

There are discrepancies regarding the size and number of gensets being used at each facility.

Figure 16. List of gensets located at each Phase 1 hospital[4]

Facility	Baseline (kVA)	Catalyst (kVA)	Prospect (kVA)
Kabala	100	100	100
		150	
		Small	
Masanga	50	100	50
Bonthe	100	100	100
Kambia	35	35	35
	10	10	10
ODCH	100	100	100
PCMH	22	27	22
	16 (not in use)	100 (not in use)	16 (not in use)

For the baseline study, Prospect data was used as a source, hence both baseline and Prospect columns are matching. The Catalyst data comes directly from field interviews and observations. It is unclear why there are discrepancies, but it is likely that Prospect doesn't always capture updated genset capacity data, as it needs to be updated manually.

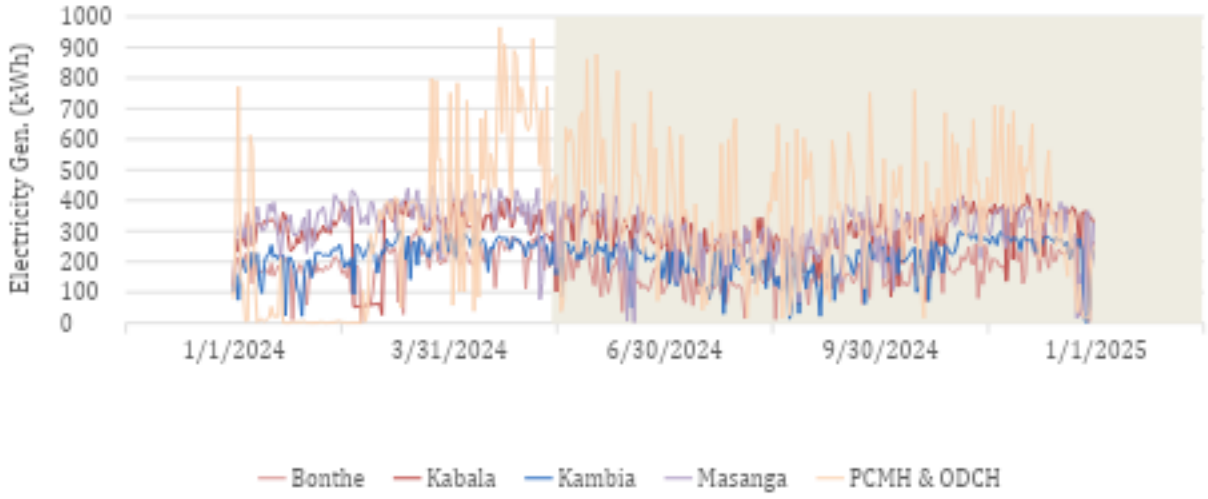
The 150 kVA genset in Kabala is used for the oxygen plant; this demand is expected to be met by the expansion of the solar PV system. The additional small genset in Kabala supplies the mortuary.

7.1.2. Seasonality

Sierra Leone's climate consists of two seasons: 1) a rainy season from May to November, and 2) a dry season from December to April. Seasonality directly impacts the country's power systems; reduced solar radiation during the rainy season leads to increased use of alternative electricity sources, such as the grid, where available and gensets in areas that are not connected to the national grid. Data from Alpha ESS illustrates these seasonal changes, showing decreased electricity production from solar PV systems during the rainy season.

[4] The sources of data correspond to Crown Agent's Baseline Report, Catalyst Energy Advisor's on-site interviews, and RMS data from Prosect/A2EI sensors by column, respectively.

Figure 17. Daily electricity generation from the solar PV system at Phase 1 hospitals



7.1.3. Diesel consumption from gensets

Target: There is no defined target for the reduction of diesel consumption from gensets at the targeted facilities. However, it remains a critical climate KPI as it currently presents the most reliable and straightforward pathway to calculating avoided CO_2 emissions at facilities.
2024 actual: 38% reduction in diesel consumption per year (or 22,492 fewer litres consumed)
Confidence level: Medium

Figure 18 shows the estimated volume of diesel fuel consumed by gensets at Phase 1 hospitals. The accent box or highlighted cells identify which source was used to calculate the improvements relative to the baseline, in this case, comparing baseline data as presented in Crown Agent's baseline report and post-installation data from Catalyst and Tetra Tech[5].

Figure 18. Estimated volume of diesel consumed by gensets at Phase 1 hospitals

Facility	Baseline (12 Sept. - 11 Dec. 2023)			Post Installation (1 Jan - 31 Dec. 2024)			Selected Baseline (litres/yr)	Selected Post Installation (litres/yr)
	Est. Diesel Cons. (litres/yr) [Report]	Est. Diesel Cons. (litres/yr) [Prospect]	Est. Diesel Cons. (litres/yr) [Catalyst]	Est. Diesel Cons. (litres/yr) [Tetra Tech]	Est. Diesel Cons. (litres/yr) [Prospect]	Est. Diesel Cons. (litres/yr) [Catalyst]		
Total	58,437	36,627	94,899	32,572	3,846	62,178	58,437	35,945
Kabala	7,629	4,312	15,600	12,987	1,911	5,200	7,629	5,200
Masanga	34,675	20,510	21,900	-	96	11,160	34,675	11,160
Bonthe	1,789	993	38,325	3,460	122	27,720	1,789	3,460

[5] Tetra Tech is the project management firm that took over mid-project from Crown Agents. This shift posed a limitation in knowledge transfer and consistency throughout the assessment.

Facility	Baseline (12 Sept. - 11 Dec. 2023)			Post Installation (1 Jan - 31 Dec. 2024)			Selected Baseline (litres/yr)	Selected Post Installation (litres/yr)
	Est. Diesel Cons. (litres/yr) [Report]	Est. Diesel Cons. (litres/yr) [Prospect]	Est. Diesel Cons. (litres/yr) [Catalyst]	Est. Diesel Cons. (litres/yr) [Tetra Tech]	Est. Diesel Cons. (litres/yr) [Prospect]	Est. Diesel Cons. (litres/yr) [Catalyst]		
Kambia	8,651	6,684	12,000	8,009	572	12,000	8,651	8,009
ODCH	4,964	4,128	6,000	8,117	1,144	4,500	4,964	8,117
PCMH	730		1,074			1,598	730	

Figure 19. Improvement against the baseline of the volume of diesel consumed by gensets

Facility	Improvements vs. baseline	
	Absolute (litres/yr)	%
Total	-22,492	-38%
Kabala	-2,429	-32%
Masanga	-23,515	-68%
Bonthe	1,671	93%
Kambia	-642	-7%
ODCH	2,423	43%
PCMH		

Prospect sensors do not track diesel consumption data. Instead, to estimate diesel consumption from Prospect data, we applied conversion factors relating the volume of diesel to energy generation (see Annexe I: Emission factors for diesel fuelled gensets) based on the size of the genset at each facility.

Diesel consumption data for the baseline period was sourced from Crown Agent's baseline report and checked against RMS data from Prospect and on-site interviews conducted by Catalyst. There are key discrepancies between these sources, as Prospect data has significant gaps while Catalyst's interview data relied on recall, leading to potential inaccuracies. Given these limitations, the baseline report's figures were selected as the primary reference.

Post-solarisation diesel consumption data were drawn from weekly cost data provided by Tetra Tech, fuel cost and volume estimates gathered during Catalyst's field visits, and Prospect data, where applicable. However, Prospect data consistently underestimated fuel use, so Tetra Tech estimates were used for Bonthe, Kambia, ODCH, and PCMH. Tetra Tech did not have data for Masanga, and Kabala's data was an outlier, so Catalyst's figures were used for these hospitals.

Among the individual hospitals, Bonthe recorded the highest apparent increase in fuel consumption—likely due to underreporting during the baseline period. The baseline relied on data from the Prospect platform, but Catalyst's analysis suggests the sensor captured genset

data for only 63 days between September 2023 and December 2024, raising concerns about data completeness and accuracy. In contrast, on-site interviews estimate actual diesel consumption to be approximately 30 times higher than what was recorded. At Kambia Hospital, fuel consumption remained largely unchanged, as the genset reportedly continued running for six hours per day; however, prior to solarisation, the hospital had no electricity during the remaining 18 hours, indicating a substantial improvement in total energy access. Overall, diesel consumption across all Phase 1 hospitals decreased by 38% post-solarisation, highlighting the significant impact of solar PV integration.

7.1.4. Reduction of total CO2 emissions produced by gensets

Target: 75% reduction compared to the baseline value for all Phase 1 hospitals.
2024 actual: 38% reduction (72 tons fewer of CO_2 emitted per year)
Confidence level: Medium

Figure 20 shows the estimated CO_2 emissions produced by gensets at Phase 1 hospitals. The accent box or highlighted cells identify which source was used to calculate the improvements relative to the baseline, in this case comparing baseline data that was recalculated by Catalyst based on the fuel consumption presented in Crown Agent's baseline report and post-installation data from Catalyst and Tetra Tech.

Figure 20. Annual CO_2 emissions emitted from diesel genset use at Phase 1 hospitals

Facility	Baseline (12 Sept. - 11 Dec. 2023)			Post Installation (1 Jan. - 31 Dec. 2024)			Selected Baseline (ton/yr)	Selected Post Installation (ton/yr)
	CO_2 Emissions (ton/yr) [Report]	CO_2 Emissions (ton/yr) [Catalyst Recalc]	CO_2 Emissions (ton/yr) [Catalyst]	CO_2 Emissions (ton/yr) [Catalyst]	CO_2 Emissions (ton/yr) [Prospect]	CO_2 Emissions (ton/yr) [TetraTech]		
Total	93	187	304	199	12	104	187	115
Kabala	12	24	50	17	6	42	24	17
Masanga	55	111	70	36	0	-	111	36
Bonthe	3	6	123	89	0	11	6	11
Kambia	14	28	38	38	2	26	28	26
ODCH	8	16	19	14	4	26	16	26
PCMH	1	2	3	5			2	

Figure 21. Improvement against the baseline of annual CO2 emissions emitted from diesel gensets

Facility	Improvements vs. baseline	
	Absolute (ton/yr)	%
Total	-72	-38%
Kabala	-8	-32%
Masanga	-75	-68%

Facility	Improvements vs. baseline	
	Absolute (ton/yr)	%
Bonthe	5	93%
Kambia	-2	-7%
ODCH	8	43%
PCMH		

The baseline CO_2 emissions as reported in the baseline report have been recalculated to account for variations in greenhouse gas (GHG) emissions factors across gensets of different sizes. The original report applied a uniform factor of 0.8 tCO_2/MWh for all hospitals; however, in reality, only gensets of 135 kWp or larger achieve such low emissions intensities.[6] To improve accuracy, additional baseline calculations were performed using diesel consumption data collected during field visits, which are considered more reliable.

For post-installation emissions, the data source selection followed the same methodology used for the diesel consumption from the gensets indicator. Because CO_2 emissions are directly proportional to diesel use, a standard conversion factor of 3.2 kg CO_2 per litre of diesel was applied. Based on this, CO_2 emissions from genset use decreased by 38%, equivalent to approximately 72 tons of avoided CO_2 annually. However, there is a possibility that facility managers are overestimating current fuel consumption. If instead we rely on RMS data from Prospect, avoided CO_2 emissions could be as high as 149 tons per year—an 80% decrease compared to the recalculated baseline. Given the high level of uncertainty surrounding the data, it is not possible to conclusively determine whether the project met its 75% CO_2 reduction target. Nevertheless, there is clear evidence of reduced diesel use and a significant decrease in CO_2 emissions. Assuming a 20-year project lifetime, 72 tons of annual avoided CO_2 translates to 1,439 tons of lifetime emissions avoided.

A less conservative method for estimating avoided emissions would involve calculating the CO_2 that would have been produced if all additional electricity supplied by the solar PV systems had instead been generated by right-sized diesel generators. Using this approach, the emissions would have amounted to approximately 446 tons of CO_2 in 2024 alone, or 8,912 tons over a 20-year period.

Target: There is currently no target for this indicator.
2024 actual: 79 tons of CO_2 avoided CO_2 annually (36% reduction vs. the baseline)
Confidence level: Low

[6] https://cdm.unfccc.int/UserManagement/FileStorage/YP1U4E0H976Z3WDMV2NGSTBLQIRCK5

Figure 22. Total CO_2 emissions from electricity consumption

Facility	Baseline (12 Sept. - 11 Dec. 2023)		Post Installation (1 Jan. - 31 Dec. 2024)		Total Baseline CO_2 Emissions (ton/yr)	Total Post Inst. CO_2 Emissions (ton/yr)
	Genset CO_2 Emissions (ton/yr) [Catalyst Recalc]	Grid CO_2 Emissions (ton/yr) [Catalyst]	Genset CO_2 Emissions (ton/yr) [Selected Baseline]	Grid CO_2 Emissions (ton/yr) [Catalyst]		
Total	187	33	115	26	220	141
Kabala	24		17		24	17
Masanga	111		36		111	36
Bonthe	6		11		6	11
Kambia	28		26		28	26
ODCH	16	14	26	26	30	52
PCMH	2	18			21	

Figure 23. Improvement against the baseline of total avoided CO_2 emissions from electricity consumption

Facility	Improvements vs. baseline	
	Absolute (ton/yr)	%
Total	-79	-36%
Kabala	-8	-32%
Masanga	-75	-68%
Bonthe	5	93%
Kambia	-2	-7%
ODCH	1	1%
PCMH		

This indicator accounts for estimated CO_2 emissions from genset use at each facility and electricity consumption from the national grid (for ODCH and PCMH only). Genset-related CO_2 emissions were calculated using baseline and post-installation values from Figure 20. Emissions from grid electricity were estimated based on grid electricity demand reported in the baseline study and post-solarisation demand measured through RMS data from AlphaESS and Prospect, applying a CO_2 emission factor of 0.048 t/MWh[7].

7.1.5. Genset uptime

Target: 75% reduction of run-time compared to the baseline.
2024 actual: 52% reduction in genset uptime
Confidence level: Low

[7] Electricity Data Yearly Release, EMBER, April 2024

Figure 24 shows average daily genset uptime at Phase 1 hospitals. The accent box or highlighted cells identify which source was used to calculate the improvements relative to the baseline, in this case, comparing baseline data as presented in Crown Agent's baseline report and post-installation data from Catalyst and nLine.

Figure 24. Average daily genset uptime at Phase 1 hospitals

Facility	Baseline (12 Sept. - 11 Dec. 2023)		Post Installation (1 Jan. - 31 Dec. 2024)		Selected Baseline (hrs/day)	Selected Post Installation (hrs/day)
	Average Uptime (hrs/day) [Report]	Average Uptime (hrs/day) [nLine]	Average Uptime (hrs/day) [Catalyst]	Average Uptime (hrs/day) [nLine]		
Average	3.8	2.9	4.1	0.4	3.8	1.8
Kabala	3.5	3.4	4.0	0.8	3.5	4.0
Masanga	11.5	6.5	3.0	1.0	11.5	3.0
Bonthe	1.7	2.7	3.5	0.1	1.7	3.5
Kambia	3.4	4.7	6.0	0.3	3.4	0.3
ODCH	1.4	0.0	-	0.0	1.4	0.0
PCMH	1.1	0.1	-	0.0	1.1	0.0

Figure 25. Improvement against the baseline of average daily genset uptime

Facility	Improvements vs. baseline	
	Absolute (hrs/day)	%
Average	-2.0	-52%
Kabala	0.5	15%
Masanga	-8.5	-74%
Bonthe	1.9	112%
Kambia	-3.2	-92%
ODCH	-1.4	-100%
PCMH	-1.1	-99%

Obtaining reliable genset uptime estimates has proved challenging. While nLine RMS attempts to capture said data, Catalyst believes that it does not do so reliably. nLine sensors, in theory, can identify when the load switches from the solar PV system to the gensets, but the team believes that the sensors significantly underestimate genset uptime across all hospitals.

The baseline data presented in Crown Agent's baseline report is comparable to that calculated with nLine, therefore, it was selected as the reference baseline. For the post-solarisation period, the Catalyst team worked to collect its own data during the field visits. However, since reliable

estimates were not obtainable for ODCH, PCMH, and Kambia, the team fell back on nLine estimates for these hospitals.

Masanga, Kambia, ODCH, and PCMH display a reduction of genset uptime for the examination period, while Kabala exhibits a slight increase. Bonthe has increased its daily genset use by about 2 hours per day. Our low confidence level in this KPI is exemplified when comparing the 52% reduction in daily genset uptime across all Phase 1 hospitals and the 38% reduction in diesel use.

7.1.6. Other climate indicators

Figure 26. Other climate indicators

Indicator	Target	Impact Assessment	Additional comments	Confidence level
Uptake of energy-efficient behaviour and equipment	None	Moderate impact	**Positive**: Retrofitting of existing electrical infrastructure has improved efficiency. Staff are actively managing energy use, including switching off ACs at night and identifying non-critical loads to be powered down in the evening. All installed light bulbs and tubes are low-consumption LEDs. **Negative**: Some hospitals reported that staff brought inefficient personal appliances, such as old refrigerators, which had to be confiscated due to excessive energy consumption. No additional energy-efficient equipment (beyond lighting) was introduced.	Medium – Strong qualitative evidence from staff interviews, but no systematic tracking of behavioural changes.

7.2. Energy

7.2.1. Installed capacity of solar & battery storage at Phase 1 hospitals

Target: 500 kWp of installed capacity.
2024 actual: 627 KWp of installed capacity, not including expansions
Confidence level: High

Figure 27. Description and status of solar PV systems installed at Phase 1 hospitals

Facility	Phase 1			Expansion		Total to Date	
	Solar Capacity [kWp]	Battery Capacity [kWh]	Status	Solar Capacity [kWp]	Status	Solar Capacity [kWp]	Battery Capacity [kWh]
Total	627.0	1,561	Commissioned	284.0	Varies	911.0	1,561
Kabala	90.8	290	Commissioned	49.5	Commissioned	140.3	290

Facility	Phase 1			Expansion		Total to Date	
	Solar Capacity [kWp]	Battery Capacity [kWh]	Status	Solar Capacity [kWp]	Status	Solar Capacity [kWp]	Battery Capacity [kWh]
Masanga	105.6	290	Commissioned	52.8	Commissioned	158.4	290
Bonthe	70.4	217	Commissioned	26.5	Commissioned	96.9	217
Kambia	59.4	217	Commissioned	35.2	Commissioned	94.6	217
ODCH PCMH	300.8	547	Commissioned	120.0*	On going	300.8	547

** An additional 150 kWp standalone mini-grid solar PV system is scheduled to be installed at ODCH/PCMH by UNICEF in December 2025. The plant will be dedicated to supplying electricity exclusively to the oxygen plant.*

The data displayed in Figure 16 reflects the latest advancements as shared by SEforALL as of December 2024. The status of expansion projects is subject to change.

The total solar capacity exceeds the target of 500 kWp by 127 kWp, without considering the expansion projects.

7.2.2. Reduction in electricity generation from on-site gensets

Target: 75% reduction compared to the baseline of 320 kWh across the six hospitals.
2024 actual: 12% reduction (~39 fewer kWh from gensets per day)
Confidence level: Low

Figure 28 shows the average daily genset uptime at Phase 1 hospitals. The accent box or highlighted cells identify which source was used to calculate the improvements relative to the baseline, in this case comparing baseline data as presented in Crown Agent's baseline report and post-installation data from Catalyst and Tetra Tech.

Figure 28. Average daily electricity generation from on-site gensets at Phase 1 hospitals

Facility	Baseline (12 Sept. - 11 Dec. 2023)		Post Installation (1 Jan. - 31 Dec. 2024)			Selected Baseline (kWh/day)	Selected Post Installation (kWh/day)
	Generation (kWh/day) [Report]	Generation (kWh/day) [Prospect]	Generation (kWh/day) [Catalyst]	Generation (kWh/day) [Prospect]	Generation (kWh/day) [Tetra Tech]		
Total	320.4	298.5	516.3	30.2	252.0	320.4	281.6
Kabala	41.8	37.8	45.6	16.8	113.9	41.8	45.6
Masanga	190.0	179.8	97.8	0.8	-	190.0	97.8

Facility	Baseline (12 Sept. - 11 Dec. 2023)		Post Installation (1 Jan. - 31 Dec. 2024)			Selected Baseline (kWh/day)	Selected Post Installation (kWh/day)
	Generation (kWh/day) [Report]	Generation (kWh/day) [Prospect]	Generation (kWh/day) [Catalyst]	Generation (kWh/day) [Prospect]	Generation (kWh/day) [Tetra Tech]		
Bonthe	9.9	8.7	243.0	1.1	30.3	9.9	30.3
Kambia	47.4	44.4	79.6	3.8	53.1	47.4	53.1
ODCH	27.1	0.0	39.5	0.0	54.7	27.1	54.7
PCMH	4.2	27.8	10.8	7.7		4.2	

Figure 29. Improvement against the baseline of electricity generated by on-site gensets

Facility	Improvements vs. baseline	
	Absolute (kWh/day)	%
Average	-38.8	-12%
Kabala	3.8	9%
Masanga	-92.2	-49%
Bonthe	20.4	206%
Kambia	5.7	12%
ODCH	23.4	75%
PCMH		

Estimating electricity generation from gensets with RMS data from Prospect is a challenge because of the elevated levels of missing data. On average, there is greater than 90% missing data throughout the six Phase 1 hospitals for the period between September 2023 and December 2024. This was calculated by dividing the total number of reported daily points by the expected number of data points. Prospect sensors omit a significant amount of data points daily and, due to the nature of genset technology, which can be switched on/off instantaneously and can work at any given capacity, there is no way of determining whether the missing data indicates that the genset is not operating or that the sensor is offline.

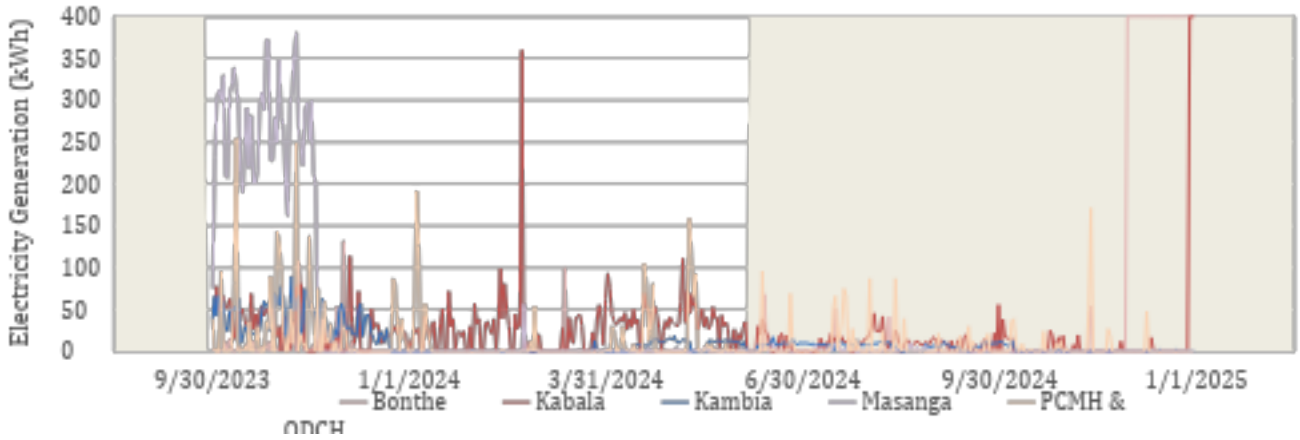
Catalyst and Tetra Tech values for electricity generated with on-site gensets were deemed most reliable and were estimated using standard conversion factors that convert litres of diesel to electricity generation (in kWh). The factors vary according to the size of the genset (see annexe). Annual diesel consumption was determined based on interviews conducted during the field visit with various actors at each facility.

The notable increase in electricity generated from on-site gensets at Bonthe Hospital is attributed to the enhanced reliability of the energy system following solarisation. The hospital

predominantly utilises the gensets during the rainy season to charge the batteries. A similar rationale applies to the hospitals in Kabala, Kambia, ODCH, and PCMH. Masanga Hospital is distinctive in that it had the highest baseline genset usage; consequently, total electricity generation did not increase as observed in other hospitals. Instead, genset usage was directly supplanted by the solar PV system. Overall, we estimate a 12% reduction in electricity demand from on-site gensets across all Phase 1 hospitals, well short of the 75% reduction target. However, given the data gaps and uncertainties regarding the reliability of both baseline and post-solarisation data, our confidence level regarding this KPI is low.

Despite significant data gaps from the Prospect sensors, some insights can be drawn from the available data (Figure 30). For example, Masanga's genset use decreased significantly post-solarisation, and genset use increased during the rainy season (highlighted in grey) at all hospitals.

Figure 30. Daily electricity generation from gensets at Phase 1 hospitals



7.2.3. Absolute amount of on-site renewable energy supplying the facilities

Target: No target has been set for this indicator.
2024 actual: 1,316 kWh per day on average
Confidence level: Medium

Figure 31 shows the average daily genset uptime at Phase 1 hospitals. The accent box or highlighted cells identify which source was used to calculate the improvements relative to the baseline, in this case comparing baseline data as presented in Crown Agent's baseline report and post-installation RMS data from AlphaESS.

Figure 31. Average daily electricity generation from solar PV systems at Phase 1 hospitals.

Facility	Baseline (12 Sept. - 11 Dec. 2023)	Baseline (12 Sept. - 10 Nov. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)		Selected Baseline (kWh/day)	Selected Post Installation (kWh/day)
	Avg. Solar Generation (kWh/day) [Report]	Avg. Solar Generation (kWh/day) [Prospect]	Avg. Solar Generation (kWh/day) [AlphaESS]	Avg. Solar Generation (kWh/day) [Prospect]		
Total	298	370	1,316	287	298	1,316
Kabala	38	41	289	30	38	289
Masanga	234	297	310	109	234	310
Bonthe	0	0	166	-	0	166
Kambia	26	32	215	148	26	215
PCMH	0	0	336	-	0	336
ODCH				-		

Figure 32. Improvement against the baseline of average daily electricity generation from solar PV systems

Facility	Improvements vs. baseline	
	Absolute (kWh/day)	%
Average	1,018	342%
Kabala	251	661%
Masanga	76	32%
Bonthe	166	∞
Kambia	189	725%
ODCH	336	∞
PCMH		

Kambia, Masanga, Kabala, and Bonthe had existing solar PV systems that had been installed to supply specific circuits. The baseline period for Prospect RMS data was adjusted to ensure that the data does not include any generation from the newly installed solar PV systems.

Overall, AlphaESS sensor data appears to be the most complete. Prospect sensor data is unreliable, and the coverage varies from hospital to hospital. Bonthe Hospital, for example, does not have a sensor tracking the solar PV system. For ODCH and PCMH, the sensors tracking the solar PV system are combined with the grid, so there is no way to isolate generation from each source.

In using only AlphaESS data for the post-installation period, we are necessarily underestimating the total solar generation at facilities with other functioning solar PV systems. That said, all hospitals display a significant increase in electricity generation from solar PV systems thanks to

the new installations. Aside from ODCH and PCMH, the newly installed solar PV systems largely replaced the demand that was being met by gensets. However, in some cases, hospitals have focused on leveraging the new solar systems to increase electricity uptime rather than constraining genset use.

7.2.4. Total electricity consumption

Target: There is no defined target for this indicator.
2024 actual: 3,061 kWh per day on average (23% increase vs. the baseline period); 1,206 kWh per day when excluding ODCH/PCMH (105% increase vs. the baseline)
Confidence level: Medium

Figure 33. Average daily electricity consumption at Phase 1 hospitals

Facility	Baseline (12 Sept. - 11 Dec. 2023)			Post Installation (1 Jan. - 31 Dec. 2024)			Total Baseline Cons. (kWh/day)	Total Post Inst. Cons. (kWh/day)
	Avg. Grid Cons. (kWh/day) [Report]	Avg. Genset Cons. (kWh/day) [Report]	Avg. Solar Cons. (kWh/day) [Report]	Avg. Grid Cons. (kWh/day) [AlphaESS/ Prospect]	Avg. Genset Cons. (kWh/day) [Catalyst/ Tetratech]	Avg. Solar Cons. (kWh/day) [AlphaESS]		
Total	1,867	320	298	1,463	282	1,316	2,485	3,061
Kabala	0	42	38	0	46	289	80	335
Masanga	0	190	234	0	98	310	424	408
Bonthe	0	10	0	0	30	166	10	196
Kambia	0	47	26	0	53	215	73	268
PCMH	1,043	4	0	1,463	55	336	1,047	1,854
ODCH	824	27	0				851	

Figure 34. Improvement against the baseline of total average electricity demand

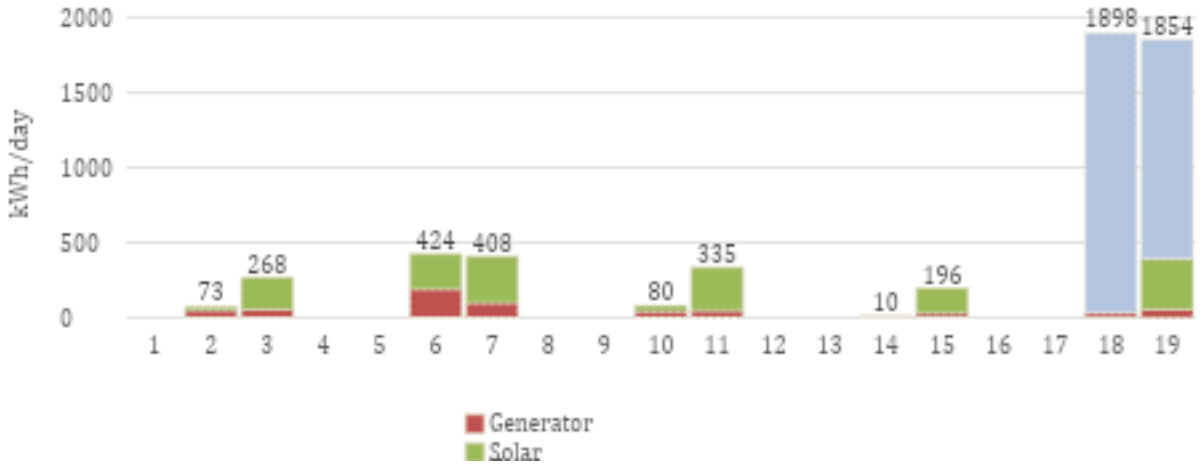
Facility	Improvements vs. baseline	
	Absolute (kWh/day)	%
Total	575	23%
Kabala	255	319%
Masanga	-16	-4%
Bonthe	186	1882%
Kambia	194	265%
ODCH	-44	-2%
PCMH		

As previously noted, significant data gaps in Prospect's RMS data have led to inconsistencies in post-solarisation electricity generation figures across hospitals. For example, at Bonthe Hospital, total electricity consumption only accounts for genset use, because Prospect is not tracking solar

PV generation. Consequently, post-solarisation electricity generation data is compiled from multiple sources, with the most reliable data selected for each energy source.

Kabala, Bonthe, and Kambia show a substantial increase in electricity consumption, while Masanga, ODCH, and PCMH display a slight decrease, which may be attributed to data quality issues rather than an actual reduction in usage. The increase in electricity consumption is likely due to increased use of the service, thanks to the higher availability and reliability.

Figure 35. Baseline and post-installation comparison of average daily electricity generation at Phase 1 hospitals*



**Abbreviations: BL – Baseline, PS – Post-Solarisation*

The figure above shows a graphical representation of the composition of electricity sources for baseline and post-solarisation energy systems at each hospital. The data used corresponds to the data that is displayed in Figure 33.

7.2.5. Share of electricity supplied by on-site renewable energy

Target: an average of 50-75% of the power supply comes from renewable energy sources.
2024 actual: 69% of power supply met by RE sources; 89% when excluding ODCH/PCMH
Confidence level: Medium

Figure 36. Share of electricity generation supplied by on-site renewable energy at Phase 1 hospitals

Facility	Baseline (12 Sept. - 11 Dec. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)	Improvements vs. baseline	
	Share of Solar Generation [Report]	Share of Solar Generation [AlphaESS]	Absolute (%)	%
Average	23%	69%	46%	200%
Kabala	48%	86%	39%	81%
Masanga	55%	76%	21%	38%
Bonthe	0%	85%	85%	∞
Kambia	35%	80%	45%	126%

Facility	Baseline (12 Sept. - 11 Dec. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)	Improvements vs. baseline	
	Share of Solar Generation [Report]	Share of Solar Generation [AlphaESS]	Absolute (%)	%
ODCH PCMH	0%	18%	18%	∞

At the start of the baseline period, some hospitals had existing solar PV systems in place; however, their utilisation was often minimal and insufficient to meet overall hospital energy demand. On-site interviews revealed that these systems often lacked a proper operations and maintenance (O&M) strategy—Masanga Hospital, for example, had been waiting several months for a spare part. In some cases, the systems were installed to serve isolated functions, such as powering a water pump or a specific ward, rather than supporting the hospital's broader energy needs. It remains unclear whether the baseline report's solar PV generation figures include output from the newly installed systems, introducing uncertainty into any comparison between baseline and post-installation performance.

Currently, on-site renewable energy sources supply an average of 69% of total electricity across Phase 1 hospitals.

7.2.6. Solar PV system performance

Target: There are currently no targets for the performance of the solar PV system. Please see the methodology note below the following table.
2024 actual: 51% performance ratio across all five solar systems; 74% when excluding ODCH/PCMH
Confidence level: Low

Figure 37. Solar PV system performance ratio

Facility	Post Installation (1 Jan. - 31 Dec. 2024)
	PV System Performance Ratio
Average	51%
Kabala	78%
Masanga	72%
Bonthe	58%
Kambia	89%
ODCH & PCMH	27%

Note: solar PV performance ratio calculations are currently based on actual AlphaESS solar generation data divided by rough approximations of expected average PV system output given system size and average global horizontal irradiance (GHI) in Sierra Leone of 5.13 kWh per m^2. These figures will be updated if and when actual production estimates from the EPC are provided.

Methodology Note: The solar PV system performance ratio compares the average measured daily power generation to the theoretical maximum generation. Systems operating significantly below 100% are likely curtailing substantial amounts of power due to limited daytime load, insufficient battery capacity, accelerated system degradation, and/or the absence of automated switching between power sources. Performance varies widely across sites. For example, ODCH and PCMH have a performance ratio of just 27%, likely due to the need for manual switching between the grid and the solar PV system. In contrast, Kambia reaches 89%. Bonthe's relatively low performance ratio suggests underutilisation of the solar system, potentially due to a need to connect additional equipment or adjust overly conservative demand-side management practices. Overall, the average performance ratio across all sites is 51%, indicating that a substantial share of clean electricity is being lost due to technical limitations or suboptimal system management.

7.2.7. System battery performance

Target: There are currently no targets for battery performance, measured in terms of the amount of time batteries spend at different states-of-charge (SoC).
2024 actual: On average, systems spend 18% of the time at 100% SoC and 6% of the time at or under their restart SoC threshold; excluding ODCH/PCMH, systems spend just 13% of the time at 100% SoC.
Confidence level: High

Figure 38. Share of time the battery spends at 100% SoC and at or under restart SoC

Facility	Post Installation (1 Jan. - 31 Dec. 2024)	
	Share of Time Batt. at Max SOC	Share of Time Batt. at or Under Restart SOC
Average	18%	6%
Kabala	8%	13%
Masanga	15%	0%
Bonthe	18%	1%
Kambia	12%	5%
ODCH & PCMH	36%	10%

If a system spends a significant amount of time with the battery at 100% state of charge (SoC), it may indicate that the solar PV system is oversized relative to the facility's demand, or that the battery storage is undersized—meaning the battery becomes fully charged quickly during the day while solar generation exceeds consumption. Conversely, if a system frequently operates at or

below the restart SoC threshold, it suggests that the PV system is undersized (i.e., it struggles to fully charge the battery during the day) and/or that the battery lacks sufficient capacity to meet the facility's energy needs through the night.

The share of time the battery is at maximum SOC in ODCH and PCMH is highest among all Phase 1 hospitals, this is due to the system configuration that requires the load to be manually switched to use electricity from the solar PV system, otherwise, it prioritises the grid. Excluding ODCH and PCMH, the battery systems at the remaining Phase 1 hospitals spend about 13% of the time at maximum SOC, across a range of 8% (Kambia) to 18% (Bonthe).

7.2.8. Quality of Electricity Service

7.2.8.1. Mean daily voltage

Target: Nominal voltage in Sierra Leone is 230 V
2024 actual: 228.9V
Confidence level: High

Figure 39 shows the mean daily voltage at Phase 1 hospitals. The accent box or highlighted cells identify which source was used to calculate the improvements relative to the baseline; in this case, both the baseline and post-solarisation data come from nLine.

Figure 39. Mean daily voltage at Phase 1 hospitals

Facility	Baseline (22 Sept. - 31 Dec. 2023)	Post Installation (1 Jan. - 31 Dec.2024)		Improvements vs. baseline	
	Mean Daily Voltage (V) [nLine]	Mean Daily Voltage (V) [nLine]	Mean Daily Voltage (V) [Prospect]	Absolute (V)	%
Average	227.8	228.9	231.5	1.0	47%
Kabala	230.9	228.2	232.3	-0.9	-102%
Masanga	225.2	226.7	229.7	1.5	31%
Bonthe	232.2	231.6	-	0.6	26%
Kambia	213.1	211.6	229.1	-1.6	-9%
ODCH	228.5	238.2	234.9	-6.7	-432%
PCMH	237.2	236.8		0.3	5%

For average daily voltage, nLine data is considered the most reliable due to its high sensor uptime, whereas Prospect data contains significant gaps and is unavailable for some Phase 1 hospitals. Voltage improvements are calculated by subtracting the baseline-to-nominal voltage difference from the post-installation-to-nominal voltage difference.

7.2.8.2. Mean daily hours outside nominal voltage

Target: None
2024 actual: 0.7 hours per day (25% higher than baseline)
Confidence level: High

The total time outside nominal voltage encompasses periods when the system experiences both undervoltage and overvoltage conditions. nLine defines optimal operating conditions when the system doesn't deviate from the nominal voltage by more than 10%. This corresponds to a voltage range between 207 V and 253 V.

Figure 40. Mean daily time that the facility's voltage is outside the nominal range

Facility	Baseline (22 Sept. - 31 Dec. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)	Improvements vs. baseline	
	Avg. Time Outside Nom. Voltage (hrs/day) [nLine]	Avg. Time Outside Nom. Voltage (hrs/day) [nLine]	Absolute (hrs/day)	%
Average	0.6	0.7	0.1	25%
Kabala	0.4	0.0	-0.4	-99%
Masanga	0.8	0.0	-0.8	-99%
Bonthe	0.0	0.0	0.0	-80%
Kambia	1.4	3.6	2.2	160%
ODCH	0.8	0.1	-0.7	-85%
PCMH	0.1	0.7	0.6	555%

With the exception of Kambia, all Phase 1 hospitals maintain stable voltage levels post-solarisation, with minimal deviations from the nominal range. On average, the time spent outside the nominal voltage range has slightly increased to 0.7 hours per day, largely due to Kambia, where nLine data indicates extended periods of low voltage. However, qualitative assessments from on-site visits contradict this finding, as hospital staff report improved voltage stability at Kambia.

A comprehensive analysis of voltage levels and time spent outside nominal voltage shows that Masanga and Bonthe had the most significant improvement post-solarisation. Both hospitals maintain average voltage levels within the nominal range throughout the day. Kabala's average voltage level decreased slightly post-solarisation, but the values are well within the nominal voltage. Kambia, ODCH, and PCMH's average voltage levels vary the most from the nominal voltage. Kambia is the worst-performing hospital for this indicator, spending an average of 3.6 hours outside the nominal voltage range. ODCH and PCMH voltage variation is likely a reflection of national grid fluctuations rather than solar system performance.

7.2.8.3. Mean daily frequency

Target: Nominal frequency in Sierra Leone is 50 Hz

2024 actual: 50 Hz
Confidence level: High

Figure 41 shows the mean daily frequency at Phase 1 hospitals. The accent box or highlighted cells identify which source was used to calculate the improvements relative to the baseline; in this case, both the baseline and post-solarisation data come from nLine.

Figure 41. Mean daily frequency at Phase 1 hospitals

Facility	Baseline (22 Sept. - 31 Dec. 2023)	Post Installation (1 Jan. - 31 Dec.2024)		Improvements vs. baseline	
	Mean Daily Freq. (Hz) [nLine]	Mean Daily Freq. (Hz) [nLine]	Mean Daily Freq. (Hz) [Prospect]	Absolute (Hz)	%
Average	50.0	50.0	50.3	0.02	68%
Kabala	50.0	50.0	51.6	0.03	96%
Masanga	49.9	49.9	50.0	-0.01	-11%
Bonthe	50.0	50.0	-	0.02	99%
Kambia	49.7	50.0	50.7	0.27	94%
ODCH	50.1	50.1	48.8	0.03	33%
PCMH	50.1	50.1		0.03	30%

Given the lower data quality from Prospect sensors, the nLine sensor data has been selected as the primary source for measuring this indicator.

Overall, frequency levels across Phase 1 hospitals have remained very stable, with minimal deviation from the nominal standard before and after solarisation. This consistency suggests that, despite other challenges, frequency regulation has not been a major concern in system performance.

7.2.8.4. Qualitative feedback on the quality of electricity services

Staff across all supported hospitals report a notable improvement in electricity quality, as detailed in the table below. Reliable power has reportedly led to fewer equipment failures, improved medical device performance, and enhanced healthcare service delivery.

Figure 42. Perceived quality of electricity

Indicator	Target	Impact Assessment	Additional comments	Confidence level
Number of supported facilities reporting the availability of improved quality of electricity	6/6	High impact	All staff interviewed across supported hospitals reported a significant improvement in electricity quality. Stable voltage and reduced power fluctuations have resulted in fewer equipment failures and more reliable operation of medical devices. However, grid-connected hospitals (ODCH and PCMH) still operate in bypass mode, meaning that voltage fluctuations persist when the solar system is not in use, impacting overall power stability.	High – Consistently reported in staff interviews across multiple hospitals.

7.3. Reliability of Electricity Service

7.3.1. Daily hours of electricity available.

Target: 23 hours of uptime at each facility (max 1 hour per day of downtime).
2024 actual: An average of 19.7 hours of whole-facility uptime (nLine) and at least 22.8 hours of critical-loud uptime (AlphaESS).
Confidence level: Medium

Figure 43 shows the mean daily uptime of electricity services at Phase 1 hospitals. The accent box or highlighted cells identify which source was used to calculate the improvements relative to the baseline; in this case, both the baseline and post-solarisation data come from nLine.

Figure 43. Mean daily uptime of electricity services at Phase 1 hospitals

Facility	Baseline (15 May - 11 Dec. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)				Improvements vs. baseline	
	Mean Uptime (hrs/day) [nLine]	Mean Uptime (hrs/day) [Catalyst]	Mean Uptime (hrs/day) [Prospect]	Mean Uptime (hrs/day) [nLine]	Mean Uptime (hrs/day) [AlphaESS]	Absolute (hrs/day)	%
Average	17.2	~ 24	23.1	19.7	21.8	2.5	14%
Kabala	13.1	~ 24	-	17.6	21.7	4.6	35%
Masanga	21.6	~ 24	22.4	19.1	23.5	-2.4	-11%
Bonthe	7.0	~ 24	-	21.0	23.7	14.0	201%
Kambia	15.7	~ 24	23.8	14.5	22.8	-1.2	-8%
ODCH	23.5	~ 24	23.1	23.6	17.1	0.1	1%
PCMH	22.7	~ 24		22.4		-0.3	-1%

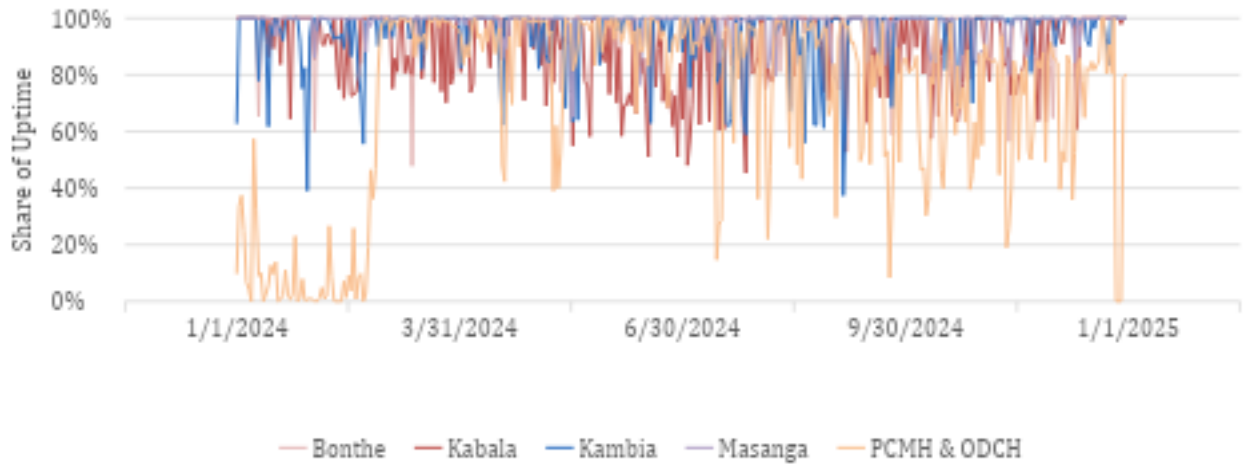
No single data source provides a complete picture of total uptime across Phase 1 hospitals. However, findings from field visits and available monitoring data indicate that all hospitals now have stable and reliable electricity throughout the day.

Because it offers a more complete dataset and was the primary source used in the baseline report, the nLine data was used for calculating improvements. While nLine provides the best available record of overall system uptime, it can register downtime even when only non-critical circuits are powered down, potentially understating true uptime. For the calculation of this KPI, facility-level outage data from nLine sensors was used. In contrast, AlphaESS data, which tracks only solar PV system performance, indicates that the uptime target of over 23 hours per day is almost certainly being met at Masanga, Bonthe, and Kambia. At Kabala and ODCH/PCMH, however, achieving the uptime target likely depends more heavily on genset usage and grid availability.

For ODCH, both nLine and AlphaESS data indicate that the hospital meets the uptime target, though limitations in tracking grid-supplied electricity introduce some uncertainty. At PCMH, the nLine data suggests slightly lower uptime readings, but this is likely due to how the system monitors non-critical loads. Given that critical hospital functions are prioritised, it is highly probable that PCMH is also exceeding 23 hours of uptime on essential circuits.

Despite sensor limitations and some data gaps, the collective evidence from monitoring systems and field assessments supports the conclusion that Phase 1 hospitals now have near-continuous power availability, representing a major improvement in reliability (Figure 44). There is the possibility of amplifying the analysis by evaluating room-level outage data from the nLine sensors to better understand system uptime of critical loads.

Figure 44. Daily share of solar PV system uptime



7.3.2. Daily number of outages

Target: None
2024 actual: 1.1 outages/day
Confidence level: Medium

Figure 45 shows the average number of daily outages at Phase 1 hospitals. The accent box or highlighted cells identify which source was used to calculate the improvements relative to the baseline; in this case, both baseline and post-solarisation data come from nLine.

Figure 45. Average number of daily outages at Phase 1 hospitals

Facility	Baseline (15 May - 11 Dec. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)		Improvements vs. baseline	
	Avg. Number of Daily Outages [nLine]	Avg. Number of Daily Outages [nLine]	Avg. Number of Daily Outages - PV System Only [AlphaESS]	Absolute (count)	%
Average	1.4	1.1	1.2	-0.3	-21%
Kabala	1.8	0.7	0.4	-1.2	-64%
Masanga	0.8	0.5	0.4	-0.4	-46%
Bonthe	1.3	0.2	0.1	-1.1	-82%
Kambia	1.4	1.1	0.1	-0.3	-20%
ODCH	0.9	1.6	5.1	0.8	86%
PCMH	1.8	2.4		0.5	29%

nLine sensors provide a nuanced picture of daily outages by collecting data from multiple sensors within each facility. This methodology can result in fractional outage readings, as brief disruptions in different areas of the hospital contribute to the overall outage calculation. Post-installation data indicates that four out of six hospitals experienced a reduction in daily outages, with three hospitals now averaging fewer than one outage per day.

In contrast, ODCH and PCMH show an increase in reported daily outages. However, further investigation is needed to determine whether these recorded outages reflect actual system failures or manual switching delays when transitioning between grid and solar power. If the latter is the case, the increase in outage readings may not indicate a decline in system reliability but rather an operational adjustment issue.

AlphaESS sensors, which exclusively track solar PV system uptime, do not capture full facility-level power availability. While these readings are only indicative, their alignment with nLine data provides further validation of observed trends.

7.3.3. Average length of electricity outages

Target: None

2024 actual: 6 hours of outages per day (nLine); 0.3 hours of outages per day (AlphaESS; solar system only)

Confidence level: Low

Figure 46 shows the average length of electricity outages at Phase 1 hospitals. The accent box or highlighted cells identify which source was used to calculate the improvements relative to the baseline; in this case, both baseline and post-solarisation data come from nLine.

Figure 46. Average length of electricity outages at Phase 1 hospitals

Facility	Baseline (15 May - 11 Dec. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)		Improvements vs. baseline	
	Avg. Length of Outage (hrs) [nLine]	Avg. Length of Outage (hrs) [nLine]	Avg. Length of Outage - PV System Only (hrs) [AlphaESS]	Absolute (hrs)	%
Average	5.8	6.0	0.3	0.2	4%
Kabala	8.4	9.0	0.2	0.6	7%
Masanga	3.8	7.9	0.4	4.1	107%
Bonthe	12.0	4.8	0.3	-7.1	-60%
Kambia	9.3	13.5	0.1	4.2	45%
ODCH	0.8	0.2	0.6	-0.5	-69%
PCMH	0.5	0.6		0.1	14%

nLine sensors determine the average outage duration by dividing the total daily length of outages by the number of recorded outages per day at a facility. Since outage frequency is calculated as a weighted average across multiple sensors, it can result in decimal values, meaning that some recorded outage frequencies are less than one per day. In such cases, the calculated outage duration may exceed 24 hours, even if the facility did not experience a full day without power. Over time, this methodology can lead to artificially high reported outage durations, making the metric appear worse than the actual power availability suggests.

Meanwhile, AlphaESS sensors track solar PV system uptime rather than total facility-level power system availability. While this makes them less comprehensive, their significantly lower recorded outage durations compared to nLine data suggest that nLine is likely to overestimate outage duration due to its methodology.

Figure 47. Daily electricity uptime, frequency, and length of outages reported by hospital staff

Facility	Reported electricity uptime	Reported number and length of outages
Kabala	• 24 h/day in critical units • 12 h/day in non-critical units • 24 h/day in staff quarters, although they are aware they might need to rationalise in the future	There are outages approx. once per week, for about 2 hours. During the rainy season (June to September) outages are more frequent and longer, and the hospital does not have enough resources to ensure uptime with the diesel genset. The installation of additional PV capacity helped reduce outages—before the PV expansion, the PV system took much longer to restart after the

Facility	Reported electricity uptime	Reported number and length of outages
		batteries were down.
Masanga	• 24 h/day in critical units • 12 h/day in non-critical units • 3 h/day in staff quarters, between approx. 6 pm and 9 pm	No outages since the installation of the solar PV system, using a combination of genset and solar PV systems. Since the expansion of the PV system in November 2024, batteries have been fully charged earlier in the day, even on rainy days.
Bonthe	• 24 h/day in critical units, in the dry season, and approx. 15 h/day in rainy season • 9 h/day in non-critical units, between approx. 8 am and 5 pm • 9 h/day in staff quarters, between approx. 8 am and 5 pm	Frequent outages during the rainy season (June to September) as batteries don't fully charge, and there are not enough resources to ensure uptime with the genset. In the rainy season, staff report that batteries are empty each day around 3 am. Charging time will depend on the weather and availability of funds to run the genset in the morning to allow batteries to charge. PV capacity expansion helped reduce outages and charge batteries more quickly.
Kambia	• 24 h/day in critical units • 12 h/day in non-critical units • 9 h/day in staff quarters, between 2 pm and 11 pm	During the rainy season, they don't always have 24h availability because batteries don't fully charge. There have been cases when staff misuse the system, e.g., forgetting to switch off the AC. PV capacity expansion helped reduce outages and charge batteries more quickly.
ODCH	• 24 h/day in critical units • 12 h/day in non-critical units	Sometimes there are outages due to inefficiencies changing between solar/grid/genset, because there's no automatic switchover. PV capacity expansion had not yet been completed at the time of the interviews.
PCMH	• 24 h/day in critical units • 12 h/day in non-critical units	If grid outages are longer than five hours, the solar PV system's batteries will go empty. For example, in January 2025, this happened about 6 times. PV capacity expansion had not yet been completed at the time of the interviews.

7.4. Economic

This section evaluates the economic impact of electrification, particularly as it relates to local economic activity and cost savings from reduced genset fuel consumption. Due to limited baseline data, direct comparisons between pre- and post-solarisation outcomes remain challenging. Qualitative data to date suggests limited economic spillover effects, but a significant impact on spending on fuel.

7.4.1. Cost savings from RE power systems

7.4.1.1. Total monthly costs of power systems

Target: None

2024 actual: Total monthly spending on electricity increased by US$ 5,911 (31%) across all Phase 1 hospitals.
Confidence level: Low

Figure 48. Total monthly power systems costs by facility

Facility	Baseline (12 Sept. - 11 Dec. 2023)		Post Installation (1 Jan. - 31 Dec. 2024)			Total Baseline Cost (USD/mo)	Total Post Inst. Cost (USD/mo)
	Genset Fuel Cost (USD/mo) [Catalyst]	Grid Elect. Cost (USD/mo) [Catalyst]	Genset Fuel Cost (USD/mo) [Catalyst/ Tetra Tech]	Solar System O&M (USD/mo) [SEforALL]	Grid Elect. Cost (USD/mo) [AlphaESS/ Prospect]		
Total	$5,867	$13,026	$3,631	$10,965	$10,208	$18,893	$24,804
Kabala	$764		$521	$1,450		$764	$1,970
Masanga	$3,471		$1,117	$1,637		$3,471	$2,754
Bonthe	$196		$379	$1,001		$196	$1,381
Kambia	$866		$802	$978		$866	$1,779
ODCH & PCMH	$570	$13,026	$813	$5,899	$10,208	$13,596	$16,920

Figure 49. Improvement vs. baseline of power systems monthly cost

Facility	Improvements vs. baseline	
	Absolute (USD/month)	%
Total	$5,911.28	31%
Kabala	$1,206.44	158%
Masanga	-$716.77	-21%
Bonthe	$1,184.65	604%
Kambia	$913.46	105%
ODCH & PCMH	$3,323.50	24%

Note: The cost of electricity from the grid was calculated using the tariff for T3 institutions as of October 1, 2023, without GST of 5.305 SLL/kWh[8], which equates to about 0.23 USD/kWh.

Baseline cost calculations were derived from the daily electricity generation figures reported in the baseline assessment. It is important to note that these calculations do not include operations and maintenance (O&M) expenses for the pre-existing solar PV systems at each facility. Additionally, baseline monthly fuel costs appear relatively low because power systems did not operate continuously throughout the day, resulting in lower recorded fuel consumption.

While overall electricity spending has increased across most hospitals, this reflects the implementation of more robust and reliable power systems that now effectively meet hospital

[8] Freetown City Energy Profile, ENACT (2024)

energy demands. When compared to a counterfactual scenario where hospitals achieve near-24-hour uptime using diesel gensets or other conventional power sources, this increase in expenditure appears more favourable.

7.4.1.2. Average cost of electricity

Target: None
2024 actual: 0.24 USD/kWh
Confidence level: Medium

Figure 50. Average cost of electricity

Facility	Baseline (12 Sept. - 11 Dec. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)	Improvements vs. baseline	
	Average Cost of Electricity (USD/kWh) [Report]	Average Cost of Electricity (USD/kWh) [Various]	Absolute (USD/kWh)	%
Average	$0.38	$0.24	-$0.14	-27%
Kabala	$0.32	$0.20	-$0.12	-38%
Masanga	$0.27	$0.23	-$0.05	-17%
Bonthe	$0.66	$0.23	-$0.43	-64%
Kambia	$0.39	$0.22	-$0.17	-44%
ODCH & PCMH	$0.24	$0.30	$0.07	27%

The post-installation average cost of electricity was calculated using generation data from AlphaESS, Prospect, Catalyst, and Tetra Tech, alongside cost data from Tetra Tech (diesel consumption), Catalyst (diesel consumption), and SEforALL (RE system O&M costs).

At non-grid-connected hospitals, the average cost of electricity has decreased, reflecting cost savings from reduced reliance on diesel gensets. In contrast, ODCH and PCMH have seen an increase in electricity costs post-installation, primarily because they are now sourcing a larger share of power from gensets compared to the baseline period and are underutilising their solar PV systems.

Figure 51. Economic indicators

Indicator	Target	Impact Assessment	Additional comments	Confidence level
Economic spillover effects	None	🟡	The increase in patient numbers could have contributed to higher demand for local micro-businesses (e.g., food vendors or transport services). Other than that, no significant businesses were created due to improved electrification.	Medium - while anecdotal evidence was collected during field visits, no structured economic study has been conducted to quantify the impact.

Indicator	Target	Impact Assessment	Additional comments	Confidence level
Spending on genset fuel	None	🟢	Hospitals that previously relied heavily on gensets now use less fuel, particularly in the dry season when solar production is high. Rainy season challenges remain, as hospitals still rely on gensets when solar generation and battery storage is insufficient.	

7.5. Social

This section assesses the social impact indicators, particularly in areas such as livelihoods, job creation, and healthcare worker motivation. Due to limited baseline data, direct comparisons between pre- and post-solarisation outcomes remain challenging. Despite this, qualitative evidence highlights notable improvements in working conditions, staff retention, and gender inclusion in technical training programmes.

Figure 52. Economic indicators

Indicator	Target	Impact Assessment	Additional comments	Confidence level
Number of female engineers trained through the project	22 by Q3 2024	🟢	SEforALL's Women in STEM training programme has already trained two cohorts of 23 female engineers as of late 2024, exceeding the target.	High – Verified through interviews with EM-ONE, SEforALL, and two trainees.
Improved livelihoods	None	🟡	While the project created temporary jobs during installation and improved working conditions for healthcare staff, long-term job creation remains limited. Some hospital workers (e.g., maintenance officers) have received training but remain unpaid volunteers, reducing the sustainability of livelihood improvements.	Medium – Qualitative evidence from focus groups, but no structured economic study to quantify impact.
Number of staff	None	Unknown	No data collected on # of staff.	N/A - no data available.
Staff turnover rates	None	🟡	Staff in solar-powered hospitals report higher job satisfaction and better working conditions, which could contribute to lower turnover rates. However, no formal data exists to track turnover trends.	Low - anecdotal evidence suggests reduced turnover rates, but the indicator could not be quantified.
Additional staff jobs were created due to increased electrification	None	🟡	While some temporary jobs were created during the solar installation phase, few new permanent healthcare positions have been created due to electrification. Some hospitals have expanded service capacity, but this has	Medium – Qualitative evidence from staff interviews, but no access to formal HR records or

Indicator	Target	Impact Assessment	Additional comments	Confidence level
			not yet led to an increase in medical or technical staff.	staff contracts for verification.
Higher motivation or greater ability for healthcare workers to perform their work	None	🟢	Healthcare workers report feeling safer, less stressed, and more confident in performing procedures, particularly emergency surgeries, neonatal care, and nighttime deliveries. Improved living conditions at staff quarters also contribute to higher motivation.	High – Consistently reported across multiple hospitals in qualitative interviews.

Figure 53. Health/ Social & Energy/ Social indicators

Indicator	Actual/ Target	Impact Assessment	Additional comments	Confidence level
Number of staff trained on solar energy in healthcare facilities	29 /29[9]	🟢	Through interviews, 18 technicians were confirmed trained on basic O&M by EM-ONE across the 6 hospitals. However, SEforALL believes 11 more were trained.	Medium - evidence from maintenance staff interviews conflicts with SEforALL Logframe data.
Number of target facilities with reported improvement in the availability of health services provided	6/6	🟢	6 of 6 hospitals report improved service availability, especially for emergency surgeries, maternal care, and neonatal services.	High - strong qualitative evidence from staff interviews in all hospitals.
Number of target facilities at which healthcare providers express improvements in the quality of health services at their facility as a result of a more steady energy supply	6/6	🟢	6 of 6 hospitals report improved service availability, especially for emergency surgeries, maternal care, and neonatal services.	High - strong qualitative evidence from staff interviews in all hospitals.
Number of facilities at which patients express improvements in the quality of health services	6/6	🟢	Patients report feeling safer, more confident, and more willing to seek care at hospitals due to stable electricity. Improved lighting, reliable oxygen supply, and uninterrupted medical services have enhanced patient trust in healthcare facilities. However, in some hospitals, it was difficult to find patients who could	Medium – While patient interviews were conducted in all hospitals, comparative insights were not always available, affecting consistency in assessment.

[9] This indicator has a discrepancy between data gathered in the field and documentation provided by SEforALL.

Indicator	Actual/ Target	Impact Assessment	Additional comments	Confidence level
			directly compare pre- and post-solarisation conditions, limiting the ability to assess long-term perception shifts.	
Improved health & safety	None	🟢	Retrofitting existing electrical installations has significantly improved safety in hospitals. Prior to solarisation, some facilities reported unsafe wiring, frequent voltage fluctuations, and sockets bursting, posing risks to staff and patients. However, solarisation introduces new safety challenges, particularly related to maintenance of rooftop solar PV systems, which require proper training and safety protocols for maintenance staff.	High – Strong qualitative evidence from hospital staff interviews.
Staff quarters electrification status	None	🟡	Staff quarter electrification status varies across hospitals. All hospitals with staff quarters have some level of electricity access, although not always supplied by the SL-HEP PV solar systems. The extent of electrification differs by facility, as detailed in Figure 55. Staff Quarter Electrification Status.	High – strong evidence from hospital staff interviews.

Figure 54. Number of trained technicians per hospital according to maintenance officers[10]

Hospital	Number of trained technicians	Share of women
Total	**18**	**0**
Kambia	3	0
Masanga	5	0
Kabala	6	0
Bonthe	2	0
PCMH &	2	0

[10] Note that these findings conflict with those of the SEforALL team.

Hospital	Number of trained technicians	Share of women
ODCH		

Figure 55. Staff quarter electrification status

Hospital	Target	Impact Assessment	Electricity available?	Source of electricity	Confidence level
Kabala	None	🟢	Yes – available 24/7.	SEforALL solar PV system.	High – strong evidence from hospital staff interviews.
Masanga	None	🔴	Yes – only for 3 hours per day.	Supplied by diesel genset. SEforALL solar PV system does not provide electricity to the staff quarters.	High – strong evidence from hospital staff interviews.
Bonthe	None	🟡	Partially – staff quarters for senior staff have electricity availability only during the day; electricity is switched off in the evening, when it would be needed the most. The nurses' staff quarters don't have electricity.	SEforALL solar PV system.	High – strong evidence from hospital staff interviews.
Kambia	None	🟡	Yes – available during the afternoon until 11 pm at the latest.	SEforALL solar PV system.	High – strong evidence from hospital staff interviews.
ODCH	None	N/A	No staff quarters at ODCH.	N/A	High – strong evidence from hospital staff interviews.
PCMH	None	N/A	No staff quarters at PCMH.	N/A	High – strong evidence from hospital staff interviews.

7.6. Health

This section uses baseline data as reported in Crown Agent's baseline report submitted in July 2024. It considers a baseline period of 12 months, from August 2022 until July 2023. The post-installation data was provided by Sierra Leone's Ministry of Health, Directorate of Policy Planning and Information, and it covers a 12-month period from January 2024 until December 2024. During the data collection process, it was noted that there are challenges with hospitals reporting data, there is no clear timeline for hospitals to report statistics on the national DHIS 2 platform, and there is no obligation for private hospitals to report data. Masanga Hospital, for example, hasn't shared data with the MoH for the entirety of 2024.

The table below provides a summary of the completeness of the information shared by the MoH from January 2024 to December 2024, indicating the number of months for which data is available within the 12-month period.

Figure 56. Health outcome data completeness of data shared by MoH - monthly availability analysis

	Normal delivery	Assisted vaginal delivery	Caesarian Section	Maternal Deaths	Headcount (all services)	Death <5	Major surgery	Minor surgery	Data quality assessment
Data points available, of total expected	**59 of 60**	**53 of 60**	**59 of 60**	**39 of 60**	**60 of 72**	**46 of 60**	**48 of 60**	**30 of 60**	
Data availability	**98%**	**88%**	**98%**	**65%**	**83%**	**77%**	**80%**	**50%**	
Kabala Govt Hospital	12/12	12/12	12/12	5/12	2/12	1/12	1/12	1/12	Mixed - complete data for deliveries, but missing for other indicators
Masanga Hospital	12/12	12/12	12/12	12/12	12/12	12/12	12/12	12/12	Mixed - data provided directly by this hospital quantifies certain indicators differently from the other hospitals.
Bonthe Govt Hospital	11/12	7/12	11/12	1/12	10/12	9/12	11/12	5/12	Poor data quality - incomplete data for all indicators
Kambia	12/12	10/12	12/12	9/12	12/12	12/12	12/12	0/12	Mixed – complete data for some indicators, but missing data points for others
ODCH	N/A	N/A	N/A	N/A	12/12	12/12	N/A	N/A	Complete - all applicable data available
PCMH	12/12	12/12	12/12	12/12	12/12	N/A	12/12	12/12	Complete - all applicable data available

7.6.1. Total headcount for all services

Target: Increase the total headcount to more than the baseline of 4,537 monthly patients, equivalent to 54,444 annual patients, across all Phase 1 hospitals.

2024 actual: Average of 6,162 patients per month, equivalent to 73,331 patients for the year, for all Phase 1 hospitals

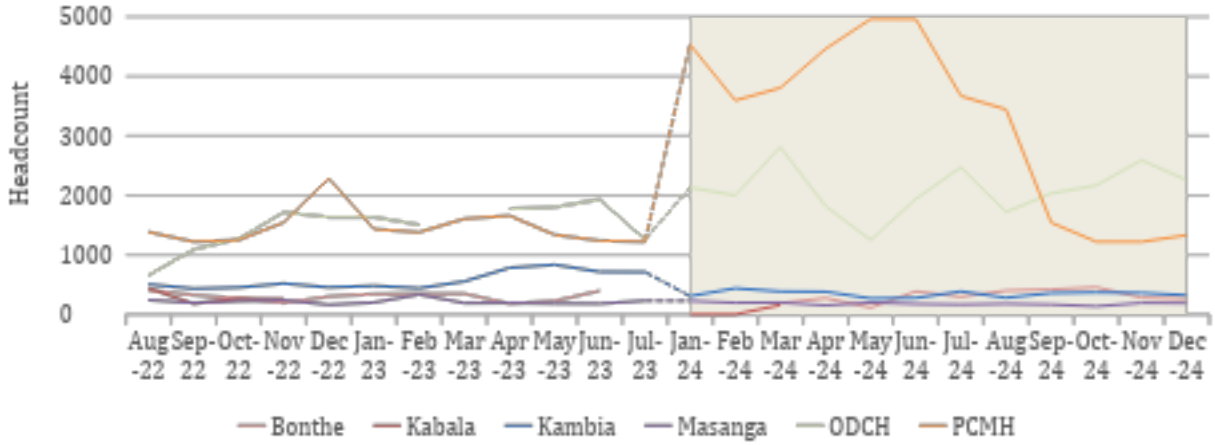
Confidence level: High for hospitals where full data is available

Figure 57. Total annual headcount for all services [11]

[11] Data displayed in this figure originates from the national DHIS2 platform, except for Masanga Hospital, which provided the data directly. For Masanga, hospital admissions were used as a proxy for total headcount, potentially differing from methodologies employed by other hospitals and possibly leading to underreporting. Additionally, Masanga's data excludes transfers from the emergency unit to the surgical ward in total hospital admissions.

Facility	Baseline (Aug. 2022 - Jul. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)	Improvements vs. baseline	
	Total Annual Headcount	Total Annual Headcount	Absolute (count)	%
Total	46,629	73,331	26,702	57%
Kabala	Data incomplete	Data incomplete	-	-
Masanga	2,576	2,180	-396	-15%
Bonthe	3,341	3,077	-264	-8%
Kambia	6,886	4,133	-2,753	-40%
ODCH	16,266	25,197	8,931	55%
PCMH	17,560	38,744	21,184	121%

Figure 58. Average monthly headcount for all services[12]



Note: the shaded region corresponds to the period post-solarisation

The average monthly headcount for hospitals with available data increased post-solarisation, except at Kambia. However, it is important to recognise that factors beyond facility electrification can influence patient influx. For instance, at PCMH, construction projects that began in Q3 of 2024 have forced the hospital to scale down certain services, likely affecting patient numbers.

Despite these external factors, the project has met its target, with a 57% increase in total monthly headcount across Masanga Bonthe, Kambia, ODCH, and PCMH post-solarisation, even with 22 months of missing data among all hospitals.

7.6.2. Number of births supported by improved power at targeted facilities

Target: 800 births per month (9,600 births per year) across all Phase 1 hospitals.[13]
2024 actual: 11,274 births in 2024

[12] Because the baseline period extends until July 2023, there is no data from August to December 2023.
[13] The target for this indicator is below the baseline average of 957 total deliveries per month across all Phase 1 hospitals.

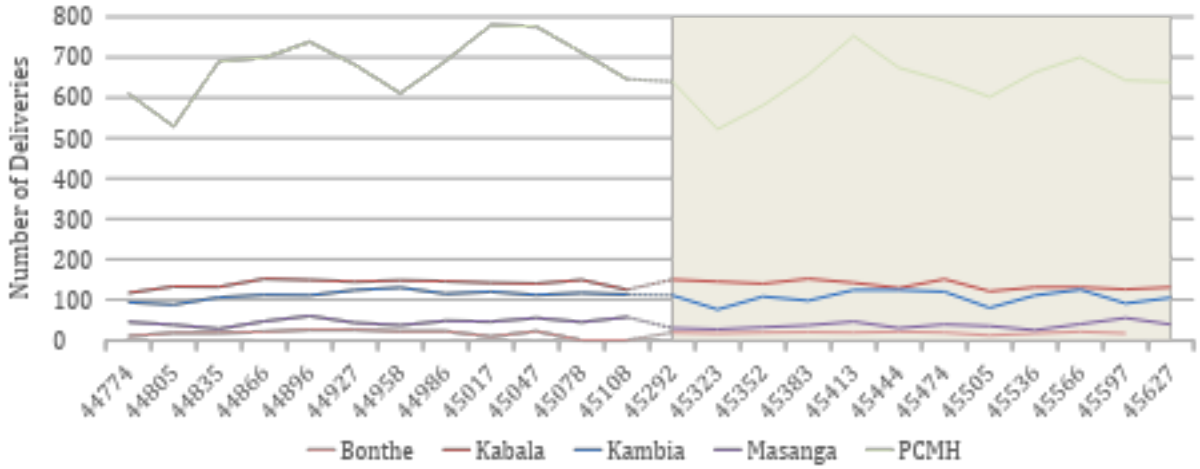
Confidence level: Low

Figure 59. Annual births at Phase 1 facilities

Facility	Baseline (Aug. 2022 - Jul. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)	Improvements vs. baseline	
	Total Annual Deliveries	Total Annual Deliveries	Absolute (count)	%
Total	11,482	11,274	-208	-2%
Kabala	1,678	1,649	-29	-2%
Masanga	105	435	330	314%
Bonthe	194	201	7	4%
Kambia	1,342	1,273	-69	-5%
ODCH	N/A	N/A	N/A	N/A
PCMH	8,163	7,716	-447	-5%

The total number of births includes normal deliveries, assisted vaginal deliveries, and caesarean sections. ODCH does not perform deliveries, so this indicator does not apply to that facility.

Figure 60. Total monthly deliveries at Phase 1 hospitals



Note: the shaded region corresponds to the period post-solarisation

Analysis of available data indicates that the number of monthly deliveries remained stable during both the baseline and post-solarisation periods across the hospitals studied. This suggests that external factors, such as family planning initiatives and socio-economic conditions, may have a stronger influence on delivery rates than electrification alone. In the absence of specific data for Masanga Hospital, it is reasonable to assume that delivery trends remained consistent throughout the period evaluated.

While electrification has significantly improved maternal healthcare services, enhancing lighting, powering essential medical equipment, and increasing staff satisfaction, there is no clear quantitative evidence that it has directly led to an increase in the number of women choosing to give birth in these facilities. However, findings from fieldwork suggest that more women are opting to deliver at hospitals due to the higher quality of care they now receive. Qualitative reports highlight substantial improvements in delivery experiences, reinforcing the positive impact of reliable electricity on maternal healthcare outcomes and patient satisfaction, even if this is not yet fully reflected in hospital delivery rates.

7.6.3. Maternal mortality

Target: 5.7 deaths across all facilities per month (fewer than 68 maternal deaths annually)
2024 actual: 7.9 deaths per month (95 deaths over the course of the year)
Confidence level: Low

Figure 61. Total annual maternal deaths at Phase 1 hospitals

Facility	Baseline (Aug. 2022 - Jul. 2023)	Post Installation (1 Jan. - 31 Dec.2024)	Change vs. baseline	
	Total Annual Maternal Deaths	Total Annual Maternal Deaths	Absolute (count)	%
Total	74	98	24	32%
Kabala	6	8	2	33%
Masanga	6	3	-3	-50%
Bonthe	6	1	-5	-83%
Kambia	11	14	3	27%
ODCH	45	N/A	N/A	N/A
PCMH	-	72	-	-

Approximately 35% of data points are missing from the post-installation dataset, as hospitals did not consistently report statistics. Additionally, there is no information regarding missing data in the baseline dataset, making it difficult to conduct a comprehensive evaluation of this indicator. For example, the post-installation figure for Bonthe is based on only one month of data, limiting its reliability. Furthermore, the 45 maternal deaths reported by ODCH during the baseline period are likely an error, as these deaths were most likely recorded at PCMH.

Despite inconsistencies in the quantitative data, qualitative findings from on-site interviews indicate that maternal mortality has decreased overall, contradicting the available numerical trends. Overall, less than 1% of births led to maternal mortality both in the baseline and post-solarisation periods. While electrification has played a role in improving maternal care, patient mortality is influenced by multiple factors, including access to medication and other critical healthcare resources.

7.6.4. Deaths of children under 5

Target: 11.9 deaths per month (less than 143 deaths per year across all facilities)
2024 actual: 91.4 deaths per month (1,097 deaths in 2024)
Confidence level: Low

Figure 62.Total annual deaths of children under 5 years old at Phase 1 hospitals[14]

Facility	Baseline (Aug. 2022 - Jul. 2023)	Post Installation (1 Jan. - 31 Dec,.2024)	Change vs. baseline	
	Total Annual Infant Deaths	Total Annual Infant Deaths	Absolute (count)	%
Total	158	1,109	951	602%
Kabala	8	3	-5	-63%
Masanga	15	12	-3	-20%
Bonthe	9	20	11	122%
Kambia	33	83	50	152%
ODCH	93	991	898	966%
PCMH	N/A	N/A	N/A	N/A

As PCMH is a maternity hospital, all newborns are transferred to ODCH after birth, meaning there are no registered infant deaths at PCMH. The 2024 dataset is missing 23% of data points for this indicator, further limiting its reliability. Kabala Hospital, for example, only has data for January 2024, while Bonthe is missing three months of data.

Despite these data gaps, qualitative findings from on-site interviews at ODCH indicate that infant mortality has slightly decreased post-solarisation. At ODCH, 991 recorded deaths of children under 5 years account for approximately 2.6% of the total patient headcount, a plausible figure given that ODCH is Sierra Leone's largest children's hospital and receives many of the country's most critical cases. Given these factors, it is likely that baseline data contains errors across multiple hospitals, further complicating direct comparisons.

7.6.5. Major and Minor Surgeries

Target: None
2024 actual: 4,387 major surgeries total in 2024 across all Phase 1 hospitals
Confidence level: Low

Figure 63. Annual number of major surgeries at Phase 1 hospitals[15]

[14] The data that is displayed in this figure originates from the national DHIS2 platform, except for Masanga Hospital, which provided the data directly. For Masanga, only neonatal deaths are included, as the hospital reports only total paediatric deaths without specific data for children under five.
[15] The data that is displayed in these figures originates from the national DHIS2 platform, except for Masanga Hospital, which provided the data directly. Masanga has a detailed record of surgeries but doesn't categorise them as "major" and "minor". Therefore, a ratio of major to minor surgeries was calculated based on data from the other four hospitals and used to estimate the data points for Masanga.

Facility	Baseline (Aug. 2022 - Jul. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)	Change vs. baseline	
	Annual Major Surgeries	Annual Major Surgeries	Absolute (count)	%
Total	5,728	5,326	-402	-7%
Kabala	154	36	-118	-77%
Masanga	1,105	939	-166	-15%
Bonthe	99	135	36	36%
Kambia	608	466	-142	-23%
ODCH	N/A	N/A	N/A	N/A
PCMH	3,762	3,750	-12	0%

As ODCH does not perform surgeries, this metric doesn't apply to the facility. There is a fair amount of missing data for this indicator, with 25% missing for both the baseline and post-installation period. For example, Masanga Hospital only reported data from August to October 2022, while Kabala's data is limited to June 2024, making it difficult to assess trends comprehensively.

Target: None
2024 actual: 595 minor surgeries total in 2024 across all Phase 1 hospitals
Confidence level: Low

Figure 64. Annual number of minor surgeries at Phase 1 hospitals[7]

Facility	Baseline (Aug. 2022 - Jul. 2023)	Post Installation (1 Jan. - 31 Dec. 2024)	Change vs. baseline	
	Annual Minor Surgeries	Annual Minor Surgeries	Absolute (count)	%
Total	1,321	774	-547	-41%
Kabala	150	10	-140	-93%
Masanga	211	179	-32	-15%
Bonthe	5	15	10	200%
Kambia	No data	No data	-	-
ODCH	N/A	N/A	N/A	N/A
PCMH	955	570	-385	-40%

The significant data gaps for this metric make it impossible to draw a fair comparison between the baseline and post-installation periods. 62% of data points are missing from the baseline dataset, while 50% are missing post-installation. For example, Bonthe Hospital only reported data for December 2022 and February–March 2023, while Kabala's data is limited to June 2024, further limiting the reliability of this indicator.

Based on the available data, the total number of major and minor surgeries appears to have decreased post-installation compared to the baseline period. However, the high proportion of missing data prevents a meaningful analysis of this trend.

8. Key Learnings

This section synthesises key insights derived from qualitative[16] and quantitative KPIs, categorising them into thematic areas that reflect the impact and operational challenges of solar electrification in healthcare facilities. These key learnings highlight both successes and areas requiring further attention and provide specific recommendations whenever relevant.

The key learnings are structured into the following thematic topics:

1. Improved healthcare delivery
2. Operational efficiency
3. Operation & Maintenance
4. Training & Capacity building
5. Solar system design considerations
6. Healthcare staff retention & motivation

8.1. Improved healthcare delivery

8.1.1. Maternal and Infant Health Outcomes

8.1.1.1. Key Takeaway

Qualitative feedback from healthcare staff and patient interviews indicates **improvements in maternal and infant health outcomes**. Staff report fewer birth complications, better neonatal care, and increased capacity for emergency interventions. However, **quantitative data from the Ministry of Health (MoH) is insufficient to confirm these claims** due to persistent data gaps in the DHIS2 platform.

8.1.1.2. Context & Analysis

Most Medical Superintendents and Matrons across hospitals report a decline in both maternal and under-five mortality rates following solarisation. However, due to data limitations at hospitals, they were unable to provide exact figures comparing pre- and post-solarisation outcomes, and MoH indicators both for baseline and post-solarisation are incomplete.

Reported maternal mortality trends:

- Kabala: Reported 9 maternal deaths in 2023 and 10 in 2024, with the increase attributed to a lack of critical drugs in December 2024. Five of the 10 deaths occurred in that single month.
- Masanga, Bonthe, and PCMH: Confirmed a general reduction in mortality but could not provide specific numbers.

[16] The list of interviewees and the interview guide can be found in Annexe IV: List of high-level stakeholders interviewed and Annexe VI: Stakeholder Interview Guide.

- Kambia: The Matron estimated a 70% reduction in both maternal and infant mortality, though this figure seems unreliable, and, for comparison, quantitative data shows an increase in mortality.

Reported under-5 mortality trends:

- ODCH: The superintendent estimated a reduction in under-5 mortality from 20% to 10% of admissions, though it was unclear if this applied to all hospital admissions or just SCBU cases.
- All other hospitals: Reported a general decrease in under-5 mortality, but no confirmed figures were provided.

Interviews indicate that maternal and children under 5 health outcomes have improved due to several key factors:

- **Improved emergency and surgical care:** Reliable electricity has led to better outcomes in caesarean sections (CS) and other maternal surgeries, reducing reliance on phone flashlights during procedures and allowing staff to perform abdominal scans at any time.
- **Neonatal and pediatric care:** Oxygen concentrators and incubators can now run continuously, improving survival rates for premature and critically ill newborns.
- **Health worker efficiency & confidence:** Midwives and doctors report feeling more confident in their ability to deliver safe care without power-related disruptions.

"*Before solarisation, infant and maternity mortality rates were really high. Fuel was often not available on the island, and patients died while the maintenance team was trying to find fuel. We had to prioritise care, leaving some patients untreated.*" - Mohammed K Kain - Community Health Officer, Bonthe Government Hospital

"*Infant mortality has decreased to 10% in the past year, which is now the regional benchmark—it used to be 20-30%. The survival rate in the SCBU is now 90%, compared to 60-70% before. The key factors behind this improvement are more specialised skills, better availability of medication and drugs, and reliable equipment, made possible by stable electricity.*" – Dr. Ayeshatu Mustapha, Medical Superintendent ODCH

8.1.1.3. Relevant Evaluation Criteria

✔ **Relevance** – Aligns with national priorities for reducing maternal and neonatal mortality.

✔ **Effectiveness** – Demonstrates improved healthcare delivery, though data gaps limit full impact assessment.

✔ **Efficiency** – Electricity improvements help optimise hospital resources, but data collection inefficiencies persist.

✔ **Impact** – Strong qualitative evidence of better patient outcomes.

✔ **Equity and Inclusion** – Ensures equitable access to healthcare for mothers and newborns.

8.1.1.4. Assessment

🟡 Moderate Concern (YELLOW) – **While qualitative feedback strongly suggests positive impacts on maternal and infant health, the lack of comprehensive quantitative data limits the ability to fully measure progress**. Addressing data collection issues is critical to validating these improvements.

8.1.1.5. Specific Recommendations

- **Support MoH to strengthen data collection & reporting**: Implement standardised digital reporting tools to ensure consistent tracking of maternal and infant health outcomes across all healthcare facilities.
- **Address facility-specific data gaps**: Investigate and address missing health outcomes data in hospitals with data gaps (Kabala, Bonthe, Kambia, and Masanga).

8.1.2. Use of medical equipment and reporting

8.1.2.1. Key Takeaway

The installation of solar systems has **significantly improved the functionality and utilisation of existing medical equipment**, particularly in critical units. However, healthcare staff consistently report **shortages of medical equipment and challenges in acquiring new equipment**, limiting the full potential of the improved electricity supply.

8.1.2.2. Context & Analysis

Improved usage of existing equipment: Before the solarisation intervention, frequent power outages severely limited the use of essential medical equipment, including oxygen concentrators, incubators, and laboratory diagnostic tools. In many cases, procedures were delayed, and critical patients, including newborns, were at risk due to unreliable power.

Post-solarisation, hospital staff report improved uptime of medical devices, leading to better patient monitoring and reduced equipment failures thanks to a better quality of electricity. For example, at Ola During Children's Hospital, doctors reported that the availability of reliable electricity has allowed them to use oxygen concentrators continuously, improving survival rates for infants in the neonatal unit. Similarly, in the surgical department at PCMH, power stability has ensured that essential equipment remains operational during procedures, reducing reliance on phone flashlights during emergencies.

"Now, we don't have to transfer our patients to the SCBU and maternity ward to treat them, especially patients in critical care. If patients need oxygen, we can provide it to them

immediately. We have seen great improvements. Before the solar system was installed, operations had to be scheduled during the hours when we had electricity, but now we don't need to do that—operations can be scheduled at any time." – Focus group discussion with healthcare workers, Kabala Government Hospital

Acquisition of additional equipment: Some hospitals have acquired new equipment since the installation of the SL-HEP PV solar systems. Specific cases include:

- Freezers for microbiology lab (Masanga): the lab has several fridges and freezers that were recently acquired, and one of them operates at -80°C. This wouldn't have been possible without the SEforALL solar system.
- Autoclave (Masanga): acquired an additional autoclave that improved efficiency in the hospital.
- X-ray machine (Bonthe): helps treat fractures, treat TB, and assess abdominal obstructions.
- Digital x-ray machine (Masanga): the hospital replaced the existing analogue x-ray with a new digital one. The old machine was inefficient and often could not be used either because of a lack of power at night or because the paper they used had to be imported and was not always available. The digital x-ray can run anytime, and they get the results immediately. For example, if there are accidents at night, they can quickly x-ray the patient and diagnose the case.
- Lab equipment (Bonthe):
    - Microscope: helps diagnose TB, malaria, or perform urine analysis
    - Blood chemistry analyser: helps diagnose patients, for example, by knowing the electrolyte balance in the body (e.g., lack of potassium), perform blood tests, assess kidney function, or know the composition of bodily fluids

Remaining challenges with equipment shortages: despite these improvements and the acquisition of equipment by some hospitals, facilities still report that existing equipment is insufficient and that they would need more, especially:

- Oxygen concentrators: hospitals struggle to meet oxygen demand. Often, one concentrator must be shared among multiple patients who require dedicated, uninterrupted oxygen support.
- Oxygen plants: hospitals that do not generate their own oxygen remain dependent on oxygen concentrators and external supplies, making them vulnerable to shortages. Installing oxygen plants would reduce reliance on oxygen transport from other hospitals and on the use of oxygen concentrators, and improve overall efficiency.

"We need more oxygen concentrators and an oxygen plant. We get a lot of referrals here and they need oxygen. An oxygen plant is very important. As it stands now, if we finish oxygen cylinders, we have to go to Connaught Hospital to refill them, we don't always have that luxury of time. Look around this ward now, and you see that one cylinder is split amongst 3 children when that shouldn't be the case. But we don't have a choice, we must treat the children, so we have to

manage with what we have for now until we have more." – Kadie Mansaray, Nurse at Ola During Children's Hospital

8.1.2.3. Relevant Evaluation Criteria

- ✔ **Relevance** – Increased use of medical equipment aligns with the MoH goals to improve medical service delivery
- ✔ **Effectiveness** –Stable electricity has enabled continuous operation of medical equipment, improving patient monitoring, surgical capacity, and diagnostic accuracy. However, persistent shortages of essential medical devices such as oxygen concentrators and diagnostic equipment limit the full effectiveness of electrification efforts.
- ✔ **Impact** – The increased availability and functionality of medical equipment have likely contributed to improved health outcomes. However, hospitals remain constrained by limited access to new medical equipment, oxygen shortages, and supply chain gaps for critical devices.

8.1.2.4. Assessment

🟡 Moderate Concern (YELLOW) – While improved electricity has significantly enhanced medical equipment use and reporting, the shortage of essential medical devices and limited access to new equipment constrain the full potential impact on healthcare service delivery and patient outcomes.

8.1.2.5. Specific Recommendations

- **Support MoH expanding procurement efforts for essential medical equipment**, particularly oxygen concentrators, diagnostic machines, and neonatal care appliances.

8.1.3. Healthcare service availability

8.1.3.1. Key Takeaway

The solarisation of hospitals has **significantly enhanced healthcare services**, leading to better emergency response, better maternal and neonatal care, safer surgical conditions, and better patient diagnosis. However, critical challenges remain, including **insufficient oxygen supply, lack of medical equipment, and limited solar system capacity, which restricts the full impact potential**.

8.1.3.2. Context & Analysis

While new healthcare services have not typically been introduced since the solarisation of the hospitals, the quality and reliability of existing services have improved.

Key improvements and challenges include:

Emergency and surgical care

- **Reliable electricity for surgeries**: Previously, power outages disrupted surgeries, requiring medical staff to use phone flashlights to continue procedures. With solar power, operating rooms now have consistent lighting, improving surgical outcomes and safety.
- **Faster response times**: Before solarisation, patients needing emergency caesarean sections (CS) were often referred elsewhere due to power shortages. Now, hospitals can perform these surgeries more promptly.
- **Enhanced surgical conditions**: Surgeons report feeling more confident in performing operations due to stable electricity, which ensures proper lighting and the functionality of medical devices.

"During one of my previous pregnancies [before solarisation], they [the Hospital] were supposed to do a CS, but because there was no light in the theatre due to a lack of fuel for the genset, they decided that the safest option was an assisted delivery. With the baby I just had [post solarisation], I was able to have the CS without complications, and my baby is now recovering well in the SCBU." – Isata Idrissa, patient at Bonthe Government Hospital

Maternal and neonatal care

- **Improved neonatal care**: Facilities now maintain consistent oxygen supply and temperature-controlled environments for newborns. However, the lack of oxygen concentrators still poses a significant risk.
- **More women seeking institutional deliveries**: Fear of delivering in the dark or using flashlights discouraged hospital births in the past. With improved lighting, more pregnant women are choosing to deliver at healthcare facilities.

"In the past, patients preferred to go to traditional birth attendants (TBAs) instead of coming to this hospital. They believed TBAs were the same as hospitals because, during night deliveries, we all had to use flashlights. But now, even TBAs come to the hospital to give birth, and some TBAs have stopped practising because more women are choosing hospital deliveries." – Isata Idrissa, patient at Bonthe Government Hospital

Oxygen supply and respiratory care

- **Consistent oxygen supply**: Hospitals previously struggled to provide oxygen to patients due to power outages affecting oxygen concentrators. With solar power, oxygen machines are now operational 24/7, preventing respiratory complications. However, a lack of sufficient oxygen still poses a major health risk in many hospitals.
- **Improved intensive care for children**: Paediatricians reported that uninterrupted electricity has made it easier to manage critical cases in neonatal and paediatric units.

"Neonatal care has really improved thanks to a reliable oxygen supply. When babies were on oxygen in the past, and there was a power outage, you had to remove the oxygen masks from all

babies to prevent accidents, as sometimes electricity would come back and would blow up sockets. Now, when the power goes out, the solar kicks in very swiftly, we don't have to wait for long, afraid that the power won't come back on and that the babies would be at an increased risk." – Dr. Cheryl Jones, Chief Resident Paediatrician at Ola During Children's Hospital

Diagnostic and laboratory services

- **Faster test results**: Laboratories can now process tests more efficiently because power-dependent equipment, such as blood analysers and scanning machines, is consistently available.
- **Expanded testing capabilities**: New services, such as TB testing using GeneXpert machines, are now operational due to reliable power.

"Before solarisation, we often had to treat patients symptomatically [i.e., based simply on the symptoms they exhibited] because we didn't have electricity and couldn't use the lab equipment. Now we get results from the lab really fast, which helps us diagnose patients and provide better treatment". – Mohammed K Kain, Community Health Officer, Bonthe Government Hospital

Vaccine storage and cold chain management

- **Improved immunisation services**: Stable electricity ensures that vaccines and temperature-sensitive medicines remain effective, increasing immunisation rates.
- **Expanded storage capacity**: Facilities can now store more medications and vaccines without the risk of spoilage.

8.1.3.3. Relevant Evaluation Criteria

✔ **Relevance** – Aligns with national priorities to improve healthcare access and emergency response.

✔ **Effectiveness** – Significantly enhances healthcare service delivery, but equipment shortages still pose challenges.

✔ **Impact** – Solarisation enables improved healthcare service delivery, but inadequate medical equipment and oxygen shortages limit its full potential.

✔ **Equity and Inclusion** – Ensures greater access to safe deliveries and emergency care, particularly for women and newborns.

8.1.3.4. Assessment

🟢 Positive Impact (GREEN) – The solarisation of hospitals has significantly improved healthcare service delivery, ensuring more reliable emergency response, safer surgical conditions, and better patient monitoring. Power stability has led to improved maternal and neonatal care, enhanced laboratory capabilities, and expanded vaccine storage capacity.

8.1.3.5. Specific Recommendations

- **Increase PV system capacity** to further improve healthcare delivery.
- **Support MoH expanding procurement efforts for essential medical equipment**, particularly oxygen concentrators, diagnostic machines, and neonatal care appliances.

8.2. Operational efficiency

8.2.1. Electricity uptime

8.2.1.1. Key Takeaway

Despite the installation of solar PV systems improving overall electricity reliability, no single data source provides a comprehensive picture of total system uptime across hospitals. Field observations and staff interviews indicate consistent power availability in critical units, but sensor data inconsistencies and seasonal variations (e.g., rainy-season challenges) affect assessments.

8.2.1.2. Context & Analysis

Overall improvement in electricity reliability:

- Fieldwork findings confirm that all hospitals now have stable and reliable electricity throughout the day, particularly in critical units such as operating rooms, neonatal care, and emergency wards.
- Findings indicate reduced reliance on gensets, leading to fewer outages and lower operating costs. While solarisation has played a key role in this improvement, other factors have also contributed. For instance, at ODCH and PCMH, improved grid reliability has significantly impacted overall electricity service uptime, further reducing dependence on backup gensets.

Challenges in monitoring system uptime – Incomplete and inconsistent data from different monitoring platforms make it difficult to accurately measure total system uptime:

- Prospect sensors have large data gaps, making it unclear whether missing data reflects true system downtime or sensor malfunctions.
- AlphaESS sensors provide the most reliable solar PV system data, but they do not account for the use of grid power or gensets, limiting their use in broader facility-level calculations.
- nLine sensors, despite being the most comprehensive, register multiple minor outages due to their sensor placement strategy, which paints a more negative picture of overall facility uptime.

Reported challenges in ensuring system uptime:

- Seasonality: All hospitals report more frequent and longer outages during the rainy season.

- Storage capacity: Hospitals report insufficient storage capacity to ensure 24-hour uptime, and most hospitals preventively use diesel gensets in the evening to postpone usage of solar batteries until later at night.
- Rationing power: Hospitals have to manage electricity demand by dividing loads into critical and non-critical, ensuring priority power supply to essential medical services. To maintain electricity uptime, non-critical loads are switched off after sunset, optimising battery storage.

Relevant Evaluation Criteria

✔ **Relevance** – Addresses a critical barrier to healthcare service delivery by ensuring stable electricity.

✔ **Effectiveness** – Improves power reliability in hospitals, but monitoring limitations prevent full validation of uptime improvements.

✔ **Impact** – Ensures continuous power in critical hospital units, leading to better patient care.

✔ **Sustainability** – Ensures long-term viability.

8.2.1.3. Assessment

🟡 Moderate Concern (YELLOW) – While field reports confirm improved electricity reliability, remote and on-site monitoring inconsistencies via the PM, MoH, and MoE present challenges that require further refinement.

8.2.1.4. Specific Recommendations

- **Expand battery capacity** at hospitals experiencing outages to reduce dependence on gensets
- To capture more accurate uptime data, **deploy a more rigorous and unified monitoring system** that:
    - Can integrate data from multiple sensor platforms.
    - Has sufficient local storage to maintain data integrity in the event of short- to medium-term network downtime.
    - Uses current transformers (CTs) upstream of power sockets (i.e., at the circuit breaker) to avoid human-induced sensor downtime.

8.2.2. Quality of electricity service

8.2.2.1. Key Takeaway

The solarisation of hospitals has improved the quality and stability of electricity, ensuring that voltage remains within the acceptable range across all facilities. This has led to more reliable

operation of medical equipment and reduced risks of damage due to power fluctuations. **However, further optimisations can be carried out to ensure that solar inverters always stabilise voltage fluctuations**.

8.2.2.2. Context & Analysis

The nominal range for voltage is between 207 V and 253 V. According to RMS data from nLine sensors, all hospitals consistently operate within this range. Kambia Hospital has recorded the lowest average voltage both during the baseline and post-solarisation at about 212 V, however, its values remain above the threshold. Conversely, ODCH and PCHM display the highest average daily voltage post-solarisation, measuring approximately 237 V, well within the acceptable range.

Qualitative feedback from maintenance officer interviews at hospitals reinforces the findings:

"*Before solarisation, there were instances where we would have power, but the voltage would be so low that we couldn't use a lot of our equipment. There were several instances when the power would come back [after a power outage], but voltage fluctuations would spoil equipment. Wall sockets would stop working, so we couldn't administer oxygen to and monitor our patients. The situation today is much better.*" – Dr. Sahr Gborie, Resident Paediatrician, ODCH

However, further optimisations are possible. For instance, at ODCH and PCMH, the grid is frequently used in bypass mode, meaning electricity does not pass through the solar inverter. As a result, voltage fluctuations from the grid persist, whereas routing power through the inverter could help regulate and stabilise voltage levels, improving overall power quality.

8.2.2.3. Relevant Evaluation Criteria

- ✔ **Relevance** – Aligns with national priorities to improve healthcare infrastructure and service delivery.
- ✔ **Effectiveness** – Improves operational stability by ensuring medical equipment functions reliably.
- ✔ **Efficiency** – Reduces costs associated with equipment repairs and replacements due to power fluctuations.
- ✔ **Impact** – Enables better healthcare service delivery by ensuring consistent power quality.
- ✔ **Sustainability** – Enhances long-term functionality of hospital electrical systems, reducing dependency on external power sources.

8.2.2.4. Assessment

🟢 Positive Impact (GREEN) – Strong improvement in voltage stability, leading to better equipment reliability and reduced risks of power-related malfunctions.

8.2.2.5. Specific Recommendations

- **Optimise grid integration at ODCH and PCMH**:
    - EM-ONE should prepare a technical note outlining the grid integration challenges encountered and recommended mitigation strategies, both for ODCH/PCMH and as a lesson learned for future grid-tied PV systems.
    - Configure the system to route grid electricity through the solar inverter rather than bypassing it. This adjustment would help regulate voltage fluctuations, ensuring a more stable power supply for medical equipment and hospital operations.

8.2.3. Reliance on gensets & grid

8.2.3.1. Key Takeaway

Although hospitals have significantly reduced their reliance on gensets following the installation of solar PV systems, they still depend on both gensets and the national grid (where available) to maintain a consistent electricity supply. Genset usage varies depending on solar system capacity, seasonal fluctuations in solar generation, and financial constraints.

8.2.3.2. Context & Analysis

Feedback from maintenance staff indicates that reliance on gensets has decreased overall, improving system resilience and reducing the burden of fuel procurement. However, the extent of genset usage depends on hospital type, seasonal factors, and financial resources.

- Off-grid hospitals (Kabala, Masanga, Bonthe, and Kambia): Gensets are used in the evenings to prevent early depletion of battery storage systems, ensuring sufficient power availability overnight for critical loads.
- On-grid hospitals (ODCH and PCMH):
    - Grid usage: The national grid remains the primary power source, with solar serving as a backup.
    - Genset usage: Gensets are activated when the grid is down for extended periods (typically over four to five hours) and when solar battery storage is depleted.

Key factors influencing genset reliance:

- Budget availability: At PCMH, diesel consumption actually increased post-solarisation (2024) compared to pre-solarisation (2023). This was due to better availability of funds—50% of the forecasted fuel budget was received in 2024, compared to just 25% in 2023, as reported by the hospital's accountant.

- Seasonal variations: hospitals like Bonthe report no change in genset usage (relative to the baseline) during the rainy season, as battery charging is less efficient due to reduced solar input. However, pre-solarisation, overall electricity uptime was much lower, and dependence on a single genset presented a significant risk.
- Solar system battery capacity: All hospitals report that gensets are still being used because solar battery capacity is not sufficient to ensure 24-hour electricity uptime.

"The maintenance team used to work tirelessly to fix the genset, but sometimes we couldn't repair it in time, and patients would not survive. Now, I'm grateful that we no longer face those issues" – Francis J. Lahai, Maintenance Officer at Bonthe Hospital

8.2.3.3. Relevant Evaluation Criteria

✔ **Relevance** – Aligns with national priorities to improve healthcare infrastructure and reduce reliance on costly, polluting gensets.

✔ **Effectiveness** – Solarisation has achieved its objective of reducing genset dependency, but has not eliminated it entirely.

✔ **Efficiency** – Optimised genset usage reduces fuel costs, but further improvements could enhance efficiency, particularly in on-grid hospitals.

✔ **Impact** – Hospitals experience greater power stability, improving service delivery, though reliance on gensets persists in some facilities.

8.2.3.4. Assessment

🟡 Moderate Concern (YELLOW) – While solarisation has reduced genset reliance and improved electricity uptime, continued use of gensets presents cost and sustainability challenges and an opportunity to increase PV and battery capacity.

8.2.3.5. Specific Recommendations

- **Optimise energy storage solutions**: assess the feasibility of increasing battery capacity to reduce genset dependency, particularly during night-time and rainy seasons.
- **Improve grid integration for on-grid hospitals:** explore automatic switching mechanisms to improve the transition between grid and solar power, minimising inefficiencies in ODCH and PCMH.
- **Optimise solar-genset integration**: ensure that there is an automatic switch over between the solar system and the gensets.

8.3. Operation & Maintenance

8.3.1. Routine maintenance protocols

8.3.1.1. Key Takeaway

Hospital staff effectively carry out routine maintenance tasks, but a weak maintenance culture poses a risk to long-term system performance.

8.3.1.2. Context & Analysis

Maintenance staff in hospitals claim that they are doing routine maintenance, such as cleaning PV panels (typically once per month), cleaning power rooms, or inspecting cable connections in power rooms.

Field observations confirm that powerhouses were well-maintained, indicating that maintenance officers are actively cleaning these areas. However, some PV panels appeared dusty, though this may not necessarily indicate poor maintenance. The site visits took place in late January, coinciding with the Harmattan season, which causes excessive dust accumulation.

In some hospitals, staff are not conducting maintenance for non-solar equipment, indicating a broader issue with infrastructure management. For example, Kabala hospital has several old gensets that are damaged. While this issue is not directly linked to solar, it shows the lack of maintenance culture in some hospitals and highlights the risk of long-term functionality of the solar systems if maintenance is not institutionalised.

8.3.1.3. Relevant Evaluation Criteria

- ✔ **Efficiency** – Routine maintenance protocols ensure lower O&M and component replacement costs down the line.
- ✔ **Impact** – Conducting routine maintenance helps achieve intended impacts, however, long-term benefits are at risk if maintenance is not institutionalised.
- ✔ **Sustainability** – Solar system performance depends on consistent maintenance practices.

8.3.1.4. Assessment

🟡 Moderate Concern (YELLOW) – While hospitals are performing routine maintenance, gaps in broader infrastructure management indicate a risk to the long-term functionality of solar systems.

8.3.1.5. Specific Recommendations

- **Refresher training**: Establish a structured refresher training programme for O&M personnel, with a mandatory follow-up session six months after system installation.

- **Training and maintenance manuals**: Ensure that the hospitals receive training and user manuals to help them manage the systems, troubleshoot issues, and conduct regular maintenance.
- **Maintenance officer evaluation**: Establish a formal evaluation of maintenance officers, for example, through audits.

8.3.2. Feedback on O&M service provider

8.3.2.1. Key Takeaway

EM-ONE's responsive O&M support is praised for its timely and professional resolution, but further digitalisation of O&M services could improve transparency for all stakeholders and contribute to long-term sustainability.

8.3.2.2. Context & Analysis

In cases where systems experienced technical issues requiring troubleshooting, maintenance officers reported the problems to EM-ONE via WhatsApp. Each hospital has a dedicated WhatsApp group with EM-ONE, allowing for quick communication. EM-ONE consistently responded within minutes to an hour, providing timely remote guidance and on-site technical assistance to resolve issues.

For example, when Bonthe Hospital encountered a battery bank issue overnight, EM-ONE provided real-time instructions, enabling hospital staff to resolve the problem. This demonstrates the commitment and professionalism of the O&M service provider.

While feedback on EM-ONE's service has been overwhelmingly positive, there is room for greater transparency in tracking technical issues. Currently, EM-ONE maintains an issue log in Excel format and reports regularly to SEforALL. While this is a good first step, introducing a digital ticketing system would further enhance issue tracking, response monitoring, and overall transparency in maintenance operations.

8.3.2.3. Relevant Evaluation Criteria

- ✔ **Effectiveness** – Quality maintenance services are a precondition to increase system uptime and support achieving intended results.
- ✔ **Efficiency** – Quality maintenance services ensure system reliability and reduce long-term costs.
- ✔ **Impact** – Contributes to improved electricity reliability and uninterrupted healthcare services, ensuring critical medical equipment remains functional.

- ✔ **Equity and Inclusion** – While the O&M process is effective, there is limited evidence of gender and youth participation in maintenance activities.
- ✔ **Sustainability** – Quality O&M contributes to long-term system performance, but a digital ticketing system would further ensure long-term benefits.

8.3.2.4. Assessment

🟢 Positive Impact (GREEN) – Reliable and timely O&M services contribute to system uptime and functionality, but a lack of structured tracking mechanisms and a broader lack of an O&M strategy may hinder long-term planning and accountability.

8.3.2.5. Specific Recommendations

- **Deploy a digital ticketing system to improve transparency, track maintenance requests, and ensure service providers adhere to Service Level Agreements (SLAs)**. The ticketing system will also help in understanding costs associated with O&M and will help develop learning cycles to improve future budgets.

8.3.3. Hospital Energy Management & Energy Efficiency

8.3.3.1. Key Takeaway

While hospitals reported improved reliability in electricity supply, inefficient energy use, particularly overnight overconsumption, has affected system performance in some hospitals.

8.3.3.2. Context & Analysis

Post-intervention data showed that solar PV systems significantly improved power reliability across all six hospitals, reducing dependence on diesel gensets. However, inconsistent adherence to energy-saving protocols led to unnecessary strain on battery storage systems. In multiple hospitals, maintenance officers reported staff forgetting to turn off air conditioning units at night, while in some cases, hospital power was used for unauthorised personal appliances (e.g., staff bringing in personal refrigerators).

While EM-ONE's monitoring system detected abnormal consumption spikes and intervened, facilities with weaker supervisory structures experienced more frequent inefficiencies. Without strict enforcement of energy management protocols, hospitals may unintentionally reduce battery lifespan, increasing long-term maintenance costs.

8.3.3.3. Relevant Evaluation Criteria

- ✔ **Effectiveness** – Ensuring solar energy is fully utilised for healthcare needs.
- ✔ **Efficiency** – Managing hospital energy consumption effectively.

✔ **Sustainability** – Protecting long-term system performance and maintenance.

8.3.3.4. Assessment

🟡 Moderate Concern (YELLOW) – Positive impact on energy reliability, but lack of structured energy use guidelines poses risks to long-term efficiency.

8.3.3.5. Specific Recommendations

Develop stricter enforcement of energy-saving protocols at the hospital level, including possible installation of timers on non-essential appliances. Integrate energy efficiency training as part of both the system handover process and subsequent refresher sessions to promote sustainable usage practices, for example, switching off ACs and lights that are not used.

8.3.4. Long-term O&M strategy

8.3.4.1. Key Takeaway

Uncertainty over long-term O&M responsibilities and funding poses a major risk to the project's sustainability.

8.3.4.2. Context & Analysis

All project stakeholders emphasised the critical need for long-term maintenance of installed solar systems to ensure their sustained impact. However, there is widespread concern over the lack of clarity on who will take responsibility for ongoing O&M once the initial contract period ends.

Both the Ministry of Health (MoH) and the Ministry of Energy (MoE) agreed on several key challenges:

1. **Ensuring long-term maintenance**: Stakeholders recognise the importance of consistent O&M but lack a structured plan for who will oversee it.
2. **Financial limitations**: Both ministries have insufficient budgets to finance ongoing system maintenance and, critically, the replacement of expensive components such as batteries and inverters.
3. **Technical capacity**: Neither ministry currently has the in-house expertise to conduct specialised solar system maintenance and would have to either create capacity or outsource to a third party.
4. **Unclear costs of O&M**: Ministries have limited visibility into the exact Bill of Materials, component costs, and expected lifespans. As a result, they cannot accurately estimate O&M or replacement costs, making financial planning difficult.
5. **Access to supply chains**: There are logistical challenges in procuring spare parts and technical services, which could hinder long-term maintenance.

6. **Need for a holistic approach**: Solar system O&M must not be addressed in isolation but rather integrated into a broader infrastructure sustainability strategy, which also includes infrastructure funded by other programmes.
7. **Role of development partners**: Both ministries argue that donor-funded projects should not fully shift the burden of long-term O&M onto the public sector and that development partners, such as SEforALL, must contribute to sustainability planning and funding.
8. **Public-Private-Partnerships**: Ministries acknowledge their role in maintaining public infrastructure but emphasise that responsibility must be shared among stakeholders.
9. **Centralised Monitoring**: There is a strong need for a national system to track the performance and maintenance status of all installed PV systems.
10. **Accountability**: There is currently no consensus on which government entity should take full ownership of long-term O&M. Some stakeholders believe it should be under the Ministry of Energy, the Facilities Unit, while others believe it should be under the new rural electrification unit that will be created.

8.3.4.3. Relevant Evaluation Criteria

✔ **Relevance** – Aligns with national priorities to ensure sustainable healthcare infrastructure and reliable energy access in critical facilities.

✔ **Effectiveness** – Ensuring long-term benefits on health outcomes depends on a structured, well-funded O&M strategy to sustain the benefits of improved energy access.

✔ **Efficiency** – Without a streamlined approach to long-term O&M, hospitals may face higher operational costs, particularly if systems fall into disrepair and require costly emergency interventions. A lack of spare parts procurement planning could further disrupt hospital operations, reducing system efficiency.

✔ **Impact** – Without a clear O&M strategy, solar systems may fail prematurely, leading to service interruptions, increased reliance on diesel gensets, and higher costs for healthcare facilities. The inability to sustain solar systems could reverse the positive impact on patient care and hospital operations.

✔ **Sustainability** – Without a clear, long-term O&M strategy, solar systems risk gradual deterioration, leading to reduced system reliability, increased downtime, and premature component failures. The absence of dedicated financial and technical resources could force hospitals to revert to expensive and polluting backup gensets, undermining the project's intended benefits. A lack of centralised monitoring and ownership accountability further exacerbates the risk of system neglect, jeopardising healthcare service delivery in the long run.

8.3.4.4. Assessment

🔴 High Concern (RED) – The lack of a long-term O&M strategy presents a major risk to the project's sustainability, impact, and effectiveness.

8.3.4.5. Specific Recommendations

- **Develop long-term O&M strategy in collaboration with government and other stakeholders:**
  - Establish a clear governance framework defining the roles and responsibilities of the Ministry of Energy (MoE), the Ministry of Health (MoH), the future Rural Electrification Unit, and other stakeholders for ongoing O&M.
  - Ensure that O&M planning integrates existing solarisation programmes, avoiding fragmentation in maintenance efforts.
  - Establish national O&M guidelines to standardise maintenance procedures, procurement planning, and technical support across all hospitals.
- **Long-term O&M funding considerations:**
  - Forecast long-term O&M and component replacement costs and communicate the projected cashflow to all project stakeholders during the project design phase.
  - Identify long-term funding mechanisms for system maintenance, including provisions for component replacements such as batteries and inverters.
  - Explore co-financing models with development partners, leveraging public-private partnerships (PPPs) to share the financial burden of long-term maintenance. Cost savings from reduced fuel consumption could potentially be used to finance ongoing O&M, although GoSL is unlikely to have sufficient funds to cover component replacement costs.
  - Support GoSL to establish a multi-donor fund that finances long-term infrastructure maintenance.
- **Strengthen technical capacity for long-term system maintenance:** build in-house solar maintenance capacity within MoH/MoE and/or establish long-term contracts with qualified private-sector providers.
- **Support GoSL establishing a centralised monitoring and maintenance tracking system**: GoSL should be able to centrally monitor the performance of the solar systems, and have visibility over maintenance logs.
- **Review SL-HEP success indicators**: include KPIs to assess O&M performance metrics (e.g., Service-Level Agreements [SLAs], component failure rates), and O&M funding (e.g., amount of co-investment secured).

8.3.5. Spare part provision of essential components

8.3.5.1. Key Takeaway

The limited provision of spare parts for essential components, such as light bulbs, tubes, and fans, poses a risk to system functionality and hospital operations.

8.3.5.2. Context & Analysis

Hospital staff expressed concerns about the limited availability of spare parts and the lack of a clear process for requesting replacements. For example, Kambia Hospital already has faulty fans, with staff noting that fans in wards deteriorate quickly as they run 24/7. Kabala Hospital expressed the need for light tubes and bulbs. Light tubes cannot be found in local markets. Bulbs can be found, but they are of lower quality compared to the original system components.

According to EM-ONE, the project allocated 3% of bulbs and light tubes as spare parts, with hospitals able to request replacements when needed. However, no provision for spare fans was made in the project scope.

Some damaged components had not been reported for replacement, indicating a lack of awareness among hospital staff regarding the spare parts request process. This gap in communication could result in avoidable delays in repairs and underutilisation of available spare components.

8.3.5.3. Relevant Evaluation Criteria

- ✔ **Efficiency** – Without an efficient spare parts distribution system, hospitals face longer waiting times for basic components.
- ✔ **Impact** – Ensuring access to spare parts reduces equipment downtime, improving patient care.
- ✔ **Sustainability** – A lack of spare parts stock and unclear request processes could lead to system inefficiencies and increased reliance on local markets for lower-quality replacements.

8.3.5.4. Assessment

🟡 Moderate Concern (YELLOW) – The lack of a robust spare parts provision system presents a medium-level risk to the reliability and longevity of the installed systems. While some basic components like bulbs and tubes were included in limited quantities, their replenishment process remains unclear to facility staff, leading to delays and avoidable outages. The absence of spare fans in the original scope further exacerbates the risk, particularly given their intensive daily use in hospital wards

8.3.5.5. Specific Recommendations

- **Ensure on-site spare part stocking**: hospitals should receive a basic supply of essential spare parts (e.g., lights) during PV system commissioning, to reduce dependency on the O&M service provider
- **Expand the basic spare parts scope to include a provision for spare fans.**

8.4. Training and Capacity Building

8.4.1. Commissioning training & capacity of maintenance staff

8.4.1.1. Takeaway

EM-ONE's hands-on commissioning training was highly valued for its practical approach, enabling maintenance officers to better understand system functionality and troubleshooting. However, skill gaps among maintenance staff, particularly in certain hospitals, pose a risk to long-term system sustainability.

8.4.1.2. Context & Analysis

EM-ONE provided commissioning training to hospital maintenance officers and technicians as part of the solar system installation process. Unlike traditional training approaches that focus heavily on theory, this training involved direct, hands-on participation during the installation process.

Maintenance officers highly valued this approach, noting that being actively involved in the installation helped them better understand system functionality, troubleshooting, and maintenance needs. Many indicated that this practical exposure was far more beneficial than if they had received only theoretical instruction.

The number of trainees varied across hospitals. For example, Bonthe Hospital has only two technicians, whereas Kabala Hospital has six. Notably, none of the trained technicians were women.

Most technicians, apart from the official maintenance officer, work as volunteers in hospitals. The training was particularly valuable for volunteers, as it enhanced their technical skills and could improve their employability, increasing their chances of securing a remunerated position.

Figure 52. Number of trained technicians per hospital according to maintenance officers

Hospital	Number of trained technicians	Share of women
Kambia	3	0
Masanga	5	0
Kabala	6	0
Bonthe	2	0
PCMH	2	0

Hospital	Number of trained technicians	Share of women
ODCH	0*	0

* There is a new maintenance officer in ODCH who was not working in the hospital during the installation of the solar systems. The maintenance officer was not sure if his predecessor had been trained.

Field observations suggest that maintenance officers have a varying range of experience. For example, in Masanga Hospital, the maintenance team seems to be very capable. This is a result of ongoing technical cooperation with other international partners, who have engineers on site providing day-to-day training and support. As a result, the infrastructure in this hospital is much better maintained than in other hospitals. On the other hand, Kabala is at the opposite end of the spectrum, with a maintenance team that didn't seem to have a good understanding of the solar systems, was less organised (e.g., didn't have a clear routine maintenance plan), and were not able to clearly communicate which power infrastructure was providing energy to which building.

8.4.1.3. Relevant Evaluation Criteria

- ✔ **Relevance** – Supports national priorities for technical capacity-building in the healthcare sector.
- ✔ **Effectiveness** – Hands-on training enhances system maintenance skills, but varied technical knowledge across hospitals remains a concern.
- ✔ **Efficiency** – Quality commissioning training reduces future O&M costs by ensuring better system management from the start.
- ✔ **Impact** – Quality commissioning training helps achieve impacts
- ✔ **Equity and Inclusion** – Lack of female participation in technical training limits gender diversity in solar system management.
- ✔ **Sustainability** – Hands-on commissioning training equips maintenance officers with practical skills, enabling better system management, faster issue resolution, and improved long-term solar system reliability. However, the limited technical capacity of some technicians increases the risk of system failures, shortens system lifespan, and raises maintenance costs, threatening long-term reliability.

8.4.1.4. Assessment

🟢 Positive Impact (GREEN) – Strong training outcomes, but technical capacity gaps and lack of structured refresher training require attention to ensure long-term sustainability.

8.4.1.5. Specific Recommendations

- **Refresher training**: establish a structured refresher training programme for O&M personnel, with a mandatory follow-up session six months after system installation.
- **Training manuals**: ensure that the hospitals receive training or user manuals to help them manage the systems, troubleshoot issues, and conduct regular maintenance.
- **Maintenance officer evaluation**: establish a formal evaluation process of maintenance officers, for example, through audits.
- **Energy-efficiency training**: Integrate energy efficiency training as part of both the system handover process and subsequent refresher sessions to promote sustainable usage practices, for example, switching off ACs after-hours and lights that are not in use.

8.4.2. Training of STEM trainees

8.4.2.1. Key Takeaway

The Women in STEM training successfully equipped participants with technical skills and professional networking opportunities, empowering them to enter the renewable energy sector. However, strengthening post-training employment pathways is crucial to retain female talent, sustain engagement in the field, and maximise long-term impact.

8.4.2.2. Context & Analysis

The 2024 Women in STEM training in Sierra Leone trained two cohorts of all-female participants in solar installation and maintenance, combining theoretical and practical components.

According to two interviewed trainees, the training equipped them with confidence and technical expertise in solar installations. Their networking opportunities also expanded significantly, through LinkedIn and international conferences. One trainee pursued further education in renewable energy, and the other one secured an internship in the sector.

Trainees raised concerns that they struggled to find jobs despite their new skills. Without clear career prospects, trainees may switch to other fields, wasting their acquired expertise.

8.4.2.3. Relevant Evaluation Criteria

✔ **Effectiveness** – Training achieved technical skill-building objectives.

✔ **Impact** – Provided direct benefits to participants in knowledge, confidence, and networking.

✔ **Equity and Inclusion** – The project ensured equal opportunities for all applicants through a transparent and merit-based selection process, allowing women in STEM to access technical training. The focus on training women in solar installation addresses gender disparities in the renewable energy sector, helping to bridge the gap in female

representation in technical roles. However, the risk of losing female trainees to other sectors remains high if job placement support is not strengthened.

✔ **Sustainability** – Lack of career pathways may lead to skill attrition, but the training's emphasis on LinkedIn networking and personal branding helps trainees connect with industry professionals, increasing their chances of securing opportunities in the renewable energy sector.

8.4.2.4. Assessment

🟢 Positive Impact (GREEN) – The Women in STEM training successfully provided technical skills, confidence, and networking opportunities for female trainees, equipping them for careers in the renewable energy sector. The project has empowered participants, with some pursuing further education or securing internships in the field. However, a lack of structured career pathways and job placement support poses a risk, as some trainees struggle to find employment in the sector.

8.4.2.5. Specific Recommendations

- **Establish a Post-Training Employment Support programme**:
  - Develop partnerships with renewable energy companies to facilitate job placements, internships, or apprenticeships.
  - Offer career mentorship programmes for trainees to connect with professionals in the field.
- **Retain alumni as supervisors for future cohorts**: engage past trainees as mentors or supervisors for new cohorts to maintain their skills and keep them engaged in the sector.
- **Create SEforALL alumni networking & job platform**: launch an online alumni portal to track graduates, share job opportunities, and connect them with industry partners.

8.5. Solar system design considerations

8.5.1. Battery storage capacity

8.5.1.1. Key Takeaway

While solar systems adequately meet energy demands during the day, battery storage capacity remains insufficient to sustain hospital operations throughout the night. As a result, hospitals must rely on diesel gensets in the evening and strict energy rationing to prevent early battery depletion.

8.5.1.2. Context & Analysis

Interviews with hospital staff indicate that all six hospitals feel their current battery capacity is inadequate to meet nighttime energy demands. This results in:

- Genset use as a preventive measure: Many hospitals run gensets in the evening to ensure solar batteries are fully charged for nighttime operations.
- Energy rationing: Hospitals must divide loads into critical and non-critical, switching off non-essential power after sunset to minimise the risk of batteries reaching critically low SoC.

Qualitative feedback from hospital staff interviews was not conclusive around battery autonomy or perceived battery storage expansion needs. Bonthe Hospital staff claims batteries run empty around 3 AM every night, though this has not been confirmed through quantitative data. PCMH maintenance officers report that battery storage sustains hospital operations for a maximum of five hours before requiring an alternative power source.

8.5.1.3. Relevant Evaluation Criteria

✔ **Relevance** – Aligns with national priorities to provide sustainable and uninterrupted healthcare energy access.

✔ **Effectiveness** – While solar systems meet daytime energy demands, battery limitations hinder full electrification of night-time operations.

✔ **Efficiency** – Hospitals must compensate for insufficient battery capacity by relying on gensets, increasing fuel costs and operational inefficiencies.

✔ **Impact** – Limited battery storage affects healthcare service continuity.

✔ **Sustainability** – Inadequate battery capacity poses a long-term risk to a reliable energy supply, forcing continued dependence on gensets.

8.5.1.4. Assessment

🔴 High Concern (RED) – Battery capacity constraints have been identified as a challenge in all six Phase 1 hospitals, limiting the effectiveness and sustainability of solar electrification efforts.

8.5.1.5. Specific Recommendation

- **Assess battery expansion needs**: conduct a detailed battery performance audit across all hospitals to determine actual nighttime energy demand and current storage limitations
- **Consider increasing battery capacity**: prioritise battery expansion in hospitals where genset reliance remains high

8.5.2. Security lighting for ground-mounted PV plants

8.5.2.1. Key Takeaway

Insufficient lighting around ground-mounted PV plants increases their vulnerability to theft, vandalism, and unauthorised access.

8.5.2.2. Context & Analysis

Ground-mounted PV plants are often positioned on the outskirts of hospital compounds, close to exterior fences where lighting is insufficient. This increases vulnerability to theft.

8.5.2.3. Relevant Evaluation Criteria

- ✔ **Relevance** – Supports national energy security and healthcare facility resilience.
- ✔ **Effectiveness** – Reduces theft and vandalism risks, ensuring uninterrupted hospital power supply.
- ✔ **Efficiency** – Minimises repair or component replacement costs by protecting solar assets.
- ✔ **Impact** – Improves security in the facility's compound.
- ✔ **Sustainability** – Security lighting can improve long-term uptime of the solar system.

8.5.2.4. Assessment

🟡 Moderate Concern (YELLOW) – Some challenges require attention.

8.5.2.5. Specific Recommendations

- **Install security lighting around PV plant compounds**.
- **Deploy motion-sensor security lights**: Motion-activated lighting improves security while reducing energy consumption.
- **Pair security lighting with surveillance systems**: Combine lighting with CCTV monitoring or solar-powered alarm systems to improve detection and response to security threats.

8.5.3. Standardised containerised powerhouse

8.5.3.1. Key Takeaway

Inconsistent storage conditions for battery and inverter systems pose risks to equipment integrity and system reliability.

8.5.3.2. Context & Analysis

Storage conditions for batteries and inverters vary across facilities, creating inconsistencies in system protection and maintenance requirements.

Hospitals using existing infrastructure for battery and inverter storage can face security challenges:

- Weak doors and a lack of locks increase the risk of theft and unauthorised access.
- Roof leaks and inadequate ventilation expose batteries and inverters to moisture and dust, leading to accelerated wear and potential system failures.

Facilities with standardised EPC-supplied containers benefit from better security, climate control, and streamlined maintenance.

A uniform, containerised powerhouse system would improve long-term sustainability, ensuring consistent protection across all sites while simplifying maintenance, monitoring, and troubleshooting.

8.5.3.3. Relevant Evaluation Criteria

✔ **Effectiveness** – Ensures safe and reliable battery and inverter storage, minimising system failures.

✔ **Efficiency** – Reduces repair and replacement costs by preventing component damage or theft.

✔ **Impact** – Enhances system operational reliability.

✔ **Sustainability** – A containerised powerhouse can help increase the solar system's lifetime.

8.5.3.4. Assessment

🟡 Moderate Concern (YELLOW) – Variability in storage conditions poses a risk to system integrity and sustainability. Standardising storage solutions can impact consistent system performance and protection.

8.5.3.5. Specific Recommendations

- **Standardise containerised powerhouses for battery and inverter storage**. Implement a uniform, secure storage solution across all project sites to ensure consistent protection against theft and weather damage.

8.6. Healthcare staff motivation & retention

8.6.1. Motivation to work at hospitals

8.6.1.1. Key takeaway

Improved electricity access in hospitals has significantly enhanced staff motivation, creating a better working and living environment for healthcare professionals. Reliable power enables a better work-life balance, increased job satisfaction, and improved efficiency, making hospitals more attractive workplaces.

8.6.1.2. Context & Analysis

Interviews with hospital staff indicate that access to reliable electricity has positively impacted staff morale, motivation, and retention across all hospitals. Some comments that stood out from staff interviews:

- Previously, the staff viewed working at the hospital as isolating and undesirable, with one doctor even refusing to accept a posting there (Masanga Hospital).
- Previously, the hospital was considered an undesirable place to work, “a prison” in the MSs' words, and doctors often avoided assignments there. Now, people are glad to be assigned to the hospital. (Bonthe Hospital).
- Now, morale has significantly improved, which has had an unintended positive impact on reduced staff delays (Masanga Hospital).
- The maintenance team, particularly the on-call staff, is more engaged and motivated due to fewer electricity-related disruptions and can focus on other important maintenance work, which before would often be neglected due to limited time (Masanga and PCMH Hospitals).

8.6.1.3. Relevant Evaluation Criteria

✔ **Relevance** – Aligns with national priorities and sector needs

✔ **Effectiveness** – Addresses staff retention challenges by improving working conditions.

✔ **Efficiency** – Optimises resources and costs

✔ **Impact** – Enhanced staff well-being, efficiency, and motivation, leading to better patient care.

✔ **Equity and Inclusion** – Ensures gender and youth participation in training and maintenance

✔ **Sustainability** – Long-term access to electricity can help retain skilled healthcare professionals in rural areas.

8.6.1.4. Assessment

🟢 Positive Impact (GREEN) – The availability of reliable electricity has been a major driver of improved staff morale, engagement, and retention in hospitals. Staff now perceive their workplace as safer, more functional, and better suited for delivering quality care. This shift has transformed perceptions of remote or previously under-resourced facilities, making them more attractive postings. The increased motivation of maintenance personnel and healthcare workers alike translates into better service continuity, reduced absenteeism, and improved performance across departments.

8.6.1.5. Specific recommendations

None.

8.6.2. Living conditions of healthcare staff

8.6.2.1. Key takeaway

Improved electricity access has enhanced safety, comfort, and overall living conditions for healthcare workers, leading to higher motivation and job satisfaction. However, inconsistencies in power availability across staff quarters present challenges.

8.6.2.2. Context & Analysis

Extended electricity access in staff quarters has improved comfort, rest, and work-life balance, but gaps remain in certain hospitals where quarters lack nighttime power, affecting morale.

8.6.2.3. Relevant Evaluation Criteria

- ✔ **Relevance** – Aligns with national priorities and sector needs.
- ✔ **Effectiveness** – Enhanced staff motivation and retention by improving living conditions.
- ✔ **Efficiency** – Optimises resources and costs.
- ✔ **Impact** – Safer and more comfortable work environment.
- ✔ **Equity and Inclusion** – While conditions have improved, nurses and some staff remain disadvantaged due to a lack of electricity access in their quarters.
- ✔ **Sustainability** – Inconsistent power availability in staff quarters raises concerns about long-term staff retention.

8.6.2.4. Assessment

🟡 Moderate Concern (YELLOW) – While access to reliable electricity has positively influenced the living conditions of healthcare staff in many hospitals, important gaps remain. In several

facilities, only selected staff quarters (e.g., for medical officers or midwives) benefit from 24/7 electricity, while others are left without power. This uneven access has implications for staff satisfaction, retention, and equity. In facilities where staff quarters remain unelectrified, healthcare workers feel less safe at night and face challenges in carrying out their duties during off-hours.

8.6.2.5. Specific Recommendations

- **Consider extending solar power access to all staff quarters.**
- **Improve the availability of electricity at night for all staff quarters.**

8.6.3. Safety in the hospital

8.6.3.1. Key takeaway

Hospital staff perceive the facility as significantly safer than before due to improved night-time lighting, which has enhanced security, reduced risks of attacks and theft, and created a safer working environment for night-shift staff. However, outdoor lighting remains insufficient in some areas, particularly along pathways between staff quarters and hospital buildings, leaving staff vulnerable when walking at night.

8.6.3.2. Context & Analysis

- Improved security and staff safety: The installation of reliable indoor and outdoor lighting has reduced security concerns, particularly for night-shift nurses and on-call staff who previously worked in poorly lit environments.
- Remaining gaps in outdoor lighting: Despite improvements, some areas of hospital compounds remain dimly lit, particularly pathways between staff quarters and hospital buildings, making nighttime movement unsafe for staff.
- Impact on gender inclusion: Female healthcare workers, in particular, have highlighted greater safety concerns when walking to and from staff quarters at night, underscoring the need for comprehensive outdoor lighting solutions.

8.6.3.3. Relevant Evaluation Criteria

✔ **Relevance** – Aligns with national priorities to improve healthcare facility security and working conditions.

✔ **Effectiveness** – Provides greater safety for hospital staff and patients, particularly at night.

✔ **Impact** – Strengthens staff confidence, security, and overall workplace safety, reducing risks of attacks and theft.

✔ **Equity and Inclusion** – Enhancing outdoor lighting ensures greater safety for all staff, particularly female workers and night-time healthcare providers, promoting a more inclusive and secure working environment.

8.6.3.4. Assessment

🟢 Positive Impact (GREEN) – Strong improvement in staff safety and security, though outdoor lighting gaps require further attention.

8.6.3.5. Specific Recommendations

- **Improve outdoor lighting coverage**: install additional lighting along pathways connecting staff quarters to hospital buildings, ensuring safe movement at night.
- **Consider installing motion-activated solar lights to improve visibility while minimising battery consumption.**

8.6.4. Job creation & Improvement

8.6.4.1. Key takeaway

While the installation of solar systems did not generate significant new full-time employment opportunities, it greatly improved working conditions for existing hospital staff by ensuring a more stable and efficient work environment.

8.6.4.2. Context & Analysis

The solarisation project primarily aimed to enhance energy reliability in healthcare facilities rather than directly create new employment opportunities. As a result, full-time job creation was minimal. In some cases, part-time roles were established for periodic maintenance tasks, such as cleaning PV panels and maintaining the installation site, but these roles were limited to occasional work, typically once a month or less.

The most significant impact was on job quality and efficiency for existing healthcare staff. Reliable electricity reduced stress and improved working conditions, particularly in critical care units such as surgical theatres, maternity wards, and neonatal care. Before the intervention, healthcare workers had to rely on unreliable gensets or even phone flashlights during power outages, creating stressful and unsafe conditions.

The improved energy supply now allows staff to work more efficiently, use medical equipment consistently, and provide better patient care without fear of sudden power loss.

8.6.4.3. Relevant Evaluation Criteria

✔ **Effectiveness** – Enhances hospital operations and staff efficiency.

✔ **Impact** – Improves job conditions for healthcare workers.

✔ **Equity and Inclusion** – Ensures gender and youth participation in training and maintenance.

8.6.4.4. Assessment

🟢 Positive Impact (GREEN) – Although job creation was not significant, staff in all hospitals report significant improvement in working conditions.

8.6.4.5. Specific Recommendations

None.

Annexe I: Emission factors for diesel-fuelled gensets

Emission factors for diesel generator systems (in kgCO2e/kWh) for productive applications				
Genset class	**Load factor (min/max)**		**GHG Factor**	**kWh/liter**
< 15 kW	≥0	<15	1.4	2.29
≥ 15 kW, < 35kW	≥15	<35	1.3	2.46
≥ 35 kW, < 135kW	≥35	<135	1	3.2
≥ 135 kW, < 200kW	≥135	<200	0.8	4
≥ 200 kW	≥200		0.8	4

Small-scale Methodology: Renewable electricity generation for captive use and mini-grid, UNFCCC (2022).
https://cdm.unfccc.int/UserManagement/FileStorage/YP1U4E0H976Z3WDMV2NGSTBLQIRCK5

Annexe II: List of remote monitoring systems in place for all Phases

The following list was elaborated by Catalyst based on the information available in each RMS platform.

Phase	Facility name	Facility type	Sensor Platform	Sensor Name/Location
1	Bonthe Government Hospital	Hospital	Prospect	Diesel generator
1	Bonthe Government Hospital	Hospital	nLine	Bonthe - Maternity Ward - Solar & Generator
1	Bonthe Government Hospital	Hospital	nLine	Bonthe - Operating Theatre Room - Solar & Generator
1	Bonthe Government Hospital	Hospital	nLine	Bonthe - Male Ward - Solar & Generator
1	Bonthe Government Hospital	Hospital	nLine	Bonthe - Special Baby Care Ward - Solar & Generator
1	Bonthe Government Hospital	Hospital	AlphaESS	Bonthe Government Hospital
1	Kabala Government Hospital	Hospital	Prospect	Diesel generator
1	Kabala Government Hospital	Hospital	Prospect	Solar system
1	Kabala Government Hospital	Hospital	nLine	Kabala - Sarelogy Room - Solar & Generator
1	Kabala Government Hospital	Hospital	nLine	Kabala - X-Ray Room - Solar & Generator
1	Kabala Government Hospital	Hospital	AlphaESS	Kabala Government Hospital
1	Kabala Government Hospital	Hospital	nLine	Kabala - Medical Superintendent Office - Solar & Generator
1	Kabala Government Hospital	Hospital	nLine	Kabala - Paediatric Pharmacy - Solar & Generator
1	Kambia Government Hospital	Hospital	Prospect	Diesel generator
1	Kambia Government Hospital	Hospital	Prospect	Solar system
1	Kambia Government Hospital	Hospital	Prospect	Diesel generator
1	Kambia Government Hospital	Hospital	nLine	Kambia - Matron Office - Solar & Generator
1	Kambia Government Hospital	Hospital	nLine	Kambia - Administration Building - Solar & Generator
1	Kambia Government Hospital	Hospital	nLine	Kambia - Paediatric/Resuscitation Room - Solar & Generator
1	Kambia Government Hospital	Hospital	AlphaESS	Kambia Government Hospital
1	Kambia Government Hospital	Hospital	nLine	Kambia - Special Baby Care Ward - Solar
1	Kambia Government Hospital	Hospital	nLine	Kambia - Scbu Ward - Solar
1	Masanga Hospital	Hospital	Prospect	Diesel generator
1	Masanga Hospital	Hospital	Prospect	Solar system
1	Masanga Hospital	Hospital	nLine	Masanga - Administration Building - Solar & Generator
1	Masanga Hospital	Hospital	nLine	Masanga - Emergency Room - Solar & Generator
1	Masanga Hospital	Hospital	nLine	Masanga - Operation Theatre - Solar & Generator
1	Masanga Hospital	Hospital	nLine	Masanga - Surgical Ward - Solar & Generator
1	Masanga Hospital	Hospital	AlphaESS	Masanga Hospital
1	ODCH	Hospital	Prospect	Grid/Mini Grid

Phase	Facility name	Facility type	Sensor Platform	Sensor Name/Location
1	ODCH	Hospital	Prospect	Grid/Mini Grid - ODCH/PCMH
1	ODCH	Hospital	Prospect	Diesel generator
1	ODCH	Hospital	Prospect	Diesel generator
1	ODCH	Hospital	nLine	Ola During - Maintenance Office - Grid W/Solar & Generator Backup
1	ODCH	Hospital	nLine	Ola During - Hdu - Grid W/Solar & Generator Backup
1	ODCH	Hospital	nLine	Ola During - Step Down Ward Two - Grid W/Solar & Generator Backup
1	ODCH	Hospital	nLine	Ola During - Intensive Care Unit - Grid W/Solar & Generator
1	ODCH	Hospital	AlphaESS	PCMH & ODCH
1	ODCH	Hospital	nLine	Ola During - Step Down Ward Two - Grid W/Solar & Generator Backup
1	PCMH	Hospital	Prospect	Grid/Mini Grid - ODCH/PCMH
1	PCMH	Hospital	Prospect	Diesel generator
1	PCMH	Hospital	Prospect	Diesel generator
1	PCMH	Hospital	nLine	Princess Christian - Labour Ward/Maternity - Grid W/Solar & Generator Backup
1	PCMH	Hospital	nLine	Princess Christian - Hod Maintenance Office - Grid W/Solar Backup
1	PCMH	Hospital	nLine	Princess Christian - D.M.S2 - Grid W/Solar Backup
1	PCMH	Hospital	nLine	Princess Christian - Operating Theatre - Grid W/Solar & Generator Backup
1	PCMH	Hospital	nLine	Princess Christian - Ward 2 - Grid W/Solar Backup
1	PCMH	Hospital	nLine	Princess Christian - Labour - Grid W/Solar & Generator Backup
1	PCMH	Hospital	AlphaESS	PCMH & ODCH
1	PCMH	Hospital	nLine	Princess Christian - Ward 2 - Grid W/Solar Backup
2	Bayama Lela CHP	CHC	AlphaESS	Bayama Lela CHP
2	Bo School	CHC	Prospect	Grid/Mini Grid
2	Bo School	CHC	AlphaESS	Bo School
2	Cline Town CHC	CHC	Prospect	Grid/Mini Grid
2	Cline Town CHC	CHC	AlphaESS	Cline Town CHC (Host)
2	Cline Town CHC	CHC	AlphaESS	Cline Town CHC (Follower)
2	Jenner Wright Clinic	CHC	Prospect	Grid/Mini Grid
2	Jenner Wright Clinic	CHC	Prospect	Bulk Metering
2	Jenner Wright Clinic	CHC	AlphaESS	Jenner Wright Clinic (Follower)
2	Jenner Wright Clinic	CHC	AlphaESS	Jenner Wright Clinic (Host)
2	Kailahun Government Hospital	Hospital	Prospect	Bulk Metering

Phase	Facility name	Facility type	Sensor Platform	Sensor Name/Location
2	Kailahun Government Hospital	Hospital	nLine	Kailahun - Medical Store (Keeper'S Office) - Solar
2	Kailahun Government Hospital	Hospital	nLine	Kailahun - Laboratory Office - Generator
2	Kailahun Government Hospital	Hospital	nLine	Kailahun - Operating Theatre (Changing Room) - Generator
2	Kailahun Government Hospital	Hospital	nLine	Kailahun - Scbu Ward - Solar
2	Kailahun Government Hospital	Hospital	AlphaESS	Kailahun Government Hospital
2	Kamiendor PCH	CHC	AlphaESS	Kamiendor PCH
2	Kent CHC	CHC	AlphaESS	Kent CHC
2	Khalimat shahad Hospital	CHC	AlphaESS	Khalimat shahad Hospital
2	Kindoya Hospital	CHC	Prospect	Diesel Generator
2	Kindoya Hospital	CHC	Prospect	Diesel Generator
2	Kindoya Hospital	CHC	Prospect	Solar System
2	Kindoya Hospital	CHC	Prospect	Grid/Mini Grid
2	Kindoya Hospital	CHC	AlphaESS	Kindoya Hospital (Follower)
2	Kindoya Hospital	CHC	AlphaESS	Kindoya Hospital (Host)
2	Makali	CHC	AlphaESS	Makali (Host)
2	Makali	CHC	AlphaESS	Makali (Follower)
2	Mamansosanka CHC	CHC	AlphaESS	Mamansosanka CHC
2	Mokotawa CHP	CHC	AlphaESS	Mokotawa CHP
2	Moriba Town	CHC	AlphaESS	Moriba Town
2	Newton Town CHC	CHC	AlphaESS	Newton Town CHC
2	Nyandehun Ngovoihun CHP	CHC	AlphaESS	Nyandehun Ngovoihun CHP
2	Taiama Trauma	CHC	AlphaESS	Taiama Trauma
2	Tombo CHC	CHC	AlphaESS	Tombo CHC (Host)
2	Tombo CHC	CHC	AlphaESS	Tombo CHC (Follower)
2	Torwama CHC	CHC	AlphaESS	Torwama CHC
2	Under 5 PHC (Bonthe)	CHC	AlphaESS	Under 5 PHC (Bonthe)
2	Yele CHC	CHC	Prospect	Bulk Metering
2	Yele CHC	CHC	Prospect	Diesel Generator
2	Yele CHC	CHC	AlphaESS	Yele CHC
2	York Island (Bonthe)	CHC	AlphaESS	York Island (Bonthe)
2	York Village CHC	CHC	AlphaESS	York Village CHC
3	Connaught	Hospital	Prospect	Bulk Metering
3	Connaught	Hospital	nLine	Connaught - Blood Bank Office - Grid W/Generator Backup
3	Connaught	Hospital	nLine	Connaught - Operating Theatre Office - Grid W/Generator Backup

Phase	Facility name	Facility type	Sensor Platform	Sensor Name/Location
3	Connaught	Hospital	nLine	Connaught - Icu Medical Office - Grid W/Generator Backup
3	Connaught	Hospital	nLine	Connaught - Dental Operation Theatre - Grid W/Generator Backup
3	Connaught	Hospital	nLine	Connaught - Sop Unit (Sister Office) - Grid W/Generator Backup
3	Connaught	Hospital	nLine	Connaught - Dialysis Unit Medication Store - Grid W/Generator Backup
3	Connaught	Hospital	nLine	Connaught - Ward 1 (In Charge Room) - Grid W/Generator Backup
3	Kenema	Hospital	Prospect	Bulk Metering
3	Kenema	Hospital	nLine	Kenema - Eye Clinic (Surgeon'S Office) - Grid W/Generator Backup
3	Kenema	Hospital	nLine	Kenema - Power Generator Room - Grid W/Generator Backup
3	Kenema	Hospital	nLine	Kenema - Sbcu Ward - Grid W/Generator Backup
3	Kenema	Hospital	nLine	Kenema - Lassa (Fever) Lab Lead Office - Solar W/Grid Backup
3	Kenema	Hospital	nLine	Kenema - Tb Lab - Grid W/Solar & Generator Backup
3	Kenema	Hospital	nLine	Kenema - Blood Bank (In-Charge'S Office) - Grid W/Solar & Generator Backup
3	King Harman Road	Hospital	Prospect	Bulk Metering
3	King Harman Road	Hospital	Prospect	Diesel Generator
3	King Harman Road	Hospital	Prospect	Grid/Mini Grid
3	King Harman Road	Hospital	nLine	King Harman Road - Triage Outpatient Department - Grid W/Generator Backup
3	King Harman Road	Hospital	nLine	King Harman Road - General Laboratory - Grid W/Generator Backup
3	King Harman Road	Hospital	nLine	King Harman Road - Special Baby Care Unit - Grid W/Solar & Generator Backup
3	King Harman Road	Hospital	nLine	King Harman Road - Power Change Over Room - Grid W/Generator Backup
3	Koidu	Hospital	nLine	Koidu - Generator Room - Grid W/Generator Backup
3	Koidu	Hospital	Prospect	Bulk Metering
3	Koidu	Hospital	Prospect	Diesel Generator
3	Koidu	Hospital	nLine	Koidu - Pediatric Ward (In Charge Office) - Grid W/Generator Backup
3	Koidu	Hospital	nLine	Koidu - Maternity Unit (In Charges Office) - Grid W/Generator Backup
3	Lakka	Hospital	Prospect	Bulk Metering
3	Lakka	Hospital	Prospect	Diesel Generator

Phase	Facility name	Facility type	Sensor Platform	Sensor Name/Location
3	Lakka	Hospital	Prospect	Diesel Generator
3	Lakka	Hospital	nLine	Lakka - Changing Room (Bio Safety Lab) - Solar W/Grid Backup
3	Lakka	Hospital	nLine	Lakka - Office Of The Laboratory Lead - Grid W/Generator Backup
3	Lakka	Hospital	nLine	Lakka - M&E Unit - Grid W/Generator Backup
3	Lakka	Hospital	nLine	Lakka - Nurses Station - Grid W/Generator Backup
3	Magburaka	Hospital	Prospect	Bulk Metering
3	Magburaka	Hospital	Prospect	Diesel Generator
3	Magburaka	Hospital	nLine	Magburaka - Surgical Cho'S Office (Maternity Building) - Grid W/Generator Backup
3	Magburaka	Hospital	nLine	Magburaka - Power Change Over Room - Grid W/Generator Backup
3	Magburaka	Hospital	nLine	Magburaka - X-Ray Department Office - Grid W/Generator Backup
3	Magburaka	Hospital	nLine	Magburaka - Sbcu Ward - Grid W/Generator Backup
3	Magburaka	Hospital	nLine	Magburaka - Main Theatre (Drug Store) - Grid W/Generator Backup
3	Makeni	Hospital	Prospect	Bulk Metering
3	Makeni	Hospital	nLine	Makeni - Power Change Over Room - Grid
3	Makeni	Hospital	nLine	Makeni - Special Laboratory Office - Grid W/Generator Backup
3	Makeni	Hospital	nLine	Makeni - Main Operating Theatre Room - Grid W/Generator Backup
3	Makeni	Hospital	nLine	Makeni - Hospital Secretary Office - Admin Building - Grid
3	Moyamba	Hospital	Prospect	Bulk Metering
3	Moyamba	Hospital	Prospect	Solar System
3	Moyamba	Hospital	nLine	Moyamba - Power Change Over Room - Generator
3	Moyamba	Hospital	nLine	Moyamba - Maternity Ward (Nurses Office) - Generator
3	Moyamba	Hospital	nLine	Moyamba - Sbcu Ward - Solar & Generator
3	Moyamba	Hospital	nLine	Moyamba - Laboratory Department (Main Lab Room) - Generator
3	Porto Loko	Hospital	Prospect	Bulk Metering
3	Porto Loko	Hospital	Prospect	Bulk Metering
3	Porto Loko	Hospital	Prospect	Diesel Generator
3	Porto Loko	Hospital	nLine	Port Loko - Maternity Unit (Matrons Office) - Grid W/Generator Backup
3	Porto Loko	Hospital	nLine	Port Loko - Special Baby Care Unit Nurses Office - Grid W/Generator Backup

Phase	Facility name	Facility type	Sensor Platform	Sensor Name/Location
3	Porto Loko	Hospital	nLine	Port Loko - Power Change Over Room - Grid W/Generator Backup
3	Porto Loko	Hospital	nLine	Port Loko - Gene X-Part Laboratory - Grid W/Solar & Generator Backup
3	Pujehun	Hospital	Prospect	Diesel Generator
3	Pujehun	Hospital	Prospect	Solar System
3	Pujehun	Hospital	nLine	Pujehun - Sbcu Ward (Maternity Building) - Solar
3	Pujehun	Hospital	nLine	Pujehun - Pediatric Ward (Maternity Building) - Generator
3	Pujehun	Hospital	nLine	Pujehun - Dhmt (Cold Room) - Generator
3	Pujehun	Hospital	nLine	Pujehun - Ncd Laboratory - Solar & Generator
3	Rokupa	Hospital	Prospect	Bulk Metering
3	Rokupa	Hospital	Prospect	Grid/Mini Grid
3	Rokupa	Hospital	Prospect	Diesel Generator
3	Rokupa	Hospital	nLine	Rokupa - Laboratory Lead Office - Grid W/Generator Backup
3	Rokupa	Hospital	nLine	Rokupa - Hiv Unit Office - Grid W/Generator Backup
3	Rokupa	Hospital	nLine	Rokupa - Power Change Over Room - Grid W/Generator Backup
3	Rokupa	Hospital	nLine	Rokupa - Triage Finance Office - Grid W/Generator Backup

Annexe III: List of visited health facilities

S.No	Phase 1 sites	District	Date of visit
1	Bonthe Hospital	Bonthe	24th January 2025
2	PCMH & ODCH	Freetown	28th & 29th January 2025
3	Masanga Hospital	Masanga	21st January 2025
4	Kabala Hospital	Kabala	22nd January 2025
5	Kambia Hospital	Kambia	20th January 2025

Annexe IV: List of high-level stakeholders interviewed

Interviewee	Organization	Position
Benjamin Kamara	Ministry of Energy	Chief Director of Energy
Cyril Grant	Ministry of Energy	Executive Technical Adviser
Dr. Caulker	Ministry of Energy	Head of Planning Unit
Dr. Jalikatu Mustapha	Ministry of Health	Deputy Minister 2
Nelson Fofana	Ministry of Health	Acting M&E Specialist for Health
Emmanuel Mannah	SL Electricity Water Reg. Commission	Director General

Annexe V: Interview Guide – Phase 1 Health Facilities

1. General information		
#	**Question**	**Answers options**
	Facility Name	*Free text*
	Name & position of interviewee(s)	*Free text*
	Date	*Date*
	Date of solar system installation	*Date*

2. Operational efficiency / Energy KPIs				
#	**Question**	**Answer options**	**Evaluation dimension**	**Related KPI**
Electricity Uptime				
	Since the installation of the solar PV system, on average, how many hours per day is electricity available at this facility? How does this compare to the situation before the installation?		Effectiveness	Uptime of electricity services (Target: 23 hrs/day).
	Have there been any significant changes in the frequency or duration of power outages?		Effectiveness	Average outage frequency and duration
	When power outages occur, how often do they disrupt essential medical equipment usage?		Effectiveness	Impact on electricity-dependent medical devices.
	Do outages occur more frequently during specific seasons or times of the year?		Effectiveness	Seasonal reliability trends and service readiness.
	During prolonged grid outages (i.e. over 24 hours), does the solar PV system provide sufficient power for critical facility needs?		Effectiveness	System performance during grid outages
Quality of electricity service				

2. **Operational efficiency / Energy KPIs**				
	How has the quality of electricity (e.g., voltage stability, frequency) improved since the installation?		Effectiveness	Improved quality of electricity service
	Have you encountered any power fluctuations or equipment damage since the solar system was installed?		Sustainability	Operational efficiency and equipment safety
Reliance on generators & grid				
	Under what specific conditions (e.g., grid failures, emergencies) do you still rely on diesel generators?		Efficiency	Reduction of CO_2 emissions from generators Share of facility electricity supplied by on-site RE
	Can you estimate the reduction in diesel consumption and electricity costs since the system was installed? (how much diesel was used before vs. now)		Efficiency	Cost savings and energy efficiency
Solar system utilisation & design				
	How well does the solar PV system meet the specific energy needs of this facility?		Relevance	
	Was the facility involved in determining the design or capacity of the solar PV system? If not, would more involvement have helped?		Relevance	
	Is there any specific equipment that you cannot use on the solar system?		Relevance	
	Are you using the solar system as the main power source or is it used as a backup when the grid fails?			System utilisation rate and reliability
	Have any energy-efficient equipment or measures been adopted since the solar system installation? If so, what are they?"		Impact	Energy-efficient behaviour and equipment adoption

3. Improved healthcare delivery (Health KPIs)					
#	**Question**	**Answers options**	**Evaluation dimension**	**Impact category**	**Related KPI**
Maternal and infant health outcomes					
	How has the availability of energy impacted the quality of patient care you provide, particularly for maternal health and infant health		Impact	Health	Number of births supported by improved power supply in targeted facilities
	Have there been observable changes in maternal and infant mortality rates since the installation?		Impact	Health	Average number of maternal and infant deaths across targeted facilities per month.
	Can you share examples of how reliable energy has helped in treating patients, especially during emergencies and births/deliveries?		Impact	Health	Qualitative evidence of improved health outcomes.
Use of medical equipment and reporting					
	Has the use of electricity-dependent medical devices increased (e.g., imaging equipment, incubators)?		Effectiveness	Health/ Energy	Increased use of electricity-dependent medical device
	Has improved energy access led to the acquisition of new medical equipment, either provided by external donors, government programmes, or purchased by the facility? If so, what types of equipment have been		Effectiveness	Health/ Energy	Qualitative evidence of improved health services

3. Improved healthcare delivery (Health KPIs)					
	acquired, and how has their use impacted patient care?				
	Are you using more digital reporting tools or software for patient management? If yes, what impact has this had on efficiency and service delivery?		Efficiency	Health	
Service availability					
	Have new healthcare services been introduced due to improved electricity access (e.g., night-time surgeries?		Effectiveness	Health/ Social	Number of target facilities with reported improvement in availability of health services provided.
	Have existing services expanded in terms of hours or capacity?		Effectiveness	Health/ Social	Improved availability and capacity of healthcare services.
	Have you observed a reduction in power-related health service interruptions?		Effectiveness	Health	Improvements in health outcomes

4. Solar System usage & training (Social & Economic KPIs)					
#	**Question**	**Answer options**	**Evaluation dimension**	**Impact category**	**Related KPI**
	Has anyone in the facility been trained on the usage and		*Effectiveness*	Social/ Economic	Number of staff trained on solar energy in healthcare facilities (Target: 29).

4. Solar System usage & training (Social & Economic KPIs)					
	maintenance of the solar system?				
	How many facility staff were trained? How many of those were women?		Equity	Social	Number of staff trained on solar energy in healthcare facilities (Target: 29).
	Can you describe the format of the training, such as its duration and balance between theory and practice?		Efficiency	Social	Quality of training provided
	What specific topics were covered during the training? Were they relevant to your facility's needs?"		Effectiveness	Social	Training relevance and coverage
	Did the trainers leave any training materials with staff? If yes, can we review those?		Sustainability	Social	
	Has the training impacted the ability to manage the solar system?		Effectiveness	Social/ Economic	Enhanced capacity for PV system management

5. System maintenance (Operational KPIs)					
#	**Question**	**Answer options**	**Evaluation dimension**	**Impact category**	**Related KPI**
	How often is the solar system maintained and what protocols are in place for routine maintenance?		*Efficiency/ Sustainability*	Operational	Uptime of electricity services

5. System maintenance (Operational KPIs)					
	Have there been any technical issues or breakdowns since the installation of the solar system?		Effectiveness	Operational	Reliability of PV system performance
	If yes, have the issues been resolved? How? How long did it take to resolve them?		Efficiency	Operational	
	Are there specific maintenance tasks or protocols that you feel could be streamlined to improve efficiency? How does the performance of the solar PV system compare to the costs of maintaining and operating it		Efficiency/ Sustainability	Operational	

6. Staff motivation and retention (Social & Economic KPIs)					
#	**Question**	**Answer options**	**Evaluation dimension**	**Impact category**	**Related KPI**
	Have you noticed any changes in staff motivation or retention since the facility became electrified? If yes, what is the reason for the change in motivation/retention?		*Impact*	Social/ Economic	Higher motivation or greater ability for healthcare workers to perform their work.

6. Staff motivation and retention (Social & Economic KPIs)					
#	**Question**	**Answer options**	**Evaluation dimension**	**Impact category**	**Related KPI**
	Do staff members feel safer or more efficient working here now? Why? (e.g., no generator noise, improved air quality, improved lighting at night, improved electrical installation, etc.)		Impact	Social	Improved safety and efficiency for healthcare workers
	Does staff live on the facility's compound, and if so, has the solar installation improved their living conditions?		Impact	Social/ Economic	Improved livelihoods through electrification
	Have there been any jobs created in the facility due to increased electrification?		Impact	Social/ Economic	Improvements in social impact

7. Community perception and health seeking behaviour (Social & Economic KPIs)					
#	**Question**	**Answer options**	**Evaluation dimension**	**Impact category**	**Related KPI**
	Do you think that the community's perception regarding the facility changed since the installation of the solar system? How?		*Impact*	Social	Community perception of improved services.
	Have you observed an increase in patient visits or health-seeking behaviour? If so, do you believe it has anything to		*Effectiveness*	Social/ Economic	Increased health-seeking behaviour

7. Community perception and health seeking behaviour (Social & Economic KPIs)					
#	**Question**	**Answer options**	**Evaluation dimension**	**Impact category**	**Related KPI**
	do with the solar system?				
	Have you observed any other unintended impacts on the community? (e.g., economic spillover effects)		*Impact*	Social/ Economic	Unintended economic or social impacts

8. Challenges / recommendations				
#	**Question**	**Answer options**	**Impact category**	**Related KPI**
	Have you faced any challenges using or maintaining the solar system?		Effectiveness	Operational challenges and gaps
	Are there any areas where you feel additional support is needed?		Sustainability	Enhanced capacity for PV system management
	Do you have any recommendations for improving the solar system or scaling the intervention to other facilities?		Sustainability	
	Has there been any other unexpected impact (positive or negative) from the solar system? E.g., reduction in noise from generator		Impact	

Annexe VI: Stakeholder Interview Guide

Ministry of Energy Interview Guide

1. Relevance of project and integration within national policy		
#	**Question**	**Answer**
1.1	**What was the role of the Ministry of Energy in the project?**	
1.2	**How does this project align with your ministry's strategic priorities in energy access? Are there any priorities that are missing or should have been included?**	
1.3	**How has the project influenced or been influenced by evolving national policies or international commitments (e.g., SDGs, Paris Agreement)?**	
1.4	**How effectively have your ministry and other stakeholders collaborated on this project and are there areas where alignment or coordination could be improved?**	
1.5	Are there any other projects in Sierra Leone working on electrification of healthcare facilities? If yes, how well does SL-HEP align with the other projects?	

2. Efficiency		
#	**Question**	**Answer**
2.1	**Were there any significant challenges in coordinating between ministries, implementing partners, and other stakeholders? How were these addressed?**	
2.2	How effective and transparent were procurement processes for equipment and services?	

2. Efficiency		
#	**Question**	**Answer**
2.3	**Were you involved in the procurement process of the equipment? Do you think you should have been involved?**	

3. Perceived programme sustainability		
#	**Question**	**Answer**
3.1	**What is the ministry's role in ensuring long-term sustainability of installed systems?**	
3.2	What measures have been taken to ensure the sustainability of installed systems?	
3.3	Are maintenance protocols and budgets sufficient to support long-term operations?	
3.4	How are the impacts of this project being integrated into broader health and energy policies?	
3.5	Whose responsibility is it to operate and maintain the systems?	
3.6	Does the Ministry have any resources to fund operation and maintenance of these systems?	
3.7	**Does the Ministry have a good understanding of the costs involved in operating and maintaining these systems?**	
3.8	**Does the Ministry have the technical expertise to operate and maintain these systems?**	
3.9	Are there plans to reduce reliance on external funding for maintaining the systems in the long term?	

4. Cross-cutting and closing		
#	**Question**	**Answer**
4.1	**What were the most significant risks encountered during implementation, and how were they mitigated?**	
4.2	What lessons have been learned that could inform future projects?	
4.3	Do you see potential for scalability or replicability of this intervention in other regions or facilities?	
4.4	**What do you see as the main challenges to replicating this model in other regions or countries?**	
4.5	Is there anything else you'd like to add or emphasise about the project's implementation or impacts?	

Ministry of Health Interview Guide

1. Relevance of project and integration within national policy		
#	**Question**	**Answer**
1.1	What was the role of the Ministry of Health in the project?	
1.2	How does this project align with your ministry's strategic priorities? Are there any priorities that are missing or should have been included?	
1.3	How has the project influenced or been influenced by evolving national policies or international commitments?	
1.4	How effectively have your ministry and other stakeholders collaborated on this project and are there areas where alignment or coordination could be improved?	
1.5	Are there any other projects in Sierra Leone working on electrification of healthcare facilities? If yes, how well does SL-HEP align with the other projects?	

2. Efficiency		
#	**Question**	**Answer**
2.1	Were there any significant challenges in coordinating between ministries, implementing partners, and other stakeholders? How were these addressed?	
2.2	Were you involved in the procurement process of the equipment? Do you think you should have been involved? Why?	

3. Perceived programme sustainability		
#	**Question**	**Answer**
3.1	What measures have been taken to ensure the sustainability of installed systems?	
3.2	Whose responsibility do you think should it be to operate and maintain the solar systems?	
3.3	What should be the ministry's role in ensuring long-term sustainability of installed systems?	
3.4	What other challenges do you see to ensure long-term sustainability of installed systems?	

4. Cross-cutting and closing		
#	**Question**	**Answer**
4.1	What lessons have been learned that could inform future projects?	
4.2	Do you see potential for scalability or replicability of this intervention in other regions or facilities?	
4.3	What do you see as the main challenges to replicating this model in other regions or countries?	
4.4	Is there anything else you'd like to add or emphasise about the project's implementation or impacts?	

Annexe VII. Theory of Change