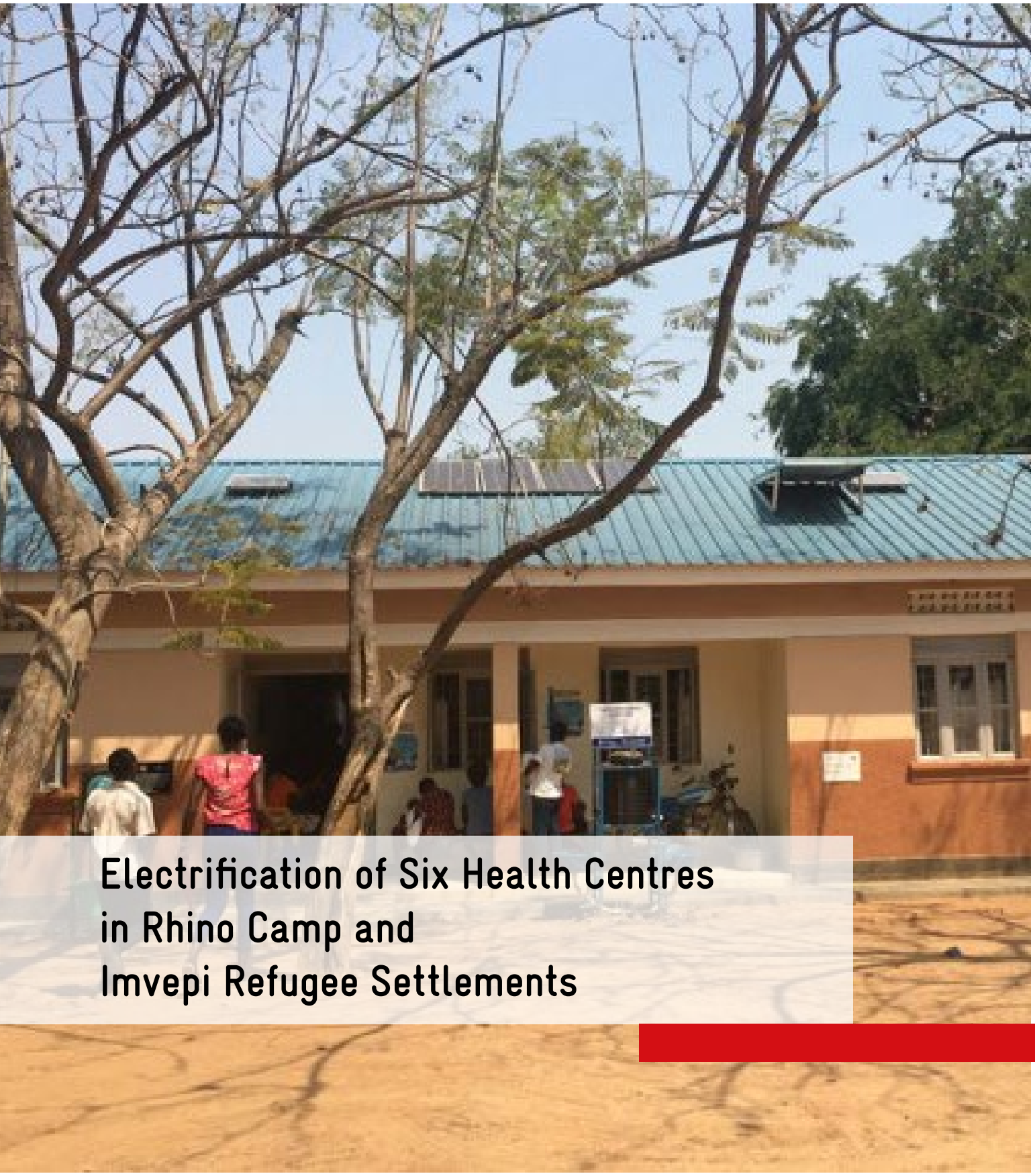

Electrification of Six Health Centres in Rhino Camp and Imvepi Refugee Settlements

Baseline Assessment Report

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Energy Solutions for Displacement Settings (ESDS) is a component of the Global Programme "Support to UNHCR in the implementation of the Global Compact on Refugees in the Humanitarian-Development-Peace Nexus" (SUN), which is commissioned by German Ministry for Economic Cooperation and Development (BMZ) and implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. ESDS supports the Ministry of Energy and Mineral Development, the Office of the United Nations High Commissioner for Refugees (UNHCR) and the Office of the Prime Minister (OPM) in addressing the lack of a sustainable energy supply in refugee hosting areas through global advisory services and the implementation of technical measures in displacement settings in Uganda, Kenya and Ethiopia.

Funded by

Implemented by:

Energising Development (EnDev) is a global multi-donor partnership implemented by GIZ that facilitates access to modern energy services currently in 21 countries worldwide and is funded by the BMZ, the Directorate-General for International Cooperation (DGIS) at the Ministry of Foreign Affairs of the Netherlands, the Norwegian Agency for Development Cooperation (NORAD), the Swiss Agency for Development and Cooperation (SDC) and the Foreign, Commonwealth & Development Office of the United Kingdom.

Funded by

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Published by:
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Photo credit/source:
Sharon Tsui, PhD, MPH, Kampala

Location and year of publication
Kampala, Uganda 2021

Maps:
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On behalf of
German Federal Ministry for Economic Cooperation and Development (BMZ)
Referat 221
10963 Berlin, Germany

Bonn, 2022

Federal Ministry
for Economic Cooperation
and Development

Acknowledgments

Review of protocol, data collection tools, and coordination of on-the-ground data collection activities:

- GIZ – Bettina Baesch Ssemwaka, Florent Eveille, Samuel Oyaku, Phillip Rohloff, Noah Ochima
- UNHCR – Emmanuel Ekakoro, Emmanuel Kerukadho
- IRC – Levi Byarunhanga, Lazarous Drile, Muhammed Marjjid
- MTI – Andrew Hoskins, Moses Rubangakene

Key informants for the health facility survey and qualitative interviews:

- Frontline healthcare workers and facility staff at
  Yinga HC III, Imvepi HC II, Siripi HC III, Ofua HC III, Ocea HC II, Odoubu HC II
- District Health Officers of Terego and Madi Okollo
- Health program representatives from UNHCR and IRC

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- UNHCR – Emmanuel Ekakoro, Emmanuel Kerukadho
- IRC – Levi Byarunhanga

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Tables and Figures

Acronyms and Abbreviations

AIRD	African Initiatives for Relief and Development
ANC	Antenatal Care
ART	Antiretroviral Therapy
BMZ	German Federal Ministry of Economic Cooperation and Development
CO	Clinical Officer
DHO	District Health Officer
DBS	Dried Blood Spot
DLG	District Local Government
EID	Early Infant Diagnosis
EnDev	Energising Development
EPI	Expanded Programme on Immunization
ESDS	Energy Solutions for Displacement Settings
FGD	Focus Group Discussion
FIC	Facility In-Charge
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
HC	Health Centre
HCW	Health Care Worker
HIS	Health Information System
HUMC	Health Unit Management Committee
IDI	In Depth Interview
IPD	In-Patient Department
IRC	International Rescue Committee
MEMD	Ministry of Energy and Mineral Development
MOH	Ministry of Health
MTI	Medical Teams International
OGS	Off Grid Solar
OPD	Out-Patient Department
OPM	Office of the Prime Minister
PNC	Postnatal Care
PREEEP	Promotion of Renewable Energy and Energy Efficiency Programme
PV	Photo Voltaic
RDT	Rapid Diagnostic Test
QUAL	Qualitative
QUAN	Quantitative
RWC	Refugee Welfare Committee
SARA	Service Availability Readiness Assessment
SEM	Social Ecological Model
TB	Tuberculosis
UNHCR	United Nations High Commissioner for Refugees
VHT	Village Health Team
WHO	World Health Organization

Electrification of Six Health Centres in Rhino Camp and Imvepi Refugee Settlements

Project Info: **SUN-ESDS**

The BMZ commissioned Global Program "Support to UNHCR in the implementation of the Global Compact on Refugees in the Humanitarian-Development-Peace Nexus (SUN)", implemented by GIZ, seeks to support UNHCR in its role as facilitator of the implementation of the **Global Compact on Refugees** (GCR) and the Comprehensive Refugee Response Framework (CRRF) in selected refugee contexts and sectors. The program is part of the German Special Initiative "Tackling the Root Causes of Displacement, (Re-)integrating Refugees". It currently provides advisory services to UNHCR on a global level and supports UNHCR in creating and mainstreaming knowledge on the operationalization of the GCR.

The Energy Solutions for Displacement Settings (SUN-ESDS) component works closely with UNHCR and local partners to provide energy solutions that cater to the needs of both refugee and host communities in our project countries- Uganda, Kenya, and Ethiopia. SUN-ESDS is also the German contribution to the **Clean Energy Challenge** issued by UNHCR in 2019 with the following objective: **"All refugee settlements and nearby host communities will have access to affordable, reliable, sustainable and modern energy by 2030."**

The SUN-ESDS project works through three intervention areas:

Improving the policy framework through providing advisory services to governmental stakeholders to promote the inclusion of refugees into national service delivery systems. The project collaborates with the affected communities, and governmental, non-governmental and private sector partners to develop more sustainable energy solutions.

Greening infrastructure in displacement settings through supporting the solarization of UNHCR offices as well as settlement/camp and communal infrastructure, thereby promoting more environmentally sustainable and cost-efficient energy solutions. The project develops energy delivery models that are attractive to the private sector.

Increasing energy access through developing self-sustaining markets for basic energy related services and products, improving access to finance and promoting participatory design processes benefitting households, social services, and small businesses of both refugees and host communities while reducing the pressure on the environment.

We contribute to the following SDGs

Project Info: EnDev

Energising Development (EnDev) is an international flagship programme for providing needs-based, modern energy access, having reached more than 25 million people. The multi-donor partnership focuses on decentralised energy solutions, particularly for rural regions. These solutions provide access to electricity, for example from solar systems and isolated networks. This is supplemented by modern cooking energy. The project reduces greenhouse gas emissions by placing the focus on renewable energy.

EnDev operates in more than 20 countries worldwide and cooperates with governmental, private sector and civil society stakeholders. The driving force behind EnDev is the partnership of Germany, the Netherlands, Norway, and Switzerland: donors who are committed to accelerating energy access and socio-economic development. The programme is coordinated by the Deutsche Gesellschaft für International Zusammenarbeit (GIZ) and The Netherlands Enterprise Agency (RVO.nl).

EnDev's interventions impact three main areas:

Energising Lives
Ensuring that no one is left behind, EnDev enhances access to affordable, reliable, sustainable and modern energy (SDG 7). Thereby, it helps reduce poverty (SDG 1), improves people's health and well-being (SDG 3), enables a better quality in education (SDG 4) and promotes gender equality (SDG 5

Energising Opportunities
By providing private households, social institutions and small as well as medium-sized businesses with modern energy, EnDev helps creating job opportunities, especially in rural areas, and contributes to economic development broadly (SDG 8).

Energising Climate
EnDev promotes the transition towards clean and renewable energies. Supporting efforts to combat climate change is at the core of EnDev's work and in line with SDG 13 and the Paris Agreement. Sustainable and modern energy access is key to reducing greenhouse gas emissions.

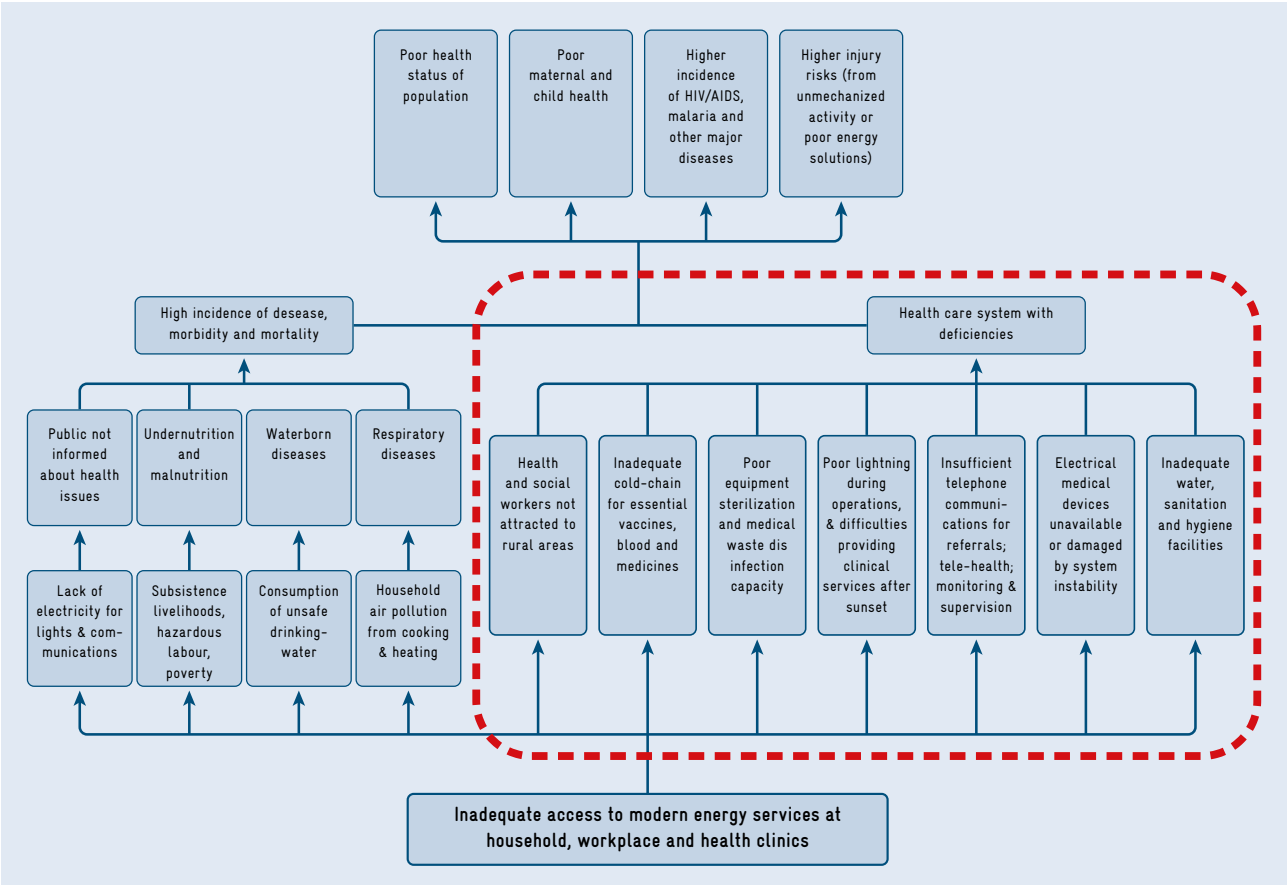
For more information visit the official website: **endev.info**

Background

Significance of energy access for health

Approximately 840 million people around the world live without electricity and half of them are found in sub-Saharan Africa [1]. Uganda is among twenty countries with the largest population lacking access to electricity [1] where only 43% of the total population have access to electricity [2]. The importance of access of energy for health facilities is increasingly recognized. Electricity is a vital precondition to effective essential health service delivery (Figure 1) [3]. Electricity is required for lighting to visualize patients for examination, procedures, and monitoring, and to operate life-saving electric medical devices and diagnostic equipment, sterilize equipment, refrigerate medicines and biologic samples for diagnostic testing, and facilitate communication between healthcare providers for emergency medical transport, consultations, coordination and more [4]. A dependable source of power is especially important for quality of care. Reliable electricity is required to maintain 'cold chain', or appropriate temperate range, for vaccines, medical and surgical consumables, and the temporary storage of biologic samples for diagnostic testing. Having electricity whenever it is in demand is critical for extending hours of operation at a health facility, and enabling healthcare workers to respond to efficiently and effectively for emergencies at night [3-5].

Figure 1 Impact of energy access on public health [3].



Electricity is also an important precursor for safety, security, efficiency, and comfort of people working and residing within health facility premises in hard-to-reach locations. Electricity within staff quarters can aide in the retention of healthcare workers in rural areas, particularly in countries already experiencing a human resource for health crisis [3].

Table 1 Common devices requiring electricity at a health center [4].

Category	Equipment	Purpose	Power (W)	Hours used per day (h)	Energy per day (Wh/day)
All health facilities	Lights (fluorescent)	Service delivery at night, security	11	6	66
	Mobile phone charger	Communication	5-20	8	40-160
	Radio	Communication	2-30	8	16-240
	Water pump	Sanitation	100	6	600
	Computer	Data management	15-200	4	60-800
	Printer (ink, laser)	Data management	65-1000	4	260-4000
	Small waste autoclave	Solid waste treatment	600-6000	1	600-6000
Medical equipment	Sterilizer (steam)	Sterilization of medical tools	500-1560	2	1000-3200
	Suction	Device used to extract mucus and other bodily fluids	24	10	240
	Pulse oximetry	Vital monitoring – small device to measure level of oxygen in blood	24	2	48
	Reverse-osmosis water purifier	Water purification for drinking	260-570	8	2080-4560
	X-ray machine, non-dental (portal)	Medical projectional radiography, produces 2D images by x-ray radiation	3,000-50,000	0.5	1500-25,000
	Newborn incubator	Clear plastic bed that helps keep baby warm	420	24	10,080
	Mechanical ventilator	Machine that pushes warm air and oxygen through breathing tube to help breathing	200	10	2000
	Ultrasound scanner	Device used to detect objects and measure distances through sound waves	75	2-3	150-225
	Electrocardiogram (ECG)	Records electrical signals from heart to check for different heart conditions	50-80	0.5	25-40
	Nebulizer	Turns liquid medicine into a mist to help treat asthma	180	3-5	540-900
Laboratory equipment	Vaccine refrigerator (165L)	Pharmaceutical-grade or purpose-built units designed and manufactured specifically for the storage of temperature sensitive vaccines such as influenza, rotavirus, and MMRV.	40-500	4	160-2000
	Microscopes	Instrument used to see objects that are too small to be seen for the naked eye	30	2	60
	Centrifuge	Device that uses centrifugal force to separate various components of a fluid, or liquids from solids	600	2	1200
	Spectrophotometer	Device used for the measurement of transmittance or reflectance of solutions	63	1	63
	Blood chemistry analyser	Device that runs assays on clinical samples such as blood serum, plasma, urine, and cerebrospinal fluid to detect the presence of analytes relating to disease or drugs.	45	2	90
	Haematology analyser	Device used to count and identify blood cells at high speed and accuracy.	230	2	460
	Arterial blood gas analyser	Device to aspirate blood from syringe and measure pH and the partial pressures of oxygen and carbon dioxide.	250	0.5	125

Energy access and health service performance

There is a dearth of empirical evidence linking health facilities' energy access rates and health outcomes. The 2014 World Health Organization (WHO) systematic global literature review did not identify any studies linking energy access and health outcomes as the primary objective [3]. Energy access, or its lack of, has been highlighted in the literature as a supply-side barrier to maternal health and reproductive health services in India and Mali [6-9]. Following the WHO systematic review, one peer-reviewed article has been published documenting the effect of reliable electricity of health facilities on child and maternal health service utilization in Gujarat, India [6]. This study utilized matched data from India's District Level Household and Facility Survey (DLHS-II and DLHS-III) and administrative data from electricity distribution companies for intervention state, Gujarat, rural electrification program and a 'control', non-intervention state, Maharashtra, for a difference-in-difference analysis to assess impact [6]. The study found that electricity improved the operational capacity of primary health centres through increased availability and functionality of essential devices and equipment, increased access to health information through television, and increased utilization of health services [6]. Decentralized household level data and data on timing of electrification of households are not easily available in most countries. Furthermore, many contributing and confounding factors shape health service provision, including staff skills and knowledge, availability of medicines, proximity to treatment, and time-lag before measurable improvements, and these factors need to be measured and accounted for analytically [3]. The combination of limited data availability and difficulties in measuring causal impacts of energy on health have resulted in scanty rigorous evidence on the relationship between energy access and health outcomes [10]. Rather, the relationship between energy access and health is typically assessed through intermediate impacts on health using proxy indicators on facility performance, availability of electricity and/or electrical equipment for health service delivery, and healthcare worker attitudes and motivation (Table 2).

Table 2 Proxy indicators used to indirectly assess impact of energy on health [3]

Category	Proxy Indicator	Impact on Health
Facility performance	Operating hours – night time, total hours per day Clinic visits	• In Kenya electrified clinics are open on average four more hours per day; in Bangladesh, electrified clinics are opened one more hour per day [11]
Health service indicator in relation to availability of electricity and/or electrical equipment	Availability of specific types of electrical equipment in health facility (WHO/SARA and USAID/ Measure Health surveys)	• Clinics lacking electricity did not have lower immunization rates possibly because of mitigating strategies such as mobile immunization teams and immunization campaigns in areas where refrigeration was unavailable [11] • Electrified clinics improved the operational capacity of primary health centres by increasing availability and functionality of a wide range of essential devices and equipment [6]
Health worker attitudes and performance	Health worker attitudes and motivation	• Community electricity access was a key factor in attracting and retaining qualified health workers [12] • Bangladesh health workers preferred living in electrified communities and this reduced absenteeism in health facilities [13] • Ugandan health workers express dissatisfaction with unreliable or unavailable electricity in clinics and hospitals [14]

Energy access among health facilities in sub-Saharan Africa and Uganda

Limited contemporary data exist on energy access among health facilities in sub-Saharan Africa and Uganda. Available data indicate that many lower health facilities (non-hospitals) are in need of electrification and all health facilities (hospitals and lower-level health facilities) need better access to reliable electricity. In 2013, the WHO conducted a secondary quantitative data analysis of health facilities' energy access using nationally representative samples of public and private health facilities collected in or after 2000 [15]. The 2013 study clearly defined "reliable" electricity as "no outages of more than two hours in the past week" [15], enabling comparison within and across country comparison. Among the eleven African countries assessed, about a quarter (26%) health facilities did not have any access to electricity and only one-third (34%) of hospitals had 'reliable' electricity [15]. The analysis for Uganda utilized data from the 2007 Uganda Service Provision Assessment of 491 health facilities [16]. Results among all health facilities (not stratifying by facility type) indicate that 58% of health facilities had no electricity and only 15% had 'reliable' electricity. When the results were stratified by health facility type, only 1% of hospitals had no electricity while 60% of lower level health facilities reported no access to electricity, and only 15% hospitals and 16% lower level health facilities reported access to 'reliable' electricity [15].

Energy Solutions for Displacement Settings (ESDS) and Energising Development (EnDev)

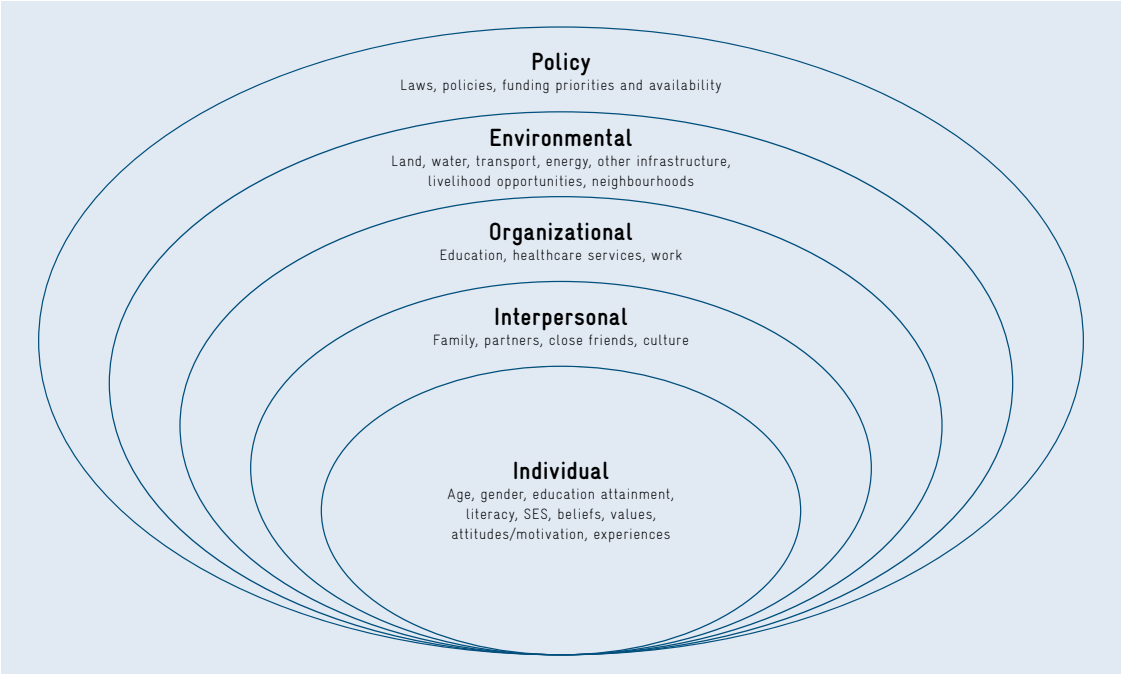
Uganda hosts more than 1.4 million refugees from South Sudan, the Democratic Republic of Congo, Burundi, Rwanda, and Somalia. A majority of refugees live in settlements with rural host communities across 13 of the 134 districts [17]. There is a gross need for quality energy products and services for refugees and host communities in these locales. Prior studies conducted by development advisors of GIZ Promotion of Renewable Energy and Energy Efficiency Programme (PREEEP) in West Nile and District Energy Focal Persons between 2013-2016 found unreliable energy access among health facilities and more than 50% of the sampled health centres had dysfunctional off-grid solar (OGS) photovoltaic systems (PVS\) [17]. Limited access to energy affects refugees and host members' capacity to meet his/her basic needs and capacity to strive for self-reliance.

In response, GIZ PREEP in Uganda, Energy Solutions for Displacement Settings (ESDS) and Energising Development (EnDev) are collaborating with the Ministry of Energy and Mineral Development, the Office of the Prime Minister, and the United Nations High Commissioner for Refugees (UNHCR) to improve sustainable access to energy for refugees and host communities. Specifically, ESDS and EnDev intend to provide and install OGS PVS for six purposefully selected health centres located within Rhino Camp and Imvepi Refugee Settlements in Terego and Madi Okollo districts, Uganda in 2021 [17].

Conceptual Framework

The conceptual framework linking energy access, health, and socioeconomic status is grounded in the social ecological model (SEM) [18, 19]. The SEM posits that multilevel factors influence health and socioeconomic outcomes that include, and go beyond, the individual, including the interpersonal, organizational, community, and societal levels (Figure 2). Policy is reflected by ESDS and EnDev's funding priorities and available resources to provide sufficient, sustainable, and modern electricity to health facilities within refugee settlements. Environment is reflected in factors such as infrastructure and neighbourhoods: both availability of permanent buildings and the locales of health facilities to be within the refugee settlement areas have shaped the selection criteria of health facilities to be included in the intervention. Organization is reflected in the health facility, including the facility infrastructure, service delivery, health workforce, access to essential medicines and commodities, financing, leadership/ governance, and health information system. Interpersonal is reflected in the dynamics among healthcare workers, catchment population (refugee and host), implementing partners and funders supporting the health facility. Interpersonal dynamics can shape perceptions of ownership of the solar systems, willingness to ensure security and maintenance of the solar systems, and willingness to support activities for the sustainability of the solar systems. Finally, individual is reflected by individual users of energy within the health facility, such as night duty staff utilizing lighting to provide emergency or inpatient services at night, laboratory assistants and technicians utilizing microscopes or other electric diagnostic equipment, records assistants entering data into the computer or printing reports, healthcare workers participating in phone consultations or coordinating an emergency medical referral and transfer of a patient to a higher level of care, and patients charging their phones while they are admitted to inpatient ward or maternity. Individual characteristics can shape energy use, health-seeking behaviours, and willingness to participate in protection and maintenance of the solar systems.

Figure 2 Social Ecological Model of Health and Socio-Economic Status



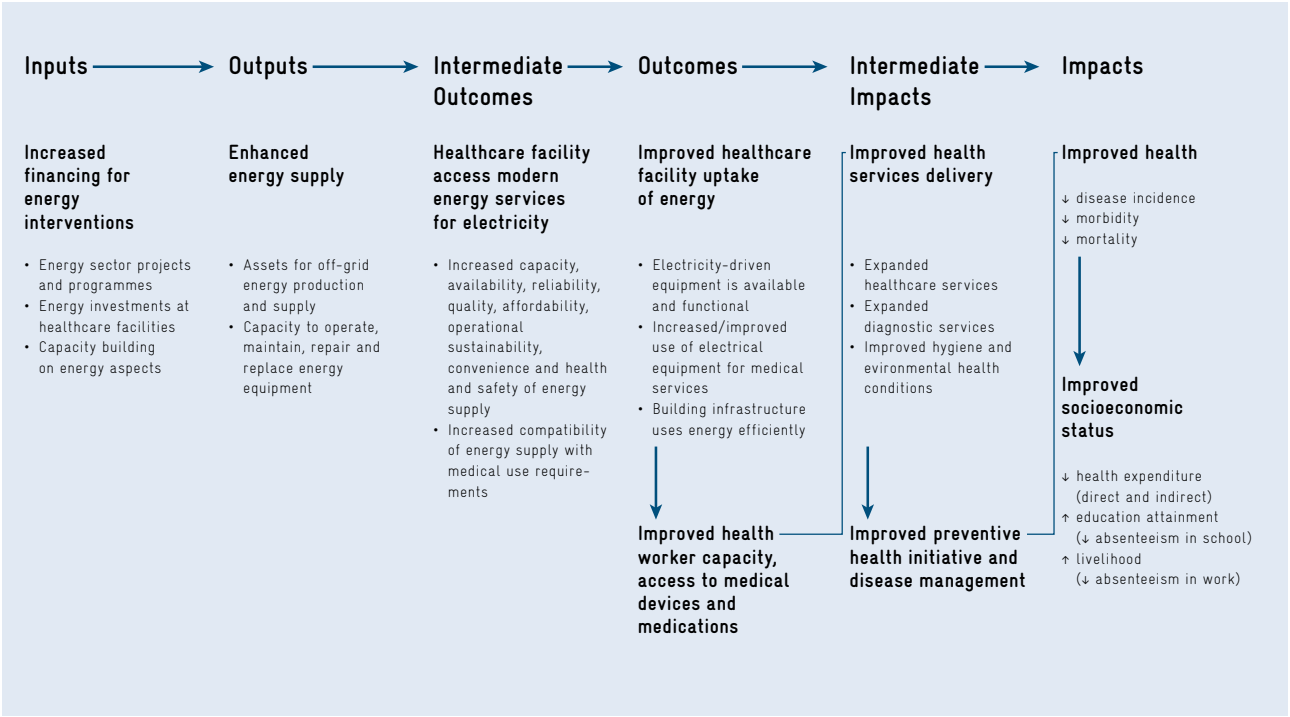
The SEM emphasizes the reciprocal relationship between multilevel factors: the environment influences individual behaviours and individuals also create and shape the environments in which they live [19]. For example, available energy within the health facility can shape how healthcare workers provide health services through reliance on electrical diagnostic equipment or medical devices; similarly, healthcare workers who are used to using these diagnostic equipment or medical devices for health service provision can also create a higher demand on energy than originally anticipated.

Theory of Change

The theory of change illustrates the potential mechanism of how improved energy access at health facilities can ultimately improve health and socioeconomic status (Figure 3). The theory of change is adapted from the WHO Energy Results Chain Framework for Health Services. The theory posits that electrification of health centres will improve the uptake of energy in health facilities, enabling improved health worker capacity, access to medical devices and medications, which will then result in improved health service delivery.

Improved health service delivery should improve preventive health initiatives and disease management, ultimately resulting in improved health outcomes. Improved health outcomes can translate to reduced direct and indirect health expenditures. If households have reduced health expenditures, then they can reallocate resources to support education and livelihood initiatives. Notably, improved health can also reduce sickness-related absenteeism affecting education attainment and livelihood efforts.

Figure 3 Theory of Change on Electrification of Health Centers and Impacts on Health and Socioeconomic Status [3]



Baseline Assessment Aims and Objectives

The overall aims of the baseline assessment are to describe the status of health centres, service provision, and electrification prior to the intervention of ESDS and EnDev, and provide an explanatory model ('if', 'how', 'why') the provision of sufficient, reliable, and modern electricity will contribute to positive impacts in the health facilities.

The specific objectives of the baseline assessment are four-fold:

1. To quantitatively describe the characteristics of the six health centres, including status of electrification, with a semi-structured health facility survey

2. To quantitatively describe the six health centres' health service provision and utilization with UNHCR's balanced health scorecards and health information system data

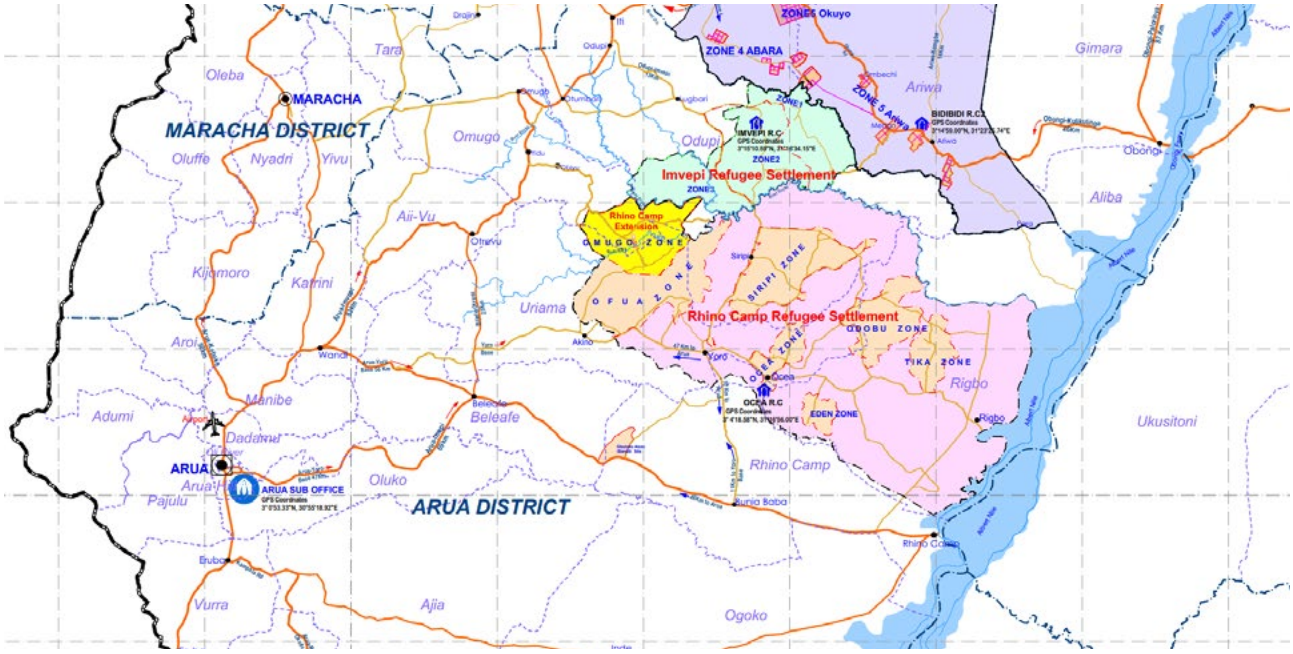
3. To qualitatively explore the effect of electricity and health service delivery among frontline healthcare providers and key stakeholders through in-depth interviews

4. To qualitatively explore the effect of electricity, healthcare access, and health expenditure among members of the Village Health Team (VHT), Refugee Welfare Committee (RWC), and Health Unit Management Committee (HUMC) through focus group discussions

Methods

Study setting

Figure 4 Map of Rhino Camp and Imvepi Refugee Settlements.



The baseline assessment took place in north-western Uganda in Rhino Camp and Imvepi Refugee Settlements. Rhino Camp straddled across Terego and Madi Okollo districts and Imvepi is located within Terego district (Figure 4[1]). Rhino Camp first opened in 1980 to host the influx of refugees stemming from the South Sudanese civil war. Since then, there have been two major influxes of South Sudanese refugees to Rhino Camp as a result of additional civil unrest – these occurred in January 2014 and August 2016 [20]. According to the November 2020 OPM Refugee Statistics, Rhino Camp hosts a total population of 121,505, including 121,484 refugees within its seven administrative zones. Imvepi Refugee Settlement opened in February 2017 to accommodate excess refugees after the Palorinya Refugee Settlement in Moyo district reached maximum capacity [20]. According to the November 2020 OPM Refugee Statistics, Imvepi hosts a total population of 67,514, including 67,478 refugees in its four administrative zones. In both settlements, the vast majority of refugees come from South Sudan (97 in Rhino Camp and 99% in Imvepi), slightly more than half are women (51% in Rhino Camp and 52% in Imvepi), over half (60%) are less than 18 years, and approximately one-third are working (32% in Rhino Camp and 34% in Imvepi) [21].

1 Arua district was subdivided into Arua, Terego, and Madi Okollo districts in 2020. The map is not yet updated to reflect these administrative changes.

Table 3 Population and demographic characteristics of Rhino Camp and Imvepi Refugee Settlements

Characteristics (as of November 2020)	Rhino Camp Refugee Settlement	Imvepi Refugee Settlement
Total population	121,505	67,514
Total refugees	121,484	67,478
Total households	30,317	19,924
Country of origin		
South Sudan	117,616	66,574
Democratic Republic of the Congo	2,977	913
Sudan	809	23
Rwanda	44	0
Burundi	24	0
Central African Republic	12	1
Kenya	10	0
Chad	0	1
Senegal	0	1
United Republic of Tanzania	0	1
Sex		
Female	51%	52%
Male	49%	48%
Age (years) among females		
0-4	7%	8%
5-11	13%	13%
12-17	9%	8%
18-59	20%	20%
60+	2%	2%
Age (years) among males		
0-4	7%	9%
5-11	13%	13%
12-17	11%	9%
18-59	17%	16%
60+	1%	1%
Have occupation among 18-59 years	31.8%	34.0%

Sampling strategy

The six health centres in the baseline assessment were purposefully selected for inclusion because ESDS and EnDev identified them as the project sites for provision and installation of OGS PVS. Figure 5 lists the ten criteria ESDS and EnDev used to identify eligible health facilities for potential inclusion in the sustainable electrification of health centres project [22]. The criteria identified seven eligible health facilities. Then, ESDS and EnDev selected six of the seven eligible health facilities for the project based on most urgent needs and available project funds.

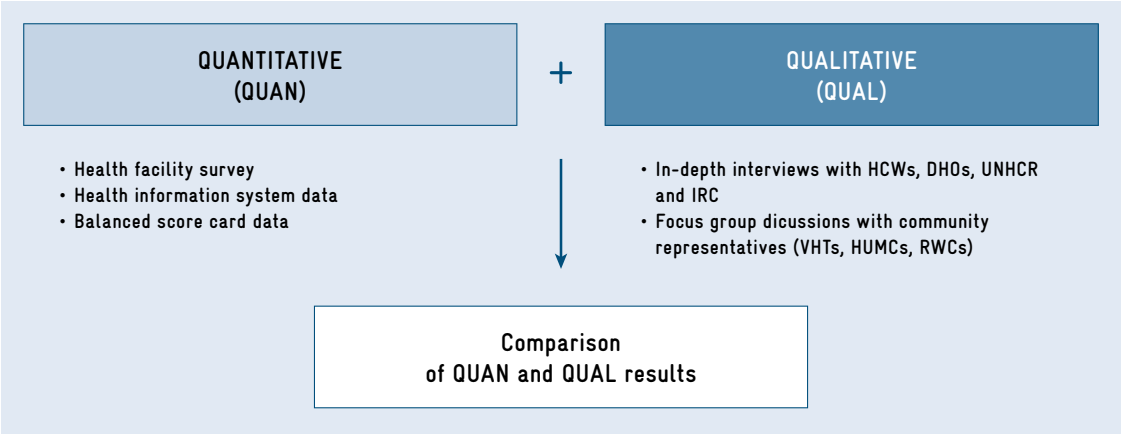
Figure 5 Selection criteria for health centres for the solarisation/ electrification in refugee settings

1. Selected health centre should be within the geographic scope of the ESDS/Endev's implementation area of refugee energy access in Imvepi, Rhino camp and Omugo refugee settlements-where the previous and continuing activities are taking place.
2. Selected health facilities should be accessible and benefiting both refugees and host communities.
3. The health centre selected must be currently operational and able to offer basic primary health care (OPD, IPD, antenatal, postnatal and other relevant heath education services).
4. Health facility selected should be having preparedness or potential preparedness for COVID 19 isolation activities or services.
5. Selected health facility should of Grade II, III and/or IV level with existing equipment or already planned to have equipment that need to utilize the energy provided under this installation.
6. The health centre should have a functioning Heath Unit Management Committee (HUMC) or a management structure that defines the responsibilities and offers supervisory roles of checks and balances to technical staff.
7. Selected health facility MUST have minimum of at least (1-2) permanent buildings on ground, to house the installation and equipment.
8. The heath centre should have a secure perimeter fencing of its compound or the key facilities where such solar equipment can be in secure enclosure.
9. The health centre should have an envisioned energy gap, identified through the need's assessment, or through recommendations from development partners (UNHCR, OPM, District Local authorities etc.).
10. The health centre that has an already existing electrification or preliminary solarisation plans stands added advantages.

Mixed method design

The baseline assessment utilized a cross-sectional, convergent mixed method design with concurrent quantitative and qualitative data collection (Figure 6). A mixed method design was utilized to leverage the methodological strengths of each method: quantitative data to enable comparison of systematic measures across health facilities and over time (at baseline and future time points), and qualitative methods to provide context and depth of understanding among relevant stakeholders, such as healthcare workers and community representatives of the catchment population. Quantitative methods included a semi-structured health facility survey to describe the status of electrification and health service delivery at the health facilities, and descriptive analysis of Health Information System (HIS) data from 2018, 2019, and 2020 and the Balanced Score Card data from 2020 were collected from UNHCR and the health partners (IRC and Medical Teams International) to characterise trends of health service utilization and health status prior to the installation of sustainable, reliable, and modern electricity. Qualitative methods included in-depth interviews with key stakeholders, such as frontline healthcare workers, district health officers, and health program staff at UNHCR and IRC, and focus group discussions with community representatives, such as Refugee Welfare Committees, Health Unit Management Committees, and Village Health Teams, to understand the role of electricity on health service provision and health access in the refugee settlement health facilities, current practices to maintain or repair existing sources of power, and recommendations on how best to sustain solar assets at health facilities over time.

Figure 6 Convergent mixed method design



Sampling strategy of key informants

Key informants, such as frontline healthcare workers (clinical officers, nurse/midwives, laboratory personnel, data clerks), District Health Officers, and health program representatives of UNHCR and IRC, were purposefully invited to participate in the in-depth interviews to share their demonstrated experiences planning, coordinating, and providing health services, as well as residing in the refugee resettlement areas within an environment of energy constraints. In-depth interview informants were interviewed and probed to explore the role of electricity and health service delivery and quality of care.

Key informants who were current members of a Refugee Welfare Committee (RWC), Village Health Team (VHT), and Health Unit Management Committee (HUMC) were purposefully invited to participate in focus group discussions to share their experiences of seeking health services at night, to explore their perceptions on electricity and health services, and to explore the impact of health on household expenditure. RWCs were selected as community representatives of refugees residing within the resettlement area. RWCs serve as the first point of contact by refugees, and helps link refugees and refugee workers, including OPM, UNHCR, Ugandan People Defense Force, and non-governmental organizations. The purpose of RWC is to implement physical protection and access justice for refugees within their communities. VHTs are lay community health workers who can be Ugandan nationals or refugees. VHTs are trained to mobilize communities for health programs and strengthen delivery of health services through referral and linkage at the household level. Finally, HUMC members include lay community leaders (e.g., headteacher, public figure with "high integrity" and not holding a political position) as well as health facility staff representatives (e.g., facility in-charge, maternity in-charge, etc.). HUMCs were established to strengthen the management of the health centre through community participation and decision-making, promote transparency in the management of human, material, and financial resources of the health centre, and advocate for improved quality of service delivery in the health centre.

Data collection tools development

The semi-structured health facility survey included questions to characterize the health facilities, such as its name, locale (village, parish, sub-county, county, district, and zone within the refugee settlement area), level (HC II, III, and IV), managing authority, year started, wards and units, services provided, staffing (type of cadres available, numbers, cadres supported by the MOH or an implementing partner), operating hours, catchment size (total, refugee, and host), and inpatient size. The survey also collected information on the status of electrification, including number of power sources, diesel generators, and OGS PVS, their functionality and reliability, and the practice of routine maintenance for each of these systems. Finally, the survey collected information on essential health service provision or systems requiring electricity, such as immunization, diagnostics, obstetrics and newborn care services, blood transfusion, and sterilization. Health facility survey questions were adapted from standardized tools such as the Uganda Service Provision Assessment Survey and the WHO Service Availability Readiness Assessment. Questions on the maintenance of OGS PVS were developed using the USAID Guyana Solar PV System Maintenance Guide. See Appendix I for the semi-structured health facility survey. In addition, frontline healthcare workers at inpatient department and maternity ward were left with a form to collect information on electrical outage over the course of 24 hours over 31 days. Data from this form will provide empirical information on the reliability of electricity in these wards that are supposed to provide around the clock care for patients. See Appendix II for the reliability of electricity form.

Open-ended questions and probes were developed for the key informant in-depth interview guides and focus group discussions with community representatives. These questions were reviewed by the GIZ, IRC, and UNHCR team for content validity. The questions were carefully reviewed, edited to ensure words could be translated meaningfully in the local language, and translated verbatim into the local languages, Madi, Lugbara, and Arabic, by the study team translator who is a native Lugbara living within Rhino Camp Ref-

ugee Settlement. See Appendices III, IV, and V for the qualitative interview guides for healthcare workers, district health officers, and community representatives, respectively. See Appendix VI for the sociodemographic form for focus group discussion participants.

Training of data collectors

The data collection team comprised of three women (Sharon Tsui, Esther Amulen, and Mourin Hakia) who were familiar with conducting research in the Ugandan health system and working in a refugee settlement. Sharon, the principal investigator, conducted a one-day training with the data collectors on research ethics and how to conduct the informed consent process, the qualitative interview guides, research entry protocol, data collection and management procedures, and study participant reimbursement and accountability procedures.

Research ethics

The baseline assessment protocol did not undergo ethical review. The baseline assessment questions were designed specifically not to collect any private, identifiable information that would meet the definition of "human subjects" research. The data collected revolve around general questions on service delivery and status of electrification at each health facility. Further, the study team did not directly engage any patients of the health facilities. Instead, the study team interviewed formally recognized members of community representatives, such as members of the RWC, HUMC, and VHT, to obtain the community perspective. To ensure utmost protection of study participants, every qualitative informant underwent the informed consent process to learn about the purpose of the study, how they were invited to participate, what questions they could expect, what potential risks/ discomforts and benefits they could expect, and that participation was voluntary, meaning there would be no implication on one's employment or health access if he or she chose not to participate in an interview (see Appendices VII and VIII for informed consent forms). The informed consent process was conducted individually in the language of choice for the potential study participant to ensure comprehension. Willing study participants provided written informed consent by signing and dating the informed consent form.

Data collection

The data collection team was based in Arua Town and travelled to the refugee settlements for data collection from January 8 to 16, 2021. IRC and UNHCR provided vital support by introducing the data collection team to the Settlement Commandant and facility in-charges prior to the team's arrival on the ground. The data collection team visited the Settlement Commandant at Imvepi Refugee Settlement and Rhino Camp Refugee Settlement to explain the purpose and length of visit per protocol prior to engaging the health facilities. Then, the team travelled to the health facility to meet with the facility in-charge who then organized department leads to participate in health facility survey and in-depth interviews and the HUMC, VHT, or RWC chairperson to organize the focus group discussion. All interviews were conducted in an open-air location (under a tree or a waiting shelter) and away from patients and other healthcare workers to maximize social distancing and audio privacy. Also, interviewers and interviewees wore masks. Survey data were recorded on the data collection forms and interview data were audio-recorded with the permission of study participants. In addition, the facility in-charge also appointed a staff member, sometimes the security guard or health educator, to walk the team through the health facility and take photographs of the structures and OGS PVS. Care was taken to avoid photography of patients and healthcare staff. When possible, the team conducted all data collection activities in one day. When not possible, the team returned another day to finish data collection activities. Table 4 summarizes the data collection schedule for the baseline assessment.

Table 4 Data collection schedule

Date	Location	Data Collection Activities
06/01/2021	Arua Town	IDI with UNHCR Health Officer
07/01/2021	Arua Town	Training of data collectors
08/01/2021	Imvepi Refugee Settlement	Courtesy call with Imvepi Settlement Commandant
	Yinga HC III	Health facility survey IDI with facility in-charge (midwife)
09/01/2021	Yinga HC III	IDI with data assistant FGD with HUMC
11/01/2021	Imvepi HC II	IDI with IPD in-charge (clinical officer) FGD with HUMC
12/01/2021	Imvepi HC II	Health facility survey IDI with maternity in-charge (midwife)
	Rhino Camp Refugee Settlement	Courtesy call with Rhino Settlement Commandant
	Siripi HC III	Health facility survey
13/01/2021	Siripi HC III	IDI with IPD in-charge (clinical officer) IDI with OPD in-charge (clinical officer) FGD with RWC
	Ocea HC II	Health facility survey IDI with ART/TB in-charge (clinical officer) IDI with maternity midwife FGD with VHT
15/01/2021	Ofua HC III	Health facility survey IDI with facility in-charge (clinical officer) IDI with maternity in-charge (midwife) FGD with RWC
16/01/2021	Arua Town	IDI with Terego DHO IDI with Madi Okollo DHO
18/01/2021	Oduobu HC II	Health facility survey IDI with maternity in-charge (midwife) IDI with laboratory assistant FGD with VHT
25/01/2021	Kampala (Remote via Zoom)	IDI with IRC Health Manager

Data management and analysis

The health facility survey data were recorded by hand on paper, and then entered electronically onto EpiData 3.1 data entry screens with built-in skip patterns and logic ranges to enhance data cleanliness. The EpiData 3.1 database was backed up onto a password protected server on Dropbox. Once all health facility records were entered, the data were exported into Microsoft Excel for additional data cleaning and analysis. Descriptive statistics were produced – frequencies and percentages for discrete or categorical variables and means, standard deviations, medians, minima, and maxima for continuous variables.

In-depth interviews with healthcare workers, district health officers, and representatives from IRC and UNHCR were conducted in English and audio-recorded, backed up onto a password protected server on Dropbox, and then simultaneously transcribed verbatim into Microsoft Word. Focus group discussions with community representatives were conducted in a mixture of English and local language, audio-recorded, backed up onto a password protected server on Dropbox, and then summarized into expanded field notes in Microsoft Word. Both verbatim in-depth interview transcripts and focus group discussion expanded field notes were imported into MaxQDA 2020 for qualitative storage and analysis. Qualitative texts were analysed using a thematic content analysis approach: data were read and re-read to identify recurrent themes and concepts to develop a coding tree, codes were applied to the text, and codes were summarized in a table across sites to identify overall patterns. Finally, memos were written to summarize key findings and document salient quotes.

To verify the accuracy of data collected on the status of electrification at each health facility, the GIZ technical team for solar energy compared results collected by the baseline assessment with data collected by the OGS PVS sizing team. The consultant and GIZ technical team discussed and resolved any inconsistencies. The report presents status of electrification data after they have been verified by the GIZ team and resolution of any inconsistencies.

Table 5 Summary of collected data, by cadre and sex

Methods	Type by cadre	Male	Female	Total Sample Size
Quantitative	Semi-structured health facility survey	-	-	n=6
	UNHCR Balanced Score Card 2020	-	-	n=6
Qualitative	In-depth interview: nurse/midwives	0	6	n=6
	In-depth interview: clinical officer	3	1	n=4
	In-depth interview: laboratory assistant	1	0	n=1
	In-depth interview: records assistant	1	0	n=1
	In-depth interview: IRC health manager	1	0	n=1
	In-depth interview: UNHCR health officer	1	0	n=1
	In-depth interview: district health officer	1	1	n=2
	Focus group discussion: VHT	7	3	n=2 groups
	Focus group discussion: RWC	11	3	n=2 groups
	Focus group discussion: HUMC	9	4	n=2 groups
TOTAL	**N=6 surveys, N=22 qualitative interviews**			

Study Limitations

There are three main study limitations:

1. **Lack of facility disaggregated Health Information System**
   The consultant researcher was only able to access Health Information System (HIS) data disaggregated at the level of the refugee settlements (Imvepi or Rhino Camp), but was unable to access HIS data disaggregated at the health facility level. According to contacts at IRC and MTI, the electronic database does not allow users to export data by organisation unit. The lack of disaggregated HIS data means that one cannot track health service utilization and health status by health facility specifically. The electrification of health centre project is implemented in six health facilities only within the entire refugee settlements of Imvepi and Rhino Camp. It would not be appropriate to interpret changes in aggregated data over time as one cannot tease out where exactly these changes occurred.

2. **Unequal sex ratio among community representatives**
   The research team wanted to conduct sub-analyses of qualitative findings by gender. During planning discussions with GIZ, IRC, and UNHCR, it was determined that mixed sex focus group discussions would not inhibit the representation of women's perspectives. The team recruited both male and female community representatives, and asked the community group's chairperson and supporting coordinator at the health facility to invite an equal number of men and women to participate in the focus group discussions. However, there was a greater representation of men across all groups and all sites, and women were a minority in each focus group discussion. The unequal sex ratio among community representatives is reflective of current cultural and gender dynamics within the community. The limited representation of women means their perspective may not be adequately represented.

3. **Unable to access some solar components for observation and documentation**
   The research team was unable to access some solar components, such as solar panels on the roofs of health facilities, or batteries encased in a locked cage without keys, or other solar components in a locked room, to observe its condition and document its brand and model number. The inability to access these solar components resulted in missing data.

Results

Health Facility Characteristics

General

The general characteristics of the six health facilities are summarized in Table 6. Overall, the six health facilities included three HC IIs and three HC IIIs. Despite the formal designation these health facility levels, all six health facilities have a maternity ward and in-patient ward and serve over 10,000 catchment population, which are characteristics of at least a HC III. Limited diagnostic capacity, often directly related to inadequate electricity, limit the upgrading of at least one of the HC IIs to be a HC IIIs (Imvepi HC II). Similarly, limited capacity for blood transfusion as a result of inadequate and unreliable electricity for the storage of blood, has limited eligible HC IIIs to be upgraded to HC IVs.

Five health facilities fall under the direct managing authority of the Ministry of Health (three in Terego and two in Madi Okollo) and one health facility is under the direct managing authority of IRC. Regardless of managing authority, all health facilities receive support – technical, infrastructural, staffing, and other – from the Ministry of Health, a multitude of implementing partners, and UNHCR. The managing authority of health facilities have important implications on the engagement of stakeholders for ownership, maintenance, and sustainability of the OGS PVS assets.

Health facilities that are under the managing authority of the Ministry of Health have been in service for longer (ranging from 25 to 29 years) and the health facility under the managing authority of IRC has been in service for 5 years.

Across all health facilities, the largest number of nationals within the health facility catchment population are from South Sudan, followed by Uganda, and then the Democratic of Congo. Refugees from Burundi, Kenya, and the Central Africa Republic are also represented in Ocea HC II in Madi Okollo, Rhino Camp.

Figure 7 Summary of Uganda's Health System

Uganda has a tiered, referral-based health system. The first point of contact for someone living in a rural area is a Village Health Team (VHT) member. VHTs are lay community-based volunteers who typically live within the community and are briefly trained by the Ministry of Health or an implementing partner to advise patients and refer them to health centres. Health Centre IIs (HC II) are supposed to be situated at every parish and intended to serve about 5,000 people. A HC II is an outpatient clinic run by nurses and they treat common diseases such as malaria and offer antenatal care. Health Centre IIIs (HC III) are supposed to be situated in every sub-county and intended to serve about 10,000 people. HC IIIs provide general outpatient clinic services, basic diagnostic services, and has a maternity ward with basic emergency obstetric and newborn care. HC IIIs are typically managed by a clinical officer. Health Centre IVs (HC IV) serves a county and is a mini-hospital with surgical capacity in addition to the services provided at a HC III; therefore, it is supposed to be able to provide blood transfusion and comprehensive emergency obstetric care. A HC IV should have a senior medical officer and another doctor, as well as a functioning theatre for carrying out emergency operations.

Table 6 General health facility characteristics (data collected from 2021 Baseline Health Facility Survey)

Health Center	Refugee Settlement	District	Health Facility Level	Managing Authority	Years of Service	Catchment Population		
						Refugee	Host	Total
Imvepi HC II	Imvepi	Terego	HC II	MOH	26	19,668	3,224	22,892
Yinga HC III	Imvepi	Terego	HC III	MOH	25	10,813	7.351	18,164
Siripi HC III	Rhino Camp	Terego	HC III	MOH	27	13,090	5,500	18,590
Ofua HC III	Rhino Camp	Terego	HC III	IRC	5	26,952	Unknown	Unknown
Ocea HC II	Rhino Camp	Madi Okollo	HC II	MOH	26	18,428	3,729	22,157
Odoubu HC II	Rhino Camp	Madi Okollo	HC II	MOH	29	12,461	4,500	16,961

Staffing

Staffing at each facility, including available cadre and number of full and part time staff are summarized in Table 7. There is a severe shortage of staffing required to deliver essential maternal and child health services – none of the health facilities (0/6) met the WHO minimum threshold of 23 doctors, nurses, and midwives per 10,000 population (Table 7).

None of the health facilities (0/6) had a full-time physician specialist - consistent with the hiring practices of Uganda's health system for HC IIs and IIIs. Two high-volume health facilities (Ocea HC II and Ofua HC III) have a part-time roving medical officer with the support of IRC. Each health facility, even the HC IIs, had at least one clinical officer. The practice of staffing HC IIs with a clinical officer is atypical within Uganda's rural health system – most only have midwives and nurses – and in these health facilities all the clinical officers were project supported staff (directly by IRC or through the UNHCR project with the local government). The total number of nurses and midwives ranged from 11 to 12 at HC IIs and 10 to 14 at HC IIIs. None of the facilities had a pharmacist; 1/3 HC II and 2/3 HC IIIs had a pharmacy dispenser – otherwise the nurses dispensed medications. None of the health facilities had a laboratory technologist. All HC IIIs (3/3) had a laboratory technician and a laboratory assistant, and 1/3 HC IIs had a laboratory technician and 2/3 HC IIs had a laboratory assistant. Imvepi HC II did not have any laboratory specialist – technologist, technician, or assistant; the clinicians (midwives and clinical officers) performed the rapid diagnostic tests. Every HC III (3/3) had an HIV/AIDS counsellor and 1/3 HC II had an HIV counsellor – all the counsellors were project supported. All health facilities (6/6) had at least one translator and 5/6 health facilities had at least one records clerk.

Table 7 Human resource for health staffing (data collected from 2021 Baseline Health Facility Survey)

Health Facility Staff	Health Center II			Health Center III		
	Imvepi HC II (Imvepi)	Ocea HC II (Rhino Camp)	Odoubu HC II (Rhino Camp)	Yinga HC III (Imvepi)	Siripi HC III (Rhino Camp)	Ofua HC III (Rhino Camp)
Physician Specialist	0	0	0	0	0	0
Medical Officer	0	1 (part-time)	0	0	0	1 (part-time)
Clinical Officer	1	3	1	1	1	4
Midwife (enrolled, registered)	4	7	5	6	2	5
Nurse + Nurse Assistant (enrolled, registered, comprehensive)	7	6	6	7	12	5
HIV/AIDS Counsellor	0	2	0	1	1	1
Nutritionist	0	0	0	0	0	1
Nutrition Assistant	1	0	0	0	0	2
Translator	3	1	2	4	4	4
Pharmacist	0	0	0	0	0	0
Pharmacy Dispenser	0	1	0	1	0	1
Laboratory Technologist	0	0	0	0	0	0
Laboratory Technician	0	1	0	2	1	1
Laboratory Assistant	0	1	1	1	1	2
Records Clerk	1	1	0	2	2	2
Cleaner	5	4	1	10	2 (part-time)	4
Security Guard	3	5	2	3	3	5
Total Full Time Clinician (CO, Nurse, and Midwife)	12	16	12	14	15	14
Ratio of Full Time Clinician per 10,000 population	5.2	8.8	6.5	5.2	6.8	8.3*

* Ratio to refugees only, no data on total catchment population

Health service provision

Health services provided at each health facility are summarized in Table 8, organized by groupings such as outpatient, inpatient, diagnostic, emergency and other social services.

- **Outpatient services:** All health facilities (6/6) provided the same range of outpatient health services regardless of health facility level, including general outpatient services, maternal and child health, family planning, antenatal care, delivery, HIV testing and counselling, prevention of mother to child transmission of HIV, HIV and TB treatment, home-based care for people living with HIV, and nutrition screening and supplementary feeding. Mental health and psychosocial support were the only outpatient services which was not universally available in all health facilities; it was found in two HC IIs and two HC IIIs (4/6).

- **Inpatient services**: All health facilities (6/6) offered inpatient services with a general medical ward and a maternity ward. All pregnant women, regardless of reason for admission (it can be for malaria or a road accident), were assigned to the maternity ward. Two health facilities (1 HC II and 1 HC III) had a dedicated paediatric ward; in other facilities, children and non-pregnant women were placed in the same general medical ward. Two health facilities (both HC IIIs) had an inpatient nutrition treatment ward for the severely malnutrition children. Finally, two health facilities (1 HC II and 1 HC III) had a dedicated inpatient TB ward. In other facilities without a dedicated TB ward, TB patients stay in the "isolation tent" which can be organized for patients with TB, COVID-19, Ebola, and other infectious diseases.

- **Emergency services**: All health facilities (6/6) reported providing emergency/ casualty services to their catchment population. All health facilities (6/6) had access to an ambulance supported through phone call, and 4/6 health facilities (3/3 HC IIIs and 1/3 HC II) had access to an ambulance parked on-site at the health facility. In all cases, the ambulance, fuel, and driver costs are supported by a partner, particularly IRC. All HC IIIs (3/3) and no HC IIs (0/3) had access to a project-supported landline to make phone calls for emergency referral and transport. In addition, 2/3 HC IIIs and 0/3 HC IIs had mobile phone airtime supported by a project to make phone calls for emergency referral and transport. None of the health facilities provided blood transfusion services (0/6); facilities within Imvepi Refugee Settlement referred patients to Omugo HC IV or Arua Regional Referral Hospital and facilities within Rhino Camp Refugee Settlement referred patients to Rhino Camp HC IV or Arua Regional Referral Hospital for higher level care. Notably, the ambulance at Yinga HC III is also used to start the diesel generator as the facility's generator battery does not work.

- **Other services**: All health facilities have an isolation tent built for COVID-19 and other infectious diseases; however, at Imvepi HC II, the isolation tent has been repurposed for mental health and psychosocial support services. In addition, two health facilities (Imvepi HC II in Imvepi Refugee Settlement and Odoubu HC II in Rhino Camp Refugee Settlement) have dedicated buildings called "SGBV protection house" providing temporary shelter for people experiencing gender-based or intimate partner violence.

- **Diagnostic services**: All health facilities provided basic diagnostic testing for pregnancy, malaria, HIV, and syphilis through rapid diagnostic test kits (6/6). Five health facilities already have a functional light or fluorescent microscope and these health facilities have the potential to offer diagnostics by microscopy if they had adequate or reliable access to electricity (5/6), offer blood glucose testing using a glucometer (5/6), and haemoglobin testing using a HemoCue (5/6).

  All the health facilities (6/6) collected dried blood spot samples for early infant diagnosis or HIV viral load testing, sputum for TB testing, and other as part of the Hub Rider system to submit samples and obtain results from centralized laboratory locations. Select health facilities within the refugee settlements (Yinga HC III for health facilities within Imvepi; Ocea HC II, Ofua HC III, and Rhino Camp HC IV for health facilities within Rhino Camp) have higher level laboratory capacity (e.g., Ziehl Neelsen testing for TB and Genexpert for multidrug resistant TB and CD4 count and PCR for HIV viral load and EID), and these facilities have additional energy support from a diesel generator.

  None of the health facilities (0/6) offered liver function tests, renal function tests, or full blood count and differential testing on-site.

  Finally, only two health facilities (2/6) had any imaging equipment. Yinga HC III has an electrocardiogram but does not have power to operate it. Ocea HC II has an ultrasound machine and an electrocardiogram device, which can be powered by a petrol generator with fuel supported by IRC.

Table 8 Available health services (data collected from 2021 Baseline Health Facility Survey)

Services	Health Center II			Health Center III		
	Imvepi HC II (Imvepi)	Ocea HC II (Rhino Camp)	Odoubu HC II (Rhino Camp)	Yinga HC III (Imvepi)	Siripi HC III (Rhino Camp)	Ofua HC III (Rhino Camp)
Outpatient						
General Outpatient	●	●	●	●	●	●
Maternal and Child Health (including immunization)	●	●	●	●	●	●
Family Planning (including youth friendly services)	●	●	●	●	●	●
Antenatal Care	●	●	●	●	●	●
Delivery	●	●	●	●	●	●
HIV Testing and Counselling	●	●	●	●	●	●
Prevention of Mother to Child Transmission of HIV	●	●	●	●	●	●
HIV and TB Treatment Clinic	●	●	●	●	●	●
Home-Based Care for HIV Clients	●	●	●	●	●	●
Nutrition Screening and OP Treatment	●	●	●	●	●	●
Mental Health and Psychosocial Support	●	●		●		●
Inpatient						
General Medical Ward	●	●	●	●	●	●
Paediatric Ward	●			●		
Maternity Ward	●	●	●	●	●	●
Nutrition Treatment Ward				●		●
TB Ward	●					●
Emergency Services						
Casualty/ Emergency	●	●	●	●	●	●
Access to an Ambulance	●	●	●	●	●	●
Ambulance Parked On-Site		●		●	●	●
Landline Supported by HF				●	●	●
Cellular Airtime Supported by HF					●	●
Blood Transfusion						
Other						
Isolation Ward		●	●	●	●	●
SGBV Protection House	●		●			

Services	Health Center II			Health Center III		
	Imvepi HC II (Imvepi)	**Ocea HC II** (Rhino Camp)	**Odoubu HC II** (Rhino Camp)	**Yinga HC III** (Imvepi)	**Siripi HC III** (Rhino Camp)	**Ofua HC III** (Rhino Camp)
Diagnostics – Laboratory						
Malaria						
Malaria RDT	●	●	●	●	●	●
Smear test		●	●	●	●	●
TB						
Ziehl Neelsen Test for TB				●		●
Genexpert for drug resistant TB				●		
HIV						
HIV RDT	●	●	●	●	●	●
HIV antibody test by ELISA CD4 cell count				●		
Dried blood spot collection for viral load testing and early infant diagnosis	●	●	●	●	●	●
PCR for HIV viral load and EID				●		
Syphilis						
Syphilis RDT	●	●	●	●	●	●
Serology testing		●		●	●	
Pregnancy and Management						
Pregnancy (urine dipstick)	●	●		●	●	●
Glucose/ketone (urine dipstick)	●	●		●	●	●
Blood glucose (glucometer)		●		●	●	●
Haemoglobin (HemoCue)	●	●		●	●	●
ABO blood group		●		●	●	
Rhesus blood group		●		●	●	
Other testing						
ALT (liver function)						
Serum creatinine (renal function)						
Full blood count and differential						
Serum electrolyte						
General microscopy/wet mounts		●	●	●	●	●
Urine microscopy		●		●	●	●
Gram stain				●		●
CSF/body fluid counts				●		
Cryptococcal antigen		●		●		
Diagnostics – Imaging						
X-ray						
Ultrasound		●				
Electrocardiogram (ECG)		●		●		

Health Facility Performance and Quality of Care

Electricity is assumed to be a critical determinant or precondition to effective, high quality, and efficient health service delivery as described in the theory of change. Performance and quality of care indicators using the UNHCR Balanced Scorecard 2020 and the WHO Service Readiness Availability Assessment implemented in January 2021 are documented in Tables 9 to 15. These performance and quality of care indicators collected prior to the installation of ESDS and EnDev-supported OGS PVS will serve as baseline on health facility performance. Change in performance and quality of care can be assessed by comparing the baseline and future endline indicators, and findings can inform whether electricity is an important precondition to effective health service delivery.

The following health service/service delivery areas are focused upon given their relevance in the primary health care setting and reliance on electricity for service delivery:

- Health facility observation (Table 9)
- Immunization (Table 10)
- Reproductive health, obstetric and neonatal care (Table 11)
- Blood transfusion (Table 12)
- Diagnostics – laboratory and imaging (Table 13)
- Client satisfaction (Table 14)
- Processing equipment for reuse/sterilization (Table 15)

Health facility observation.

These health system characteristics provide important contextual information on how well a health facility is doing. A complex nexus of factors contributes to the improvement of health service delivery quality, including adequate human resource for health, building infrastructure, medical equipment, supply chain systems, and practice protocols. For example, even if reliable electricity was achieved at a health facility but staff lacked training, equipment, commodities or medicines, then it would not be possible to detect improvements in health service delivery.

Table 9 Health Facility Observation Baseline (data from 2020 UNHCR Balanced Score Card)

Data Source	Health Centre II			Health Centre III		
	Imvepi HC II (Imvepi)	Ocea HC II (Rhino Camp)	Odoubu HC II (Rhino Camp)	Yinga HC III (Imvepi)	Siripi HC III (Rhino Camp)	Ofua HC III (Rhino Camp)
UNHCR Balanced Score Card: 2020 HF Observation						
Staffing	75%	67%	50%	89%	56%	No data
Facility infrastructure	90%	90%	80%	80%	80%	No data
Infection control supplies	100%	100%	100%	100%	88%	No data
Lab infrastructure equipment	70%	No data	No data	No data	No data	No data
Equipment for consultations	77%	69%	100%	62%	54%	No data
Common equipment for consultations	77%	90%	100%	62%	54%	No data
Vaccines	90%	90%	90%	100%	80%	No data
HIS	60%	60%	80%	40%	60%	No data
General medicine supply management	95%	95%	98%	93%	70%	No data
General medicines	100%	95%	100%	89%	63%	No data
Medicine management protocols	75%	100%	100%	100%	88%	No data
General facility protocols	73%	55%	100%	91%	73%	No data
Nutrition	100%	100%	100%	100%	100%	No data
Overall HF Observation	**80%**	**80%**	**89%**	**82%**	**73%**	No data

Immunization.

Vaccines for infants, children, adolescents and adults, and oxytocin for postpartum haemorrhage management are typically heat sensitive and rely on effective cold chain. Provision of reliable electricity can ensure maintenance of cold chain to ensure vaccines are stored within appropriate temperature ranges to remain effective. Five health facilities have a standalone EPI solar fridge and one health facility uses a dedicated fridge supported by a diesel generator to store the vaccines. Only 1/5 health facilities with an EPI solar fridge have experienced temperatures out of range in the last 30 days. The districts have trained personnel and transport fuel to support health facilities in the use and maintenance of these EPI solar fridges; Odoubu HC II, which reported problems with its EPI solar fridge verified that the district provided a trained technician to repair the fridge/ solar system when the temperature went out of range for two days. The ESDS and EnDev solarization project will unlikely affect immunization outcomes given existing standalone fridges to ensure cold chain maintenance of vaccines and oxytocin.

Table 10 Immunization Baseline (data from 2020 UNHCR Balanced Score Card and 2021 Baseline Health Facility Survey)

Data Source	Health Centre II			Health Centre III		
	Imvepi HC II (Imvepi)	**Ocea HC II** (Rhino Camp)	**Odoubu HC II** (Rhino Camp)	**Yinga HC III** (Imvepi)	**Siripi HC III** (Rhino Camp)	**Ofua HC III** (Rhino Camp)
UNHCR Balanced Score Card: 2020 Immunization						
Cold Chain	No data	100%	90%	90%	100%	90%
Program quality	No data	95%	100%	89%	89%	84%
Observation of EPI session	No data	87%	100%	96%	91%	87%
Overall Immunization	No data	94%	97%	92%	93%	87%
Health Facility Survey: 2021 Baseline Assessment						
Frequency of routine full child immunization services at facility	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
Frequency of routine full child immunization services as outreach	Weekly	Weekly	**Monthly**	Weekly	**Monthly**	Weekly
Facility has refrigerator available and functioning for storage of vaccines	Yes	Yes	Yes	Yes	Yes	Yes
Type of energy source for vaccine refrigerator	Solar	Solar	Solar	Solar	Solar	**Diesel Generator**
Energy source supply power to the refrigerator 24 hours a day for 7 days in the week	Yes	Yes	Yes	Yes	Yes	**No**
Thermometer available for monitoring refrigerator temperature	Yes	Yes	Yes	Yes	Yes	Yes
Continuous temperature recorder or logger available for monitoring refrigerator temperature	Yes	Yes	Yes	Yes	Yes	Yes
Temperature of refrigerator monitored twice daily	Yes	Yes	Yes	Yes	Yes	Yes
Temperature log has been completed for the last 30 days	Yes	Yes	**No**	Yes	Yes	Yes
Temperature has been out of range of 2 to 8 degrees Celsius inclusive in the last 30 days	In range	In range	**Out of range**	**Out of range**	In range	**Out of range**

Data Source	Health Centre II			Health Centre III		
	Imvepi HC II (Imvepi)	**Ocea HC II** (Rhino Camp)	**Odoubu HC II** (Rhino Camp)	**Yinga HC III** (Imvepi)	**Siripi HC III** (Rhino Camp)	**Ofua HC III** (Rhino Camp)
Items for immunization available on day of interview						
Auto-disposable syringes	Yes	Yes	Yes	Yes	Yes	Yes
Sharps container/ safety box	Yes	Yes	Yes	Yes	Yes	Yes
Vaccine carrier/ cold box	Yes	Yes	Yes	Yes	Yes	Yes
Set of ice packs for vaccine carriers	Yes	Yes	Yes	Yes	Yes	Yes
Immunization cards	Yes	Yes	Yes	Yes	Yes	Yes
Official immunization tally sheet	Yes	Yes	Yes	Yes	Yes	Yes
Official immunization registers	Yes	Yes	Yes	Yes	Yes	Yes
Vaccines available on day of interview						
Measles vaccine and diluent	Yes	Yes	Yes	Yes	Yes	Yes
DPT-Hib-HepB (Pentavalent)	Yes	Yes	Yes	Yes	Yes	Yes
Oral polio vaccine	Yes	Yes	Yes	Yes	Yes	Yes
BCG vaccine and diluent	Yes	Yes	**No**	Yes	Yes	Yes
Rotavirus vaccine	Yes	Yes	Yes	Yes	Yes	Yes
Pneumococcal vaccine	Yes	Yes	Yes	**No**	Yes	Yes
Inactivated polio vaccine	Yes	Yes	Yes	Yes	Yes	Yes
Human papillomavirus vaccine	Yes	Yes	Yes	Yes	Yes	Yes
Stock out in the last 3 months						
Measles vaccine and diluent	No	No	**No record**	No	No	No
DPT-Hib-HepB (Pentavalent)	No	No	No	No	No	No
Oral polio vaccine	No	No	No	No	No	No
BCG vaccine and diluent	No	No	**Yes**	No	No	No
Rotavirus vaccine	No	No	No	No	No	No
Pneumococcal vaccine	No	No	No	**Yes**	No	No
Inactivated polio vaccine	No	No	**Yes**	No	No	No
Human papillomavirus vaccine	No	No	**No record**	No	No	No

Obstetric and neonatal care.

Adequate lighting is necessary to monitor and support mothers in labour and delivery, select, constitute, and titrate medicines, and perform procedures in cases of complications (suturing, cannulisation, manual removal of placenta or retained products of conceptions, resuscitation. Obstetric and neonatal care often utilize small electrical devices such as the HemoCue for anaemia screening, Glucometer to measure blood sugar, and the foetal Doppler to detect foetal heartbeat, as well as phones to organize a referral and transfer to a higher-level health facility. A few maternity wards have oxygen concentrators for oxygen therapy, baby warmers to help regulate the baby's temperature, and televisions for patient education. Improved electrical access for lighting and charging of medical appliances can potentially improve maternal and neonatal health outcomes.

Table 11 Reproductive Health and Obstetric and Neonatal Care Baseline (data from 2020 UNHCR Balanced Score Card and 2021 Baseline Health Facility Survey)

Data Source	Health Centre II			Health Centre III		
	Imvepi HC II (Imvepi)	**Ocea HC II** (Rhino Camp)	**Odoubu HC II** (Rhino Camp)	**Yinga HC III** (Imvepi)	**Siripi HC III** (Rhino Camp)	**Ofua HC III** (Rhino Camp)
UNHCR Balanced Score Card: 2020 RH Assessment						
Basic RH protocols	No data	No data	33%	100%	33%	33%
Protocols	67%	56%	50%	100%	81%	81%
Detailed RH/HIV protocols	88%	46%	46%	100%	85%	77%
Referrals	92%	100%	100%	100%	No data	100%
Maternal nutrition	100%	100%	50%	100%	100%	100%
RH medicines	78%	100%	89%	100%	89%	78%
RH equipment	100%	100%	100%	75%	100%	100%
RH HIS	75%	100%	100%	100%	100%	100%
ANC observation	88%	91%	91%	93%	76%	69%
PNC observation	92%	92%	83%	96%	83%	71%
Overall RH Assessment	**84%**	**77%**	**78%**	**95%**	**80%**	**76%**
Health Facility Survey: 2021 Baseline Assessment						
Interventions routinely carried out by HCWs at facility:						
Oxytocin prevention for PPH	Yes	Yes	Yes	Yes	Yes	Yes
Partograph use for labour mgmt	Yes	Yes	Yes	Yes	Yes	Yes
Immediate and exclusive BF	Yes	Yes	Yes	Yes	Yes	Yes
Hygienic cord care	Yes	Yes	Yes	Yes	Yes	Yes
Thermal protection for newborn	Yes	Yes	Yes	Yes	Yes	Yes
Interventions for mgmt. of complications of pregnancy in the last 12 months:						
Parenteral admin of antibiotics mums	Yes	Yes	Yes	Yes	Yes	Yes
Parenteral admin of oxytocic PPH	Yes	Yes	Yes	Yes	Yes	Yes
Parental admin of MgSO4	**No**	Yes	Yes	**No**	Yes	Yes
Assisted vaginal delivery	**No**	**No**	**No**	Yes	**No**	**No**
Manual removal of placenta	Yes	Yes	Yes	Yes	Yes	Yes
Removal of retained POC	Yes	Yes	Yes	Yes	Yes	Yes
Neonatal resuscitation – bag+mask	Yes	Yes	Yes	Yes	Yes	Yes
Caesarean section	No	No	No	No	No	No
Blood transfusion	No	No	No	No	No	No
Antibiotics for preterm or PROM	Yes	Yes	Yes	Yes	Yes	Yes
Corticosteroids in preterm labour	No	Yes	Yes	Yes	Yes	Yes
Kangaroo Mother Care	Yes	Yes	Yes	Yes	Yes	Yes
Injectable antibiotics - neonatal sepsis	Yes	Yes	Yes	Yes	Yes	Yes

Data Source	Health Centre II			Health Centre III		
	Imvepi HC II (Imvepi)	**Ocea HC II** (Rhino Camp)	**Odoubu HC II** (Rhino Camp)	**Yinga HC III** (Imvepi)	**Siripi HC III** (Rhino Camp)	**Ofua HC III** (Rhino Camp)
Availability of functional, basic equipment on day of interview:						
Examination light (incl. torch)	Yes	Yes	Yes	Yes	Yes	Yes
Delivery pack	Yes	Yes	Yes	Yes	Yes	Yes
Cord clamp	Yes	Yes	Yes	Yes	Yes	**No**
Episiotomy scissors	Yes	Yes	No	Yes	Yes	**No**
Scissors or blade to cut cord	Yes	Yes	Yes	Yes	Yes	Yes
Suture material with needles	Yes	Yes	Yes	Yes	Yes	Yes
Needle holder	Yes	Yes	Yes	Yes	Yes	Yes
Manual vacuum extractor	No	Yes	Yes	Yes	Yes	Yes
Incubator	No	No	No	No	No	No
Disposable latex gloves	Yes	Yes	Yes	Yes	Yes	Yes
Blank partograph	Yes	Yes	Yes	Yes	Yes	Yes
Delivery bed	Yes	Yes	Yes	Yes	Yes	Yes
Resuscitation table with heat source	No	No	No	No	No	Yes
Newborn bag+mask size 1 (term)	Yes	Yes	**No**	Yes	Yes	Yes
Newborn bag+mask size 0 (preterm)	Yes	Yes	**No**	Yes	Yes	Yes
Electric suction pump	No	No	No	No	No	No
Suction catheter	Yes	**No**	Yes	**No**	Yes	Yes
Suction bulb, single use	No	No	No	No	Yes	No
Suction bulb, multiple use	Yes	Yes	**No**	Yes	Yes	Yes
Speculum	Yes	Yes	Yes	Yes	Yes	Yes
Infant weighing scale	Yes	Yes	Yes	Yes	Yes	Yes
Blood pressure apparatus	**No**	Yes	Yes	Yes	Yes	Yes
Cleaning running water	Yes	Yes	Yes	Yes	Yes	Yes
Hand washing soap/ liquid soap	Yes	Yes	Yes	Yes	Yes	Yes
Alcohol based hand rub	Yes	Yes	Yes	Yes	Yes	Yes
Availability of valid (unexpired) medicines and commodities on day of interview:						
Antibiotic eye ointment for newborn	Yes	Yes	Yes	Yes	Yes	Yes
Gentamicin injection	Yes	Yes	Yes	Yes	Yes	Yes
Ampicillin powder for injection	Yes	Yes	Yes	Yes	Yes	Yes
Hydralazine injection	Yes	**No**	Yes	Yes	Yes	**No**
Metronidazole injection	**No**	Yes	Yes	Yes	Yes	Yes
Azithromycin cap/tab or oral liquid	Yes	Yes	Yes	Yes	Never avail.	Yes
Cefixime cap/tab	Yes	Yes	Yes	Yes	Yes	Yes
Benzathine benzyl penicillin powder	Yes	Yes	Yes	Yes	Yes	Yes
Nifedipine cap/tab 10mg	Yes	Yes	Yes	Yes	Yes	Yes
Methyldopa tab	**No**	Yes	Yes	Yes	Yes	Yes
Calcium gluconate injection	Yes	Yes	Never avail.	Yes	Yes	**No**
Magnesium sulphate injectable	Yes	Yes	Yes	Yes	Yes	Yes
Skin disinfectant	Yes	Yes	Yes	Yes	Yes	Yes
IV solution with infusion set	Yes	Yes	Yes	Yes	Yes	Yes
Sodium chloride injectable solution	Yes	Yes	Yes	Yes	Yes	Yes
Dexamethasone injection	Yes	Yes	Never avail.	Yes	Yes	Yes
Oxytocin injection	Yes	Yes	Yes	Yes	Yes	Yes
Oxytocin stored in cold storage	Yes	Yes	Yes	Yes	Yes	Yes
Notes:	Vaccine carrier	Vaccine carrier	Vaccine carrier	Vaccine carrier	Vaccine carrier	Vaccine carrier
Qualitative Interview of Midwife						
Equipment that cannot be used because of inadequate electricity in maternity ward:				Oxygen concentrator, ECG	TV	Resuscitation table with heat source, oxygen concentrator
Hours of available lighting in maternity						
Dry season (Jan 2021)	No data	7.5 hr	11 hr	7 hr	10 hr	10 hr
Rainy season (Sep 2020)	No data	3 hr	7 hr	4 hr	7 hr	6 hr

Diagnostics.

Laboratory testing is fundamental to diagnosis of disease/ health condition, which underlies quality of health care. A proper diagnosis can improve the effectiveness of treatments and avoid long-term complications.

- **RDTs and microscopes:** All the health facilities rely on rapid diagnostic tests (RDTs) to diagnose common conditions, such as pregnancy, syphilis, malaria, and HIV. RDTs are advantageous because they do not require special equipment or intensive training to administer, as compared to diagnostic techniques using microscopy. However, all six health facilities have reported inadequate supplies of RDTs, particularly for malaria and at HC IIs. HC IIs cannot request for supplies; HC IIs rely on the push system of supply of medicine and commodities, which are based on projected or predicted demand. The National Medical Stores, the primary provider of commodities and medicines for government health facilities, project the demand based on the national population so health facilities serving both refugees and nationals often do not have adequate supplies. The microscope could serve as a back-up diagnostic approach when RDTs are not available; however, 4/6 health facilities have reported not being able to use a microscope in the last 30 days because of inadequate or unreliable electricity (Table 12). A possible reason for inadequate or unreliable electricity is that the solar systems for laboratories are designed for lighting only (although wall sockets are present). This will be discussed further under the results section on electricity and health service delivery – "inadequate sizing and reliability of solar energy".
- **Capacity to use a fridge:** All the health facilities are part of a decentralized laboratory testing network called "Hub Rider" where samples are routinely sent via boda-boda (motorcycle riders) to a regional laboratory with more advanced diagnostic capacity. Health facilities within Imvepi Refugee Settlement send the samples for testing at Yinga HC III. Similarly, health facilities within Rhino Camp send samples for testing at Rhino Camp IV. Some biologic samples, such as sputum for TB testing, must be stored within appropriate temperature range before the samples are collected by the Hub Rider and tested at the centralized laboratory. Most facilities do not have a fridge to store samples so samples are stored in vaccine cool boxes with water-based ice packs. Samples that are stored out of temperature range may result in invalid test results, wasting important limited resources (e.g., fuel for Hub Rider, collection material and testing reagents, time). Adequate sizing of electrical needs at the laboratory, including the energy needs of a fridge, can be another way in which electricity improves diagnostic services.

Table 12 Diagnostics Baseline (data from 2020 UNHCR Balanced Score Card and 2021 Baseline Health Facility Survey)

Data Source	Health Centre II			Health Centre III		
	Imvepi HC II (Imvepi)	Ocea HC II (Rhino Camp)	Odoubu HC II (Rhino Camp)	Yinga HC III (Imvepi)	Siripi HC III (Rhino Camp)	Ofua HC III (Rhino Camp)
UNHCR Balanced Score Card: 2020 Lab Assessment						
General conditions of lab structure	100%	83%	100%	50%	67%	17%
Utilities and lab structure	8%	67%	83%	50%	50%	25%
Biosafety, hygiene, and security	81%	88%	100%	81%	94%	69%
Specimen collection, handling, recording	75%	83%	75%	100%	92%	83%
Equipment and supplies	32%	32%	39%	32%	19%	23%
Reagents and supply	50%	58%	58%	75%	50%	58%
Analysis and test performed	19%	60%	38%	90%	52%	45%
Lab staff and working date	80%	60%	80%	80%	60%	80%
Reporting, surveillance, analysis and communication	82%	88%	82%	94%	76%	88%
Quality assurance	33%	75%	67%	85%	67%	65%
Outbreaks – outbreak participation	100%	100%	75%	100%	100%	100%
Overall Lab Assessment	60%	72%	72%	76%	66%	59%
Health Facility Survey: 2021 Baseline Assessment						
Accredited/certified microscopist at facility	**No**	Yes	**No**	Yes	Yes	Yes
Functional basic equipment for diagnostics available on day of interview						
Light microscope	**No**	Yes	Yes	Yes	Yes	No
Fluorescent microscope	**No**	No	No	Yes	No	Yes
Refrigerator	**No**	Yes	**No**	Yes	**No**	Yes
Glucometer	**No**	Yes	**No**	Yes	Yes	Yes
HemoCue	Yes	Yes	Yes	Yes	Yes	Yes
In the last 30 days, have you needed to use any of the electric diagnostic equipment but could not do so because you did not have electricity	NA	**Yes**	**Yes**	No	**Yes**	**Yes**
Notes:	Use dry cells for Hemocue	Couldn't use microscope or fridge	Couldn't use microscope	Use diesel generator for lab	Couldn't use microscope	Couldn't use microscope
In the last 30 days, have you needed to use any of the imaging equipment but could not do so because you did not have electricity	NA	**Yes**	NA	NA	NA	NA
Notes:		Ran out of petrol for petrol generator				

Blood Transfusion.

Blood transfusion services are not currently provided at any of the health facilities, in part because blood transfusion is not part of the HC III mandate, and in part because of inadequate and unreliable electricity to store blood (Table 13). According to IRC, if reliability and sustainable electricity for blood storage becomes possible, then Yinga HC III and Ocea HC II can be capacitated to provide blood transfusion services. The benefits of blood transfusion services within the refugee settlements include reduced time to access a lifesaving procedure, reduced referral to already high-volume HCs, and reduced use of related resources (ambulance use, fuel) required to support a referral and emergency transport of a patient to Omugo HC IV, Rhino Camp HC IV, or Arua Regional Referral Hospital.

Table 13 Blood transfusion services (data from 2021 Baseline Health Facility Survey)

Data Source	Health Centre II			Health Centre III		
	Imvepi HC II (Imvepi)	Ocea HC II (Rhino Camp)	Odoubu HC II (Rhino Camp)	Yinga HC III (Imvepi)	Siripi HC III (Rhino Camp)	Ofua HC III (Rhino Camp)
Health Facility Survey: 2021 Baseline Assessment						
Facility offers blood transfusion services	No	No	No	No	No	No
Any interruptions in blood availability in the past 3 months	NA	NA	NA	NA	NA	NA
Facility has functional refrigerator for storage of blood	No	No	No	No	No	No
Energy source used for blood refrigerator	NA	NA	NA	NA	NA	NA
Energy source supply power to refrigerator for 24 hours a day and for 7 days in the week	NA	NA	NA	NA	NA	NA
Has temperature been out of range of 2 to 6 degrees Celsius inclusive in the last 30 days	NA	NA	NA	NA	NA	NA
Facility has guidelines on appropriate blood use and safe transfusion practices	NA	NA	NA	NA	NA	NA
Facility has received training in appropriate use of blood and safe transfusion practices in the last 2 years	NA	NA	NA	Yes	NA	Yes

Client Satisfaction.

Improved lighting, operating hours, and range of diagnostics and health services may improve client satisfaction of the health facility. Beneficiaries (refugee) and general client (refugee and host) satisfaction with services at the health facility are summarized in Table 14.

Table 14 Client Interview Baseline (data from 2020 UNHCR Balanced Score Card)

Data Source	Health Centre II			Health Centre III		
	Imvepi HC II (Imvepi)	Ocea HC II (Rhino Camp)	Odoubu HC II (Rhino Camp)	Yinga HC III (Imvepi)	Siripi HC III (Rhino Camp)	Ofua HC III (Rhino Camp)
UNHCR Balanced Score Card: 2020 Client Interviews						
Beneficiaries satisfaction score	83%	94%	83%	94%	89%	94%
General clients satisfaction score	89%	76%	75%	79%	83%	84%
Overall Client Interviews	**86%**	**85%**	**79%**	**87%**	**86%**	**81%**

Processing Equipment for Reuse/ Sterilization.

None of the health facilities (0/6) rely on electrical devices to process equipment for reuse; although at least providers from three health facilities have expressed a desire for an electric autoclave or sterilizer in order to sterilize equipment more efficiently. Currently, healthcare workers report using the "three bucket" system (washing, rinsing, and sanitizing) and the non-electric autoclave to sterilize equipment. The heat source used for the non-electric autoclave are charcoal (3/6), gas (3/6), and paraffin (1/6). Adequate and reliable electricity could enable health facilities to sterilize equipment for reuse more efficiently by using electric devices.

Table 15 Processing Equipment for Reuse (Sterilization) Baseline (data from 2021 Baseline Health Facility Survey)

Data Source	Health Centre II			Health Centre III		
	Imvepi HC II (Imvepi)	Ocea HC II (Rhino Camp)	Odoubu HC II (Rhino Camp)	Yinga HC III (Imvepi)	Siripi HC III (Rhino Camp)	Ofua HC III (Rhino Camp)
Health Facility Survey: 2021 Baseline Assessment						
Available and functional equipment used for processing of equipment for reuse on day of interview:						
Electric autoclave	No	No	No	No	No	No
Non-electric autoclave	Yes	Yes	Yes	Yes	Yes	Yes
Electric dry heat sterilizer	No	No	No	No	No	No
Electric boiler or steamer	No	No	No	No	No	No
Non-electric pot w cover for boil/steam	No	No	No	Yes	Yes	No
Heat source for non-electric equipment:	Charcoal	Gas	Charcoal, Paraffin	Gas	Charcoal	Gas
In the last 30 days, have you needed to use any of the electric items for processing of equipment for reuse but could not do so because you did not have electricity	NA	NA	NA	NA	NA	NA

Status of electrification

Power sources

None of the health facilities (0/6) had a central supply of electricity by national or community grid. All health facilities (6/6) had at least one partially functioning OGS PVS and 3/6 health facilities had at least one diesel generator. Five health facilities (5/6) had standalone EPI solar refrigerators to store and ensure cold chain of vaccines and oxytocin. Four health facilities (4/6) had a We Care Solar installed to charge small devices, such as the HemoCue, Foetal Doppler, and mobile phone, and only 3 of the We Care Solar are functional as the battery of the We Care Solar was stolen at one facility. Finally, 2/6 health facilities had Mobile Power (MoPo) power banks to provide additional power. The total number of power sources (functional and dysfunctional), buildings wired to power sources for lighting only, and buildings wired to power sources for lighting and sockets are summarized in Table 16.

Table 16 Status of Electrification (data from 2021 Baseline Health Facility Survey)

Status of Electrification	Health Center II			Health Center III		
	Imvepi HC II (Imvepi)	**Ocea HC II** (Rhino Camp)	**Odoubu HC II** (Rhino Camp)	**Yinga HC III** (Imvepi)	**Siripi HC III** (Rhino Camp)	**Ofua HC III** (Rhino Camp)
Total Number of Power Sources regardless of functionality (Total number of FUNCTIONING OR PARTIALLY FUNCTIONAL power sources)						
Off-grid solar PV systems	8 (3)	11 (9)	9 (9)	23 (17)	14 (5)	33 (32)
Mobile Power (MoPo)	0	10 (10)	0	0	0	7 (7)
Diesel generators	0	1 (1)	0	2 (1)	0	2 (2)
Petrol generators	0	1 (1)	0	0	0	0
EPI Solar Refrigerators	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	0
We Care Solar	1 (1)	1 (1)	0	1 (0)	1 (1)	0
Buildings Wired to Power Sources – Wired For Lighting (functional and dysfunctional)						
Outpatient department	Yes	Yes	Yes	Yes	Yes	Yes
Pharmacy	Yes	Yes	Yes	Yes	Yes	Yes
Laboratory	Yes	Yes	Yes	Yes	Yes	Yes
Inpatient ward	Yes	No	Yes	Yes	Yes	Yes
Maternity	Yes	Yes	Yes	Yes	Yes	Yes
HIV/TB Clinic	Yes	Yes	Yes	Yes	Yes	Yes
Nutrition Ward	N/A	N/A	N/A	Yes	N/A	Yes
SGBV Protection House	No	N/A	Yes	N/A	N/A	N/A
Security Guard House	No	No	No	Yes	No	No
Staff Quarters	Partially (2/4)	Yes	Yes	Yes	Yes	Yes
Isolation Ward	No	No	No	No	No	Yes (COVID-19 only, TB ward not wired)
Latrines + Bathing Shelters	No	No	No	No	No	No
Security lights	Yes	Yes	No	Yes	Yes	Yes
Medicine Stores	Yes	Yes	Yes	Yes	Yes	Yes

Status of Electrification	Health Center II			Health Center III		
	Imvepi HC II (Imvepi)	Ocea HC II (Rhino Camp)	Odoubu HC II (Rhino Camp)	Yinga HC III (Imvepi)	Siripi HC III (Rhino Camp)	Ofua HC III (Rhino Camp)
Buildings Wired to Power Sources – Wired to Sockets for communication or medical appliances (functional and dysfunctional)						
Outpatient department	No	Yes	No	Yes	Yes	No
Pharmacy	No	Yes	No	Yes	Yes	No
Laboratory	No	Yes	No	Yes	Yes	Yes
Inpatient ward	Yes	No	No	Yes	No	No
Maternity	Yes (We Care Solar)	No	No	Yes	No	Yes
HIV/TB Clinic	No	No	No	Yes	No	No
Nutrition Ward	N/A	N/A	N/A	Yes	N/A	No
SGBV Protection House	No	N/A	Yes	Yes	N/A	N/A
Security Guard House	No	No	No	No	No	No
Staff Quarters	No	No	Yes	No	No	Yes
Isolation Ward	No	No	No	No	No	Yes
Latrines + Bathing Shelters	No	No	No	No	No	No
Security lights	N/A	N/A	N/A	N/A	N/A	N/A
Medicine Stores	No	No	No	No	No	No

Diesel generators

Ocea HC, Yinga HC III, and Ofua HC III each have access to at least one diesel generator. Table 17 summarizes available information on the coverage, functionality, reliability, and operation details of the diesel generators. At Ocea HC II and Ofua HC III, the diesel generator is wired to all buildings except maternity. The diesel generator is not yet functional at Ocea HC II because it has not been connected to the health facility, partially functional at Yinga HC III (the battery is dysfunctional so it requires a vehicle battery to start the generator), and fully functional at Ofua HC III. Typically, health facilities do not turn the diesel generator on at all times during the service delivery hours of the clinic; it is only turned on as needed during the daytime for laboratory operations at Yinga HC III, and it is only turned on as needed during the daytime and night time from 7pm to 1am at Ofua HC III. The electricity provided by the diesel generator is reliable with no interruptions at all.

Table 17 Diesel generators coverage, functionality, reliability, and operation details (data from 2021 Baseline Health Facility Survey)

Diesel Generator	Health Center II			Health Center III		
	Imvepi HC II (Imvepi)	**Ocea HC II** (Rhino Camp)	**Odoubu HC II** (Rhino Camp)	**Yinga HC III** (Imvepi)	**Siripi HC III** (Rhino Camp)	**Ofua HC III** (Rhino Camp)
Coverage of power from diesel generator						
Diesel generator wired to:	NA	Lab, IPD, OPD, HIV/TB clinic, 3/5 staff quarters	NA	OPD and lab	NA	IPD, lab, OPD, nutrition, isolation tent, security lights, shared staff hall, some of the staff quarters, warehouse for storage of new and old equipment, data center, pharmacy
Electricity from diesel generator is designed for:	NA	All electrical needs of facility (lighting, communication, and other appliances)	NA	All electrical needs of facility (lighting, communication, and other appliances)	NA	All electrical needs of facility (lighting, communication, and other appliances)
How frequently is diesel generator turned on: Daytime Nigh time	NA	NA (generator not connected)	NA	 As needed (mainly for lab) No	NA	 As needed 7pm to 1am
Functionality diesel generator						
Generator functional on day of interview Note:	NA	No New generator, not connected	NA	Yes Requires car battery to start generator	NA	Yes
Reliability of power from diesel generator						
During the past 7 days, was electricity at all times from the diesel generator available when it is turned on?	NA	NA (generator not connected)	NA	No interruptions	NA	No interruptions
How many days during the past week was electricity not available for at least 2 hours during a time when the facility was open for services and the diesel generator was turned on?	NA	NA (generator not connected)	NA	0 days	NA	0 days
Operational details of diesel generator						
Generator capacity (kVA)	NA	20 kVA	NA	No data	NA	No data
Donor or partner for diesel generator fuel	NA	UNHCR + IRC funding	NA	UNHCR + IRC funding	NA	UNHCR + IRC funding
Fuel available for generator	NA	Yes	NA	Yes	NA	Yes
Average litres of fuel to keep generator running for service delivery every day	NA	No data	NA	No data	NA	40 liters
Average budget allocated to fuel diesel generator for service delivery (not ambulance) each month (UGX)	NA	300L	NA	300L	NA	300L
Allocated fuel is enough to keep generator working	NA	Yes	NA	Yes	NA	Yes

Solar systems

Table 18 lists the solar components found in each of the health facility. The brand and model number of the solar panels could not be ascertained as the research team and health facility did not have ladders to reach the building roofs. Sometimes it was not possible to ascertain the brand and model number of the other solar components because they were locked in a metal cage, or the paint has deteriorated over time. See photographs of all accessible solar components in the health facility specific PowerPoints.

Table 18 Solar Systems: Brand and Model of Solar Components (data from 2021 Baseline Health Facility Survey)

Location	Coverage of Solar System	Charge Controller	Battery	Inverter
Imvepi HC II	IPD	Victron Energy Blue Solar Charge Controller MPPT 100 I-50	Vision Group 6FM 200D-X	TBS Electronics Inverter
	Maternity	We Care Solar		
	OPD + Pharmacy + Lab + Stores	-	-	-
	ART/TB Clinic	-	-	-
	Staff Quarters	Solarix PRS 1515	-	-
Ocea HC II	Maternity	Sunshine Solar SS30A	ADH Solar GmbH + CO KG 12-100	ADH
	OPD + Stores + Pharmacy	RoHS Solar Charge Controller	-	-
	Laboratory + Mopo	SNRE NPPI Solar Charge Controller	-	Victron Energy Lync Distributor 1000 DC
	Staff Quarters	-	ADH Solar GmbH + CO KG 12-100 Sunshine Solar	Solar Africa SI-500VA 12V to 240V AC Inverter
Odoubu HC II	Maternity + IPD + Medicine Stores	Sunshine Solar SS50A	Phoenix PX 200	-
	OPD + Lab + Dispensary + Office + ART/TB Clinic	Solarix PRS 1515	ADH Solar GmbH + CO KG 12-100	Samlex Solar Power Inverter
	Staff Quarters + SGBV Protection House	Solar Charge Controller	ADH Solar GmbH + CO KG 12-100	-
Yinga HC III	IPD	German Tec 60A	-	LC Star Solar
	Maternity	Kema Power	-	DuraLast DL-3500VA
	Nutrition	Solarix PRS 1515	-	Victron Energy Pure Sinewave Inverter Phoenix 12-375
	ART/TB Clinic	Solarix PRS 1515	-	Victron Energy Pure Sinewave Inverter Phoenix 12-350
	SGBV Protection House	-	Supershine Solar Battery Gold Star SMF-VRLA	Sunshine Solar SS30A
	OOPD + Pharmacy + Lab	Solarix PRS 1515	Rolls Engineering AGM-VRLA	Victron Energy Pure Sinewave Inverter Phoenix 12-375
	Staff Quarters	Solarix PRS 2020	Rolsl Engineering AGM-VRLA	Cotek Pure Sine Wave Inverter
Siripi HC III	Maternity + IPD	Solar Charge Controller	12-200 12V200 AH Valve Regulated Lead Acid Battery	Ajay Solar
	OPD + Pharmacy + Stores + Office + ART/TB Clinic	Solarix PRS 1515	SuKam Power Bank SPB 200	Saachi NL-DC-3753
	Staff Quarters	Solarix PRS 1515 Sunshine Solar BS30A CM3024Z	-	German King Modified Sine Wave, Samlex Solar Power Inverter, King Canada Power Inverter KC-600
Ofua HC III	Maternity	Kema Power	-	DuraLast DL-3500 VA
	OPD	Philips SIS-30 Solar Indoor System		
	IPD	Philips SIS-30 Solar Indoor System		
	Isolation Tent	CM3024Z	-	-
	Staff Quarters	-	-	-

- means "unable to ascertain"

Reliability of electricity from the solar systems

The functionality of the solar system was assessed with two measures on the "reliability of electricity". The first measure asked healthcare workers to recall in the last 7 days whether electricity was available at all times from the main or any back up sources when the facility was open for services. Healthcare worker responses were categorized into 'Always available' (no interruptions), 'Often available' (interruptions of less than 2 hours per day), and 'Sometimes available' (frequent or prolonged interruptions of more than 2 hours per day). The second measure asked healthcare workers to recall the number of days in the past week that electricity was not available for at least 2 hours during the time the facility was opened for services, including emergency services at night. Healthcare workers responses ranged from 0 (no days of interruption) up to 7 (maximum number of days in a week). The results of the two measures are interlaid on Table 19: the colour code represents the frequency of energy interruptions in the last 7 days (green for no interruptions, yellow for interruptions of less than 2 hours per day, and red for interruptions of 2 or more hours per day) and the number represents the number of days in the past week that the ward/department/unit has experienced more than 2 hours of electrical outages.

Table 19 Reliability of solar electricity (data from 2021 Baseline Health Facility Survey)

Reliability of Solar Electricity

Measure 1: During the **last 7 days**, was electricity at all times from the main or any back up sources when the facility was open for services?
1 = Always available (no interruptions) – green
2 = Often available (interruptions of less than 2 hours per day) – yellow
3 = Sometimes available (frequent or prolonged interruptions of more than 2 hours per day) – red

Measure 2: How many days during **the past week** was electricity not available for at least 2 hours during a time the facility was open for services? This includes emergency services.
0-7

Reliability of Electricity	Imvepi HC II (Imvepi)	Ocea HC II (Rhino Camp)	Odoubu HC II (Rhino Camp)	Yinga HC III (Imvepi)	Siripi HC III (Rhino Camp)	Ofua HC III (Rhino Camp)
Outpatient	7	7	3	6	7	7
Pharmacy	7	7	3	6	7	7
Laboratory	7	7	3	6	7	7
Inpatient ward	0	Not wired	0	7	0	7
Maternity	0	7	0	7	0	7
HIV/TB Clinic	7	7	3	7	7	7
Nutrition Ward	N/A	N/A	N/A	7	N/A	7
SGBV Protection House	Not wired	N/A	3	0	N/A	N/A
Security Guard House	Not wired	Not wired	Not wired	7	Not wired	Not wired
Staff Quarters	7	7 7 7 7 7 7	3	7	7	7
Isolation Ward	Not wired	Not wired	Not wired	Not wired	Not wired	COVID19 – 0 TB ward not wired
Latrines + Bathing Shelters	Not wired	Not wired	Not wired	Not wired	Not wired	Not wired
Security lights	Gate - 7 Staff quarters - 0	IPD - 7 Latrine - 7	N/A	Gate – 0 IPD – 0 Isolation – 0 Maternity - 7	0	0
Medicine Stores	7	7	0	6	7	7

Note: Ofua HC III's primary source of energy is through diesel generator.

Variability in hours of solar lighting between dry and rainy seasons

Healthcare workers reported substantial variability on hours of available lighting from the existing solar systems between dry season when the "sun heat" was "strong" and rainy season when the solar systems were perceived to not work as well. To illustrate the variability in hours of solar lighting between dry and rainy seasons, midwives at the maternity ward (a ward that is open for 24 hours every day) were asked to recall the hours of available lighting from solar in January 2021 (dry season) and in September 2020 (most recent rainy season) in the qualitative in-depth interviews. Their responses are recorded in Table 20 and the difference in hours of available solar lighting between dry and rainy seasons are calculated.

Table 20 Availability of solar lighting on a typical night in the maternity ward during dry and rainy seasons (data from 2021 Baseline Qualitative Interviews)

Health Center	Availability of Lighting on a Typical Night in Maternity Ward During Dry Season (January 2021)	Availability of Lighting on a Typical Night in Maternity Ward During Rainy Season (September 2020)	Difference in Hours of Availability of Lighting Between Dry and Rainy Seasons
Imvepi HC II	No data	No data	No data
Yinga HC III	7pm to 2am (7 hours)	7pm to 11pm (4 hours)	-3 hours
Siripi HC III	7pm to 5am (10 hours)	7pm to 2am (7 hours)	-3 hours
Ofua HC III	8pm to 6am (10 hours)	8pm to 2am (6 hours)	-4 hours
Ocea HC II	7pm to 2.30am (7.5 hours)	7pm to 10pm (3 hours)	-4.5 hours
Odoubu HC II	7pm to 6am (11 hours)	7pm to 2am (7 hours)	-4 hours

Electricity and Health Service Delivery

Inadequate electricity for health facility needs

OGS PVS is not a new innovation to these six health facilities. According to the five facility in-charges under the managing authority of the Ministry of Health, the first solar panels were installed when the health facilities were established for the arrival of the first wave of refugees from South Sudan over 20 years ago. Multiple partners, including Care International, Danish Refugee Council, and UNICEF, have since donated and installed different OGS PVS in select wards/ departments/ units and staff quarters. Some of the OGS PVS are for standalone devices, such as the Expanded Programme on Immunization (EPI)[2] solar fridge to store vaccines, We Care Solar[3] to charge small medical devices commonly used in maternity, security lights, and Mobile Power[4] (MoPo) battery bank charging stations. Other OGS PVS are designed and installed within buildings, such as maternity and staff quarters.

2 The World Health Organization established the Expanded Programme on Immunization (EPI) on 1974 to develop and expand immunization programmes throughout the world in order to reduce morbidity, disability, and mortality due to vaccine-preventable diseases. The Uganda National Expanded Programme on Immunisation (UNEPI) was launched in 1983 with a mandate to ensure full immunization of infants and women of childbearing age. UNEPI aims to increase access to immunization services, provide effective and potent vaccines, and increase demand for services. Routine immunization is carried out against tuberculosis, measles, pertussis, diphtheria, maternal and neonatal tetanus, poliomyelitis, hepatitis B, and hemophilus influenza B.

3 We Care Solar seeks to "promote safe motherhood and reduce maternal mortality in developing regions by providing healthcare workers with reliable lighting, mobile communication, and medical devices using solar electricity". The We Care Solar Suitcase® is a solar electric system that provides medical lighting and power for mobile communication and small medical devices, such as a fetal doppler, rechargeable headlamp, and USB sockets for cell phone charging, for last-mile health facilities.

4 Mobile Power is a UK-based company providing affordable energy to resource-limited communities since 2013. In the communities, MOPO uses a pay-per-charge rental model to provide smart battery packs at a price affordable to low-income communities. Mobile Power installed MOPO Hubs at health facilities to charge the battery packs and healthcare workers are able to use these batteries for free.

While each health facility appears to have many OGS PVS, few of them are fully functional (Table 16). Healthcare workers report frequent interruptions of electricity at the health facility (Tables 19 and 20). These electrical interruptions negatively affect lighting and the operation of communication equipment, medical devices, and diagnostic equipment. In addition, electrical interruptions make routine living within the health facility premise a challenge for many healthcare workers.

Lighting

Adequate lighting is vital for health service delivery, especially in the night. Healthcare workers need adequate lighting to visualize a patient for examination, monitoring, treatment, and procedures. Midwives highlight the importance of being able to see the baby's skin colour and breathing patterns when performing resuscitation, and being able to see the mother's body cannula insertion, suturing, or removal of retained products. Lighting is also important to enable a healthcare worker to select the correct medicines, materials, and equipment, and constitute the medicines, as necessary, to care for a patient. In short, lighting to enable proper visualization underlies patient quality of care.

"Like a mother when she comes and maybe she is [in] shock or she has fainted. Obviously, I need to pass for her a cannula to rehydrate her. But then when there is no source of light, how am I going to see the veins? How am I going to pass the cannula when there is no adequate source of light? It actually becomes hard." (Odoubu HC II, Midwife)

"When you are resuscitating, of course, you have to see the movement of the chest of the baby. You need to monitor the baby, whether the baby is picking or not picking. You have the breathing pattern you are supposed to monitor, to check those things. Where there is no light, it cannot happen." (Ocea HC II, Midwife)

"There are certain procedures you do and you need to have enough source of light. Like when we are doing removal for someone who has come with abortion, sometimes we even end up using a torch because the light that is up is not enough. Also, if a mother has delivered and there is a tear, maybe it is a secondary degree tear, when you repair it, the light also affects in the way that light in the room is not enough for you to vision things well. So sometimes it also affects and that is why we use torches. But for a normal delivery it helps except for other procedures like stitching the mother." (Odoubu HC II, Midwife)

"Without light it is actually hard also. It also needs a good source of light because you are going to continually monitor this baby. When you resuscitate you have to see chest movements and see if your resuscitation is picking up. You have to pass, maybe even, a cannula where the drugs are to be administered. To pass this baby a cannula, but still, you have to monitor the baby for the rest of the hours and that will still need a source of light. Maybe checking on the cord if it is bleeding." (Odoubu HC II, Midwife)

"During an emergency we also use the light like when I am supposed to administer to someone the drug. When I give a drug, I have to first read through. When there is no light, it will be hard for me to read and see which drug I am administering, and whether it has expired or not, all those things." (Odoubu HC II, Midwife)

"Regardless of the type of snake, we first consider every snake bike as a serious one. This person first of all will need an intravenous administration of hydrocortisone. Then this one needs you to first put IV, it needs you to cannulate. Without lighting it may not be easy for you put the cannula successfully. Even reconstituting the hydrocortisone. So light is very important such that you do not fail in carrying out your procedure especially at night hours." (Siripi HC III, Nurse)

Community representatives of the health facility's catchment population also perceive lighting to be important to patients' timely access to care. RWC and VHT members talked of not getting treatment, or having to wait a long time to access care when there is no lighting at the health facility.

"Sometimes back, before they brought in MoPos, people could come here at night for treatment. If by bad luck they find the light has gone off and the nurses' phone also does not have power, the services will not be offered to that person." (Ofua HC III, RWC member)

"Last year in August I was brought here at around midnight when power was not there. I had to stay up to morning hours without getting treatment and I had to stay in darkness." (Ofua HC III, RWC member)

"Sometimes the personnel take long to deliver the service because of no light." (Odoubu HC II, VHT member)

"Whenever we come to the facility at night for treatment, the personnel on duty usually take their time to wake up. So mostly people usually opt to go to the [private] clinic, because they fear the patient may die in the process due to the delay." (Odoubu HC II, VHT member)

Community representatives described the importance of lighting for patients to feel confident about the healthcare worker and the treatment he or she is receiving. In addition, lighting in a ward could help the patient feel safe and accept treatment.

"Accessing a health facility which has no light, first, makes me insecure because I know that anything can go wrong. So sometimes it scares me." (Imvepi HC II, HUMC member)

"Me, personally, I can't be comfortable to come to a health facility which does not have power at night because I will not know the person who is attending to me, and secondly, I will not be happy because what this person is giving. I will not know because there is no light." (Imvepi HC II, HUMC member)

"We have to use either our phones or this small torch to be in position to work on them when the solar system goes off; hence, bring negative impression on the patients because they don't trust whatever treatment that you as a health worker is trying to administer. For the staff who is administering the medication,

if you are not keen, you may end up picking a wrong medication." (Yinga HC III, HUMC member)

"I brought a mother at night, but on reaching here, the power was already off. Fortunately, the nurse had some power in her phone so she had to give us her as she was delivering the mother, we were torching for her, though the light was not sufficient but it was the only backup we had. At one point, we did not trust whatever she was doing." (Odoubu HC II, VHT member)

"There was a time I was brought here, and I was tested for TB, which turned out positive.
I was told to go to the isolation room. I refused because there was no light in that room, and it was far away from others." (Yinga HC III, HUMC member)

Lighting is important for healthcare worker safety. Healthcare workers spoke about the need for adequate lighting to prevent needle pricks and exposure to blood when caring for patients.

"We are also at risk working at night. In labour suite we used to have a lot of constant power because of risks like needle pricks, exposure to blood, anything can happen to use. We are really at risk at night." (Ocea HC II, Midwife)

"Now like a situation where the mother has a tear, you have to repair it. If you do not have light, you can prick yourself." (Ofua HC III, Midwife)

"In 2018, the mother was brought for delivery and in the process of disconnecting the placenta, the midwife also got hurt with the razor blade that she was using and this was caused due to lack of enough light. The absence of light in the health facility scares most of the health personnel to come and attend to the patients." (Ofua HC III, RWC member)

Health facility staff and patients, alike, also need adequate lighting to safely walk between buildings and move safely within staff quarters: to avoid tripping or falling, and to avoid encounters with scorpions and snakes which are common in the area.

"When in the compound there are some areas which are dark and there are some where this single security light, at least, it provides some light. But some areas which are dark, and anyone can slide with this sloppy rocky slanting, or can get an accident because most of the places are dark." (Ofua HC III, Medical Clinical Officer)

"We are really grateful that we are going to be gifted by light for solar... which will now remove the fear of these wild animals. The snakes, scorpions, you know those things are dangerous, when they bite you, you also suffer... yes, we fear to be hurt by those things because you the health worker, if you are hurt, who else is going to come?" (Imvepi HC II, Midwife)

"Lighting is important for security and safety. We usually have things that crawl into the ward – scorpions, snakes. The snake, I think early September, but it was just a small one." (Ofua HC III, Midwife)

"Reptiles, especially snakes, is our biggest fear. They come in. You find that at night you meet with the snake either at your door or in your room. It can't take one month when you have not killed a snake in one of these rooms... The staff, like for us at the quarters, it doesn't have light, that is it. You can get out and they come for you. Like for those days when we didn't have those wards, it was terrible, but now at least the person who is on night duty sleeps the other side – there is a duty room at least now adays. But those days where they would come for you. You first be fearing from getting out of your room. It is very dark then you have to move through this. The darkness can be terrible up to where you are going to see the patient from." (Imvepi HC II, Clinical Officer)

"In this area, we have scorpions. You know scorpions are very funny when they are here, you may not see, even it can attach here, especially the hospital beds where these bedsheets were given to patients, even in our quarters when I am sleeping. I hang my net and you find that this is a scorpion attached to the net." (Yinga HC III, Data Assistant)

"You know, this being a tropical area, it is full of reptiles. Snakes. So you can accidentally step on a snake and it bites you and for you, you are gone. You know, here, we have poisonous snakes. There was a time I t even went and entered the in-charge's house. A big one. That was last year in 2020. That was around June there." (Siripi HC III, Clinical Officer)

Lastly, lighting is important for security of patients and health care workers alike.

"When you don't have light, you will not see what is ahead of you. That is why it will be very hard when you are coming here at the facility, there are some people who might pretend to be patients and will be somebody who will come intentionally to cut. This has ever happened to a certain facility whereby some unknown people came and called the staff... the person made an alarm for help and he was rescued from there. At least, when you don't have this light, it will not give you a way to know who is coming, or to whom am I really speaking." (Imvepi HC II, Midwife)

"Even here in the compound, at night, there is no light. You can't imagine. So you walk and it is very risky. This, like the one at the gate, the security light at the gate, it just works from like 7pm and by 8pm it is off... The security guard is at risk because someone can come from anywhere and harm you. There is no light at all." (Imvepi HC II, Clinical Officer)

"I think being in darkness is at risk. You may not know, you know in the ward, there are different types of people put in the ward, so you may not know what happens at night to each other. Somebody can pick up your things when you are sleeping. At least if there is light somebody from the neighbouring bed can see and say 'Eeeh... where are you taking that thing'. You know we are not all uniform. There are some who have that wrong motivate from home of coming to benefit from somebody's property. So in the absence of light in the night you will look like total darkness and you are not safe." (Yinga HC III, Data Assistant)

Powering electronic equipment

Electricity is needed to power and operate commonly used electronic equipment in the health facility, including electronic medical devices (e.g., foetal doppler, headlamps, oxygen concentrators, baby warmers, refrigerators), and diagnostic equipment (e.g., HemoCue, glucometer, microscope, GeneXpert, pima machine), communication equipment (e.g., mobile phones, internet router) and reporting equipment (computers, printers, photocopiers). However, a majority of OGS PVS appear to be designed for lighting only and power from the wall sockets are often unavailable or unreliable (Table 16).

Phones are a fundamental tool for healthcare workers to communicate communication for effective health service delivery. Healthcare workers use phones to consult other clinicians on complicated cases, coordinate emergency referral and transfer, report weekly data into the Health Information System (HIS), and take part in meetings and continuing education.

"[Electricity] affects you in the way that the solar systems we have right now are kind of weak. The batteries we have do not store enough power for you to use maybe in night in case there is no sunlight. So sometimes it is hard charging phones because you know in a house setting like this we need to do consultations here and there and most times here we use our mobile phones to make such consultations maybe from other facilities or from other colleagues from other health facilities. So sometimes it becomes hard in a way that when it goes off in the night you will have to wait for the day to charge which will make communications in the night, maybe you have received a mother, her case is a bit complicated and you have to refer this mother to the next level, looking or an ambulance you have to communicate, like sometimes it stresses us in a way that when the batteries get off, it becomes hard to charge your phone." (Odoubu HC II, Midwife)

"When it comes to phone charging, because our phones is what we majorly coordinate with, our phones is a major way of communication here. So when my phone is not charged because even

if someone was going to call me from office the person will not reach me and I will not get the information. Even if I want some information from office, ideally, I will not reach the person. (Imvepi HC II, Clinical Officer)

Mitigation strategies for inadequate and unreliable electricity

Healthcare workers have developed multiple strategies to mitigate the impact of energy deficit on health service delivery. These mitigation strategies are categorized into four main categories: conserving energy for emergency use (e.g. only turning on lights when actively managing a patient), finding alternative systems for energy (e.g., dry cell batteries, diesel generator, Mobile Power battery banks, personal solar panels and battery banks), use of manual, non-electric methods in consultation, diagnostic, sterilization of equipment, and reporting, improvising locale of service delivery to access energy (e.g., moving patient to another ward to access lighting or electricity), and referral a patient to another health facility or sending out patient samples for analysis at another laboratory.

Table 21 Mitigation strategies for inadequate and unreliable electricity at the health facility (data from 2021 Baseline Qualitative Interviews)

Mitigation Strategy	Examples
Conserve Energy Use for Emergencies	• Only turn on light when room is in use – inpatients in general ward or maternity must use their own torches
Alternative Systems for Energy	• 3/6 health facilities have access to diesel generators with fuel – the generators are typically used to run lab equipment • 2/6 health facilities have access to Mobile Power (MoPo) battery banks to provide power for charging phones and lights • 3/6 health facilities have access to a functional We Care Solar for charging HemoCue, Glucometer, and a mobile power • Health facilities opt to purchase dry cell batteries to operate small medical devices, such as glucometer and HemoCue • Some healthcare workers are able to purchase personal solar panels and battery banks • Healthcare workers rely on personal or patients' torches or mobile phone light or to provide lighting for emergency procedures at night
Use Non-Electric Methods in Consultation, Diagnostics, Reporting, and Sterilization	• 6/6 health facilities relied on use of rapid diagnostic tests for HIV, syphilis, pregnancy, and malaria • Paper-based reporting for HMIS and monthly reporting for HIS in 4/6 health facilities • Use of charcoal, gas, or paraffin as heat source for non-electric autoclave for sterilizing equipment for re-use in 6/6 health facilities
Improvise Locale of Service Delivery to Access Energy	• Move patient to another building with adequate lighting or access to energy to run life-saving equipment (e.g., oxygen concentrator) • Carry patient sample to staff quarters to conduct testing (where there is adequate lighting to run and read result) and bring results back to ward
Send Patient Sample or Patient to Another Health Facility	• Send patient samples to a health facility with adequate energy to run diagnostics • Send patient via ambulance to another facility with adequate energy to provide the necessary treatment (e.g., oxygen therapy)

Conserve energy use for emergencies. Every health facility (6/6) described the practice of conserving energy to preserve the power in solar batteries for night time emergencies. Conserving energy typically means only turning on the lights that are absolutely necessary to provide the care needed. Many times, overhead lighting is not provided for admitted patients. If the facility has a MoPo available, then the torchlight from the MoPo is used to light the ward. In other cases, admitted patients must rely on using their own torches for lighting.

"Normally in the labour suite we switch if off when we do not have a mother in labour to reserve the power. When we get a mother, we turn it on until the mother delivers." (Ocea HC II Midwife)

"We need the light and that is why where we are putting the light in labour suite. When I am not working there, I do not put there power. And for thew wards, we keep telling the patients every evening we are not going to switch on power in the ward because if we switch it will consume and then the other side where we are supposed to work on you there is no power." (Ofua HC III Midwife)

Alternative systems for energy. Three health facilities (3/6) have access to a diesel generator. The generator is mainly used to operate laboratory diagnostic equipment, or other equipment such as the oxygen concentrator.

"The good thing the solar we have serves during the day when there is sun heat and then in the evening it is at times the generator, or during the day to run the machines, especially the microscopes, the EID machine we have, the GeneXpert machine. The solar strength is not enough. We put that generator to run for easy service delivery at the facility." (Yinga HC III, Data Assistant)

"But it [diesel generator] really comes in handy – even survival, like oxygen for a newborn who is asphyxiated, who may need to be put on oxygen. Instead of driving right from Rhino Camp to Arua Hospital to bring oxygen from Arua, if you have solar, if you have that energy and you have the concentrator, you are able to administer the oxygen there and them. And also of course, it also reduces maternal death like PPH, mothers who die due to a lot of haemorrhage will also require oxygen and some of these things need energy for you to operate them. So it kind of cuts across and it improves everything." (Key stakeholder)

None of the maternity wards are connected to the diesel generator (0/3) and only one inpatient ward is connected to the diesel generator (1/3, Ofua HC III). Five health facilities (5/6) have a solar EPI fridge and three health facilities have a functional We Care Solar box (4 facilities have We Care Solar but 1 facilities' battery is stolen and therefore non-functional, 3/6) to provide charging for small devices often used in maternal service delivery, such as the HemoCue, Glucometer, and a mobile phone. Since the We Care Solar system is one of the recently installed and functioning OGS PVS in the health facility, it often serves as the daytime phone charging station for health facility staff (as many as 30+ staff at one site). Two health facilities (2/6) have access to Mobile Power battery banks – 20 MoPos at Ocea HC II and 7 MoPos at Ofua HC III; these battery banks are capable of charging mobile phones (not laptops or medical devices) and can provide three levels of lighting (dim, medium, and very bright). The MoPos were allocated to provide back-up lighting at maternity and in-patient wards, as well as shared among staff to meet the healthcare workers' charging needs. Some health facilities opt to purchase dry cell batteries to operate devices such as HemoCue and Glucometers.

"We have our HemoCue which needs to be charged but because of lack of power we are using batteries. We are not charging them." (Ocea HC II Midwife)

Small solar panels (not mounted to the roof) were observed at the staff quarter areas of every health facility. There were personal solar panels purchased by healthcare workers who live on the premises of the health facility as the existing OGS PVS at staff quarters are mostly dysfunctional or provide inadequate energy – only enough for lighting one bulb for part of the night and not for charging phones. These panels enable health care providers to use their personal torches or mobile phone lights to provide lighting for night-time ser-

vice delivery. Due to inadequate lighting within the ward (either to reserve power for emergencies, poor batteries to hold power for the duration of the night), midwives and clinical officers reported the need to use personal lights to walk from staff quarters to their duty stations to respond to emergencies, select the right medications, perform procedures, and monitor patients. When healthcare providers do not have enough lighting from their torches or phones, they rely on the patient to bring their own light.

"Even yesterday night I was on duty. It was a mother who came with abortion and I had wanted to remove the clothes from the mother and the light went off. Good enough that mother came with the attendant. I had to switch my phone on. The battery on the head lamp was off. So I had to use the phone to finish up the procedure I started. So it was good the attendant who helped me hold the phone and light to help the mother and I finished the procedure I started." (Yinga HC III Midwife)

Use of non-electric equipment in consultations, diagnostics, sterilization, and reporting. To minimize reliance on electricity, health facilities are observed to mainly use non-electric equipment in consultation, diagnostics, sterilization of equipment for reuse and reporting. For example, maternity wards are mainly equipped with manual blood pressure apparatus and manual suction for neonatal resuscitation. Hot water bottles, extra clothing, and windows and door closure are used to keep a baby warm instead of use of a baby warmer. Rapid diagnostic tests are when available in lieu of microscopy. Non-electric autoclaves are used instead of electric autoclaves or sterilizers, and facilities rely on heat sources, such as gas, charcoal, and paraffin. Finally, only two health facilities (2/6) have a computer and printer to potentially submit electronic reporting of Health Information Management System (HMIS); others rely on submitting hard copies of data to the district.

"There are activities we do and we require electricity but we may not do them because there is no power so we start like improvising. For example, now like here, we do not have an incubator and we cannot use the baby warmer. So the situations when you have those low birth weights here we start now improvising using hot wate bottles. You know it is hectic to keep boiling water. So [electricity] makes work easy for us. And even now, like the suction, we use the manual suction and you keep stepping, keep stepping. And then our sterilization is by gas." (Ofua HC III, Midwife)

"To keep the baby warm, normally when I am still doing the resuscitation to a baby that needs resuscitation, I make sure I put the baby in clothes and I close the adjacent windows and maybe the doors to make sure there is warm. But if it is a normal baby, I keep baby and mother's tummy on skin-to-skin contact." (Odoubu HC II, Midwife)

"We have a printer and a computer in the ART room. We are not able [to use them]. I mean, we would store data, our patient data would be electronic. The equipment is there but there is no power so we can't store electronic data. We are using physical files, paper and files. Which can also in terms of privacy, it is not good. At least when you have electronic data, you can put passwords and you know you are 100% secure." (Ocea HC II, ART Clinical Officer)

Improvise locale of service delivery. Healthcare workers report taking the patient to another ward or unit of the health facility to access adequate lighting or electrical outlet in order to provide care. At Imvepi HC II and Odoubu HC II, the outpatient departments do not enough lighting to examine and treat patients that come at night. Patients with emergency but do not require actual hospital admission, are taken directly to the inpatient department for care. At Imvepi HC II, the maternity ward only has enough lighting capacity for the delivery suite. Postpartum women are taken to the inpatient general ward for monitoring after delivery. At Ofua HC III, the solar system in maternity is not strong enough to operate an oxygen concentrator. When neonates require oxygen therapy following resuscitation, the babies are moved to another ward where the oxygen concentrator can be connected to an outlet supported by the diesel generator. At Odoubu HC II, the laboratory as-

sistant takes a blood sample to the staff quarters to carryout the test there because it has power to operate the HemoCue.

"Currently, there is light in the labour suite and then the duty room. Other rooms they don't have light. Even where the women are recovering from delivery it is not there. So we moved mothers from postnatal, this side of maternity, to that general ward. Yes, so they are now all in the inpatient – that side where it is general. In fact, we are not supposed to use it but we are using it because of the conditions which are really pressing us." (Imvepi HC II, Midwife)

"We don't have enough power to run [the oxygen concentrator]. Yes, [socket] is there but it is not strong enough. On 24th of December, we had a delivery here and the baby had severe asphyxia. We resuscitated with Ambivac but the SO2 was still low. So we had to put on oxygen therapy and that was in the evening hours around 6pm. We had to call the generator man to switch on and then we transferred the baby to IPD. So when we went to IPD, they also had another baby with severe pneumonia on their concentrator. So we had to come and roll ours up to IPD to connect our baby." (Ofua HC III, Midwife)

"Because in case there is a critical case to attend to at night first of all I need light. Secondly, for the equipment, I also have a HemoCue this one for testing the hemoglobin. I don't actually charge it because there is no socket. Sometimes I used to pick the samples and take to where there is power, there is little power in these other blocks – the newly constructed staff house sometimes I take there and connect, then do it, and then bring the result to the patient. But unfortunately the power there is also unreliable sometimes, it goes off, in the staff quarters." (Odoubu HC II, Laboratory Assistant)

Send biologic samples or patient to another health facility. Health facilities that do not have sufficient laboratory capacity, in part because of insufficient energy to operate microscopes and other diagnostic equipment, need to collect patient samples, send them through the Hub Rider and send them to a centralized laboratory for testing. Health facilities also send patients they do not have the capacity to manage, in part because of insufficient energy to operate lifesaving medical appliances like the oxygen concentrator or a refrigerator to store blood, to another health facility.

"I also remember a time when I went to maternity to assist delivery. There was a mother with complication and there was a time it was around 2am when power in the maternity is gone off and it was kind of dark… It was in the evening we did resuscitation and the baby picked up but we wanted to keep the baby on oxygen until the baby was more promising to be off oxygen and above all it was premature. Because there was a big challenge of issue of power, we had to refer them to Arua. As we organized for the referral process, we brought the baby to IPC room because there is connection with a small bed. We put the baby there and we connected oxygen." (Ofua HC III Medical Clinical Officer)

Non-use of available and functional electronic equipment

Health facilities report not using the available and functional equipment they have when the electricity deficit cannot be mitigated. For example, five facilities (all except Imvepi HC II) have a light microscope or a fluorescent microscope. These microscopes are a useful alternative when facilities are stocked out of rapid diagnostic tests, especially for malaria. However, these facilities are not always able to utilize their microscopes because of inadequate and inconsistent power.

"Many things need to be done actually if the resources can allow. So today I am not working. I am just with very minimal package: HIV testing, syphilis, so, just a few, or pregnant testing, things that really don't need power… I have a microscope but it is just packed there. Because there is no power. This solar we have – it cannot run. It is very weak. It can give light but it is very weak." (Odoubu HC II, Laboratory Assistant)

In addition, Yinga HC III report having but not using its ECG machine, an oxygen concentrator, a radio, and a television. Ofua HC III has an oxygen concentrator, a hot water heater, and baby

warmer in the maternity ward. The hot water heater and baby warmer, which are not easily portable, are not used because of inadequate power. The oxygen concentrator has been rolled into another ward with an electrical outlet powered by the diesel generator and used to provide oxygen therapy. Ocea HC II has a refrigerator in the laboratory but due to inadequate and inconsistent power, a cool box with water-based ice packs is used instead to keep samples cool. It also has a computer and printer for HIV-related reporting, but the ART clinic is unable to use it because of inadequate electricity.

"We have a radio, we have a TV screen, so all those things need power. Right now, here, since the power level is low, we are not using them. We have packed them somewhere so they are not used. Those ones are supposed to be used by mothers here in MCH, for youth there in adolescent friendly services, but since power is low, we have packed them. They are not in use." (Yinga HC III, Midwife)

"Oxygen concentrator is for giving oxygen either to the mother or the neonate in case they have respiratory distress. I: Are you able to use it? R: No. We don't have enough power to run it. The solar is not strong enough." (Ofua HC III, Midwife)

"We have the baby warmer but because of power problem we just need to do with our environment… The power goes off in a very short time. The last time I tried it lasted seven minutes." (Ofua HC III, Midwife)

Health care worker needs

Inadequate electricity to meet basic user needs are also observed in the staff quarters. This is exemplified by healthcare workers describing the need to trade-off between lighting or charging his/her mobile phone.

"Sometimes when you charge the phone in the night the whole power system in the house is down. Like you are not able to have the light in the room because charging that thing in the night – it consumes the little power that you have there, it consumes it all. So sometimes it is hard actually." (Odoubu HC II Midwife)

Healthcare workers report the solar batteries in the staff quarters are not be able to hold charge so they are unable to charge devices at night. Healthcare workers would like to be able to charge phones to communicate with family, utilize a computer for self-study or entertainment, boil water with an electric kettle, or iron his/her uniform.

"Each house is having a solar panel and a light for each housing unit. The solar panel is not enough to charge a phone. It is only for lighting. Now, for other things like ironing our uniforms and entertainment, we have to come to the hall. We don't use electronic gadgets here." (Ofua HC III Midwife)

"Then in the staff quarters sometimes we get bored. When we have our entertainment, we have our screens, televisions. But because of lack of power, we are not making use of them." (Ocea HC II Midwife)

"As a healthcare worker, you see, everybody needs social wellbeing and healthcare workers need to be able to read and understand things and current affairs, current updates which are happening in other places. Now you see, you are in your place being also a hard-to-reach area, you also want to have news and you don't have a lighting system which can support the power." (Siripi HC III Clinical Officer)

"It (Mopo) is really not enough and secondly it cannot support laptops. It cannot support anything. It will only charge a phone, two or three, it has no provision for a laptop. You can't apply anything on it. And that is why I said that on the other part of my studies there is nothing much I can do here. I will only read physical work at my place and then when I go to town I print. Because at school, at the university, there is computer and power. I make sure I assign someone on the street in town to type the research reports or any other assignments because most of the work at the university they want soft copies. I will write then give someone to type write." (Ocea HC II, Clinical Officer)

Consequences of inadequate and unreliable electricity

Inadequate and unreliable electricity negatively affects lighting and powering of electronic equipment used within a health facility with serious implications on patient quality of care, efficiency in health service delivery, and health care worker retention.

Quality of care

Delays in time to treatment

Inadequate and/or unreliable electricity means that some health services cannot be provided when it is needed. Delays in time to life-saving treatment may lead to poorer health outcome. These delays are often caused by the need for healthcare workers to look for additional lighting to manage the emergency cases that come at night. A common account according to healthcare workers across the six health facilities is the search for additional lighting: typically, this involves a midwife asking the patient attendant to call the security guard to come to the maternity ward, and the guard is then dispatched to find another clinician within the staff quarters to bring light and help. This process takes time – it diminishes the capacity of healthcare workers to immediately address the emergency at hand and lengthens time to treatment.

"When it comes to [an] emergency we run around to look for other sources of light so as to help the baby. You go borrow from your friend if what you have is not enough… It was November I think the last one I did myself was in November. It happened around midnight. I was alone on duty. I couldn't leave the baby here and the mother in the room. I had to send the attendant to call the askari on duty. She called the askari and I sent him to call the in-charge. I also instructed him to tell the in-charge to come with other sources of light as I stayed resuscitating the baby with the little source of power that I had. I had a mopo power but it was not all that bright. He had to come with his personal light, the one UNHCR gives for refugees, I think he also had one, he brought that one in and we had to help the baby." (Ocea HC II, Midwife)

"At night during times when power has gone off and you receive an emergency, you have to figure it out either with your torch or it is kind of challenging to see what you need. It is kind of challenging, let me say, at night when the power is gone off. It is challenging in the sense that you either hold the torch or you put it somewhere, and if you want to get a medicine or you want to mix medication or if you want to like suture, like someone is having a bleeding from a cut wound, it is kind of challenging because the power is not enough to provide you the necessary lighting. The direction of power depends on where you put the torch. You may have like not enough human power, one person holding the torch is kind of rare. You might be like the clinician plus a nurse. The nurse will be busy doing other things and then you might ask the caretaker to be holding the torch, such kind of things." (Ofua HC III, Medical Clinical Officer)

"Any emergency got at night it becomes very hard for a duty staff to do proper management because everything you will be struggling to look for around. And at the same time, you will not even get what you want in time, you have to spend a lot of time as you struggle." (Yinga HC III, Data Assistant)

Another reason for delay is because certain health services can only be provided when electricity is available, and not when the patient is in need of it. For example, haemoglobin testing cannot be carried out when the HemoCue is not adequately charged for the night. However, healthcare workers are not able to charge the device at night because of "weak batteries" so testing is delayed until daytime when enough solar energy is restored in the solar battery. This results in patients not getting the timely diagnostic service they need. This can have dire consequences if a bleeding woman is also anaemic and in need of urgent blood transfusion.

"Now at times you would just do the basic which you can at the moment, and then you wait in the morning so that you can try to help somebody." (Siripi HC III Clinical Officer)

"When I have a power source, I will do whatever I am supposed to do at the right time when the equipment is there. I will do the needful. Okay like I am supposed to do an HB level for the mother to have an appropriate referral for blood transfusion. If the power is reliable, I just do it within one minute and then I confirm and write a referral since there is no blood transfusion in our facility here. You write a referral; you send the driver with the mother and you save her." (Yinga HC III Midwife)

At a health facility with a diesel generator to operate diagnostic equipment during the daytime, a clinician highlights the limitations of only being able to run the microscope during the time the diesel generator is scheduled to turn on – due to the long wait patients do not stay to receive their test results. Sometimes the health facility has to mobilize a Village Health Team member to track the patient and ensure follow-up care.

"Since microscope requires power, you have to wait for a test result. Patient may have gone home already. "The testing we do in the lab after the specimen is collected so the challenge of power affects us that since the microscope uses power so even if you make a request for a patient let me say maybe in the morning and he has to wait until the power sets on then that is when they will do it. So there are times they will do the tests and find the person has already gone home… yeah so we ask them to come the following day and some don't come where if they don't come and the result is positive you need to follow them through the VHTs. There have been such a few cases." (Ofua HC III Medical Clinical Officer)

Improvising diagnosis and treatment

Quality of care can also be compromised when healthcare workers have to improvise to provide diagnosis, or treatment for a condition based only on signs and symptoms and not a definitive diagnosis. An example of improvisation which may affect quality of care is the use of sunlight reflected into the mirror of the microscope in order to provide microscopy services. This practice was described in two of the five facilities with access to a microscope as a means to deal with inadequate electricity.

"They can use microscopy using solar – direct sunlight to the mirror and then they will adjust it themselves. There is no power but they will make the mirror of the microscope to trap light. It is really tricky. [The lab person will take the microscope] at the window and then try to adjust to make sure he gets some light and then observe on the object piece. He can tell although it is not all that reliable because there could be errors compared to the one using electronic life. Yeah, in such difficult situations and make sure life moves on." (Ocea HC II, ART Clinical Officer)

Another example is treatment of malaria without testing. Multiple facilities talked about being out of stock of malaria RDTs and the solar system not being able to support the use of the microscope. In these circumstances, healthcare workers may delay treatment of malaria until "cardinal symptoms" are observed, or treat without testing.

"At the moment we can't even do this test for malaria because of the high number of patients we have run out of stock and we now basically rely on the microscopy. Now if the microscope is down, then the work gets stuck. We get supply [of malaria RDTs] from the MoH, at times from UNHCR, and you know with these high turnovers, the supply from MoH only caters for some population which is very small as I told you yesterday, it is around 5000 something yet most of the population here are refugees. So the few the MOH brings is not enough. And the one UNHCR gives, you know at times you request, but it is not enough…. At times we can go out of stock. But now since we have a backup of a microscopy, we are now relying on microscopy but the lighting system cannot allow. There are times when the microscope shuts down. At times it is very hard because the MoH is also strict, they said "Test and Treat". You treat those signs and symptoms and you wait – if there is fever, you treat the fever and psychological treatment and other things, and if there are other problems you treat and you investigate then later. Now because then you are not sure whether it is malaria or not, you only give like paracetamol and you wait unless when you see that it is extreme and you see you that you are clear, all the cardinal symptoms of malaria are there, that is when you now give [coartem],

when you see it is life threatening, that is when you decide to treat clinically." (Siripi HC III, Clinical Officer)

"For malaria, this is the second week [of stock out] now. Yes, so we are giving patients treatment without testing. We have to rely on signs and symptoms." (Odoubu HC II, Laboratory Assistant)

Efficiency

Efficiency of health service delivery, or efficient use or distribution of resources in the health facility, is affected by inadequate and/or unreliable access to electricity. For example, the search for additional lighting to handle an emergency at night results in additional use of manpower. Many times, another clinician, patient attendant, or even security guard are recruited to hold and position the light.

"Even yesterday night I was on duty. It was a mother who came with abortion and I had wanted to remove the clothes from the mother and the light went off. Good enough that mother came with the attendant. I had to switch my phone on, then the battery to the head lamp was off. So I had to use the phone to finish up the procedure I started. So it was good enough the attendant who helped me hold the phone and light to help the mother and I finish the procedure I started." (Yinga HC III, Midwife)

"So the power went off, the battery went off, the battery in Ocea goes off at 11pm or around 10pm there but by 11pm it is already off if you have used lights, but if you have used lights at 9pm you are out. So that night I had mothers and unfortunately, I had to stitch. So I could not hold the phone and again I stitch so I gave my phone to the attendant and I told her to flash and as she was flashing and I was stitching she was seeing what she is not used to see. She fainted. She fainted and I had to ask the Askari to go and bring another midwife to help this mother. So that is what happens if you don't have light. Attendants do things they are not used to. Even some when they see blood they vomit." (Ofua HC III, Midwife)

Other areas of inefficiency include the non-use of available and functional equipment for health service delivery (e.g., oxygen concentrator, baby warmer, TV for health education, computer and printer) and not fully utilizing the skills of the laboratory technician or assistant because the facility does not have adequate electricity to operate other diagnostic equipment.

"We have microscopes, we have incubators, we have oxygen concentrators. We have many other equipment that actually need power to operate. So once this energy source is not there then these things are made redundant. And the more they are made redundant, they accumulate dust. Some of them are very sensitive. They could be very, very expensive machines. For example, oxygen concentrator costs about forty million. You find that just because of lack of solar, of maybe three million, five million, or ten million, this whole equipment of forty million is made redundant. It can generate dust and even break down faster." (Key stakeholder)

Healthcare worker retention

Multiple intrinsic and extrinsic factors affect healthcare worker's decision to remain at a rural and remote health facility. Documented extrinsic demotivators include a "lack of resources; inadequate leadership and management; programmes being undermined by new policies and short-term strategies or legislation and legal implications; non-availability of mobile phone networks or internet access, available bandwidth and speed; fragmentation of care and workload, all of which can lead to exhaustion, burn out, and attrition" [23].

Electricity is a key resource underlying adequate lighting to function safely and effectively at work and for personal safety, ability to perform work functions efficiently with the aid of electric equipment (e.g., microscope, electric autoclaves for sterilization, electric suction, baby warmer), access to communication and coordination through mobile phones, WhatsApp, and internet, and access to news and entertainment through TV and computers. Therefore, access to electricity is an important factor to healthcare worker motivation and retention.

"Definitely working in places with no light affects any worker so for efficient service delivery everything should be available and in order. So this is simply demotivating." (District Health Officer)

Electricity is recognized by administrative, donor and program leaders a relevant and important factor to healthcare worker work stress and personal comfort.

I: What role does electricity play in health worker motivation, particularly for these hard-to-reach facilities?
R: Very true. You know what it means to deliver a mother or attend to a child in the light, as in, you have an emergency without power. The stress that should not be of the health worker, that is, of the system, is transferred to the health worker. They really get demotivated. Even in their own houses, you are there deep in the village, maybe they want reports from you. During day you are working. In the night maybe you want to take that little time. First of all, by the way, our staffing is very poor – we are at 47% of the recommended level. So these staff are stressed. During day they are working, in the night things like reports they would want to do it but you have no power in your house. Then here me as a DHO, I'm stressing you 'I want you to give me this by this time' you see. Yeah, in total, it is not easy to go through. It is a demotivating factor. But more also, you are a human being. You also want to listen to radio, to watch TV, news on TV and all that. When you have these facilities at your disposal, because of the presence of power, you feel comfortable staying there in the hard-to-reach places. But when they are not there… I myself was there in Omugo and I would see the difficulties. Yes, even when I was a DHO, because there was one MO I thought I would get time to support him. So I occupied myself in a room in one of the staff quarters. The power was a challenge. Even the light alone sometime you get a problem to get to your laptop to check your emails, no power. So it is that difficulty at these facilities. (District Health Officer)

I: How do you find electricity affecting healthcare worker motivation?
R: It does a lot because, first of all, I said the settlements are in remote settings far away from the town… And then of course being in a rural place, there is entertainment, probably they want to watch news, they want to watch movies, they want to use their laptops, they want probably, yeah, even just for lighting around. We have had situations where snakes have entered where they reside, so you see, they are at danger of snakes, lying next to a snake or something like that which is dangerous and it poses a very, very big risk to them. And because of that we have had a very big turn over. For example, this year, we have just learned that one of our medical officers has left at Ofua. She basically left because she had an offer in a town environment in Adjumani Hospital where she will have access to a house with electricity, probably with UMEME. So, there are those small things that it makes a huge difference at the end of the day. (UNHCR Public Health Officer)

I: I was wondering what relationship you see between electricity and staff retention these facilities in the settlements?
R: Yes, it has not directly contributed to retention or to staff leaving a facility because they don't have source of power, but it is one of the things that make them have comfort to stay in a place. If they have full time source of power because they have to charge gadgets like phones, computers, such that they are able to communicate and they are maybe able to watch TV during their free time. It's one of the things that makes them comfortable because they are able to stay and do their work properly. But it has not come to our notice that maybe some staff are opting to leave because of lack of power.
(IRC Health Manager)

Healthcare workers were also asked about the role of electricity on their motivation to remain at the health facility. While healthcare workers readily admitted feeling stressed by the challenges of health service delivery and safety concerns because of inadequate and unreliable electricity, they also talked about the importance of having a job in an environment of high unemployment.

Maintenance and Sustainability of Energy Systems

Maintenance for diesel generators

All three health facilities (3/3) with at least one diesel generator reported having a routine preventive maintenance programme in place (Table 21). Two of the three facilities' generators are installed and operating and both facilities reports having received maintenance support from African Initiatives for Relief and Development (AIRD) the last quarter. The third facility's generator is not yet connected and therefore it is not yet functional and has not received any maintenance; however, healthcare workers report AIRD will also perform its maintenance. The maintenance of the diesel generator is supported by an implementing partner. Health facilities do not have their own strategies for repairing or replacing the generator – all three reported plans to call the donor if a generator part needs replacing. One facility (1/3) reported having staff trained on how to maintain the diesel generator, one facility reported (1/3) having an operations and maintenance manual for the diesel generator.

Table 22 Maintenance practices of the diesel generators (data from 2021 Baseline Health Facility Survey)

Diesel Generator Maintenance	Health Center II			Health Center III		
	Imvepi HC II (Imvepi)	Ocea HC II (Rhino Camp)	Odoubu HC II (Rhino Camp)	Yinga HC III (Imvepi)	Siripi HC III (Rhino Camp)	Ofua HC III (Rhino Camp)
Year diesel generator installed	NA	2020	NA	2018/2019	NA	2016/2017
Routine preventive maintenance for diesel generator	NA	Yes	NA	Yes	NA	Yes
Month and year of last routine maintenance	NA	NA (generator not yet connected)	NA	Nov 2020	NA	Dec 2020
Personal responsible for routine preventive maintenance for generator is from facility or outside facility	NA	Outside support (AIRD)	NA	Outside support (AIRD)	NA	Outside support (AIRD)
System for repairing or replacing the generator	NA	Call donor for replacement	NA	Call donor for replacement	NA	Call donor for replacement
Any staff member at facility received training or support to learn how to maintain diesel generator	NA	No	NA	No	NA	Yes
Facility has manual on how to maintain diesel generator	NA	Yes	NA	No	NA	Don't know

Maintenance for solar systems

Three health facilities (3/6) reported having a routine preventive maintenance programme for their solar systems. The maintenance was all performed within three months of the date of interview. One health facility reported receiving maintenance support from an external technician (Care for the solar system in the maternity ward) and two facilities reported performing on-site cleaning of the solar arrays, but without a specialized technician. Only one health facility (1/6) had a hard hat, and none had any other safety equipment for solar maintenance, such as safety googles (0/6) and protective chemical resistant gloves (0/6). Only one

health facility had any maintenance tools for the solar systems, such as tools with insulated handles (1/6), a volt meter (1/6), and a sturdy ladder (1/6). None had water and bicarbonate soda solution (0/6) to deal with acid spills and leakages. If there were problems with the solar systems at the health facility, 2/6 facilities said they would call the donor for replacement and 4/6 facilities said they did not have a formalized system in place. None of the facilities (0/6) reported having staff trained on how to maintain a solar system and one health facility (1/6) reported having an operations and maintenance manual for the solar system.

Many healthcare workers recognize the limitations of not having routine maintenance for the solar systems.

"There is no [maintenance] system and I am sure that is why those panels are hanging up. There is nothing good out of them." (Ocea HC II, ART Clinical Officer)

Table 23 Maintenance practices of solar systems at maternity ward (data from 2021 Baseline Health Facility Survey)

Solar System Maintenance at Maternity	Health Center II			Health Center III		
	Imvepi HC II (Imvepi)	**Ocea HC II** (Rhino Camp)	**Odoubu HC II** (Rhino Camp)	**Yinga HC III** (Imvepi)	**Siripi HC III** (Rhino Camp)	**Ofua HC III** (Rhino Camp)
Year solar system installed	2020	2018	2016	2019	2020	2020
Routine preventive maintenance for solar system	No	No	Yes	Yes	No	Yes
Month and year of last routine maintenance	Never	Never	Oct 2020 (GIZ)	Nov 2020 (Save)	Never	Dec 2020 (GIZ)
Solar components assessed in last routine maintenance:						
Battery inspected	NA	NA	Yes	Yes	NA	Yes
Battery electrolyte level checked			Yes	Yes		Yes
Battery checked for high state of charge			Yes	Yes		Yes
Solar array cleaned			Yes	Yes		Yes
Solar panels inspected			No	Yes		No
Solar array mounting frame checked			No	Yes		No
Inverter + charge controller dusted			Yes	Yes		No
Inverter + charge controller inspected			No	Yes		No
Wiring installation checked			No	Yes		Yes
Personal responsible for routine preventive maintenance for solar system is from facility or outside facility	NA	NA	Onsite support (cleaning only, no technician)	Outside support	NA	Onsite support
Equipment for maintaining solar system:						
Safety googles	No	No	No	No	No	No
Protective chemical resistant gloves	No	No	No	No	No	No
Hard hat	No	No	No	No	No	Yes
Water and bicarbonate soda soln	No	No	No	No	No	No
Tools with insulated handles	No	No	No	No	No	**Yes**
Volt meter	No	No	No	No	No	**Yes**
Sturdy latter	No	No	No	No	No	**Yes**
System for repairing or replacing the solar system	No system	No system	No system	Call donor for replacement	No system	Call donor for replacement
Any staff member at facility received training or support to learn how to maintain solar system	No	No	Don't know	No	No	Don't know
Facility has manual on how to maintain solar system	No	No	No	No	No	Yes

Ownership

There is a limited sense of ownership or personal responsibility for the existing OGS PVS with the exception of the Mobile Power charging stations. In general, healthcare workers and community representatives recognize that the OGS PVS belong to the health facility, but there is no designated person to look after these assets (e.g., ensure they are working, kept clean, etc.). If an OGS PVS stops working fully, then the health facility's strategy is to call the district or the partner for help and replacement. It does not seem that health facilities feel empowered to problem solve or address the challenges they face. For example, one facility feels that too many fluorescent lightbulbs in the maternity contribute to the solar battery running out of power. However, the facility does not feel empowered to even remove some of the lightbulbs in order to reduce power consumption.

According to several healthcare workers, capacitating the staff to look after the solar systems can help them feel ownership and responsibility towards these assets.

"Actually, it is good because it starts with me, because I am the one benefiting. I need to be responsible." (Ocea HC II, ART Clinical Officer)

"It would be good because it would create a sense of ownership in the community, like it makes them feel like they have been involved, and there is ownership. So they will also participate actively in seeing that there is sustainability of the project for over a long time because the biggest problem we have, projects come in, structure is set up, but there is no program for sustainability. When they get spoiled, no one will come and take responsibility for what they were not assigned for. So things just keep getting wasted like that." (Ofua HC III, Midwife)

"It will be a great pleasure. Because GIZ is a partner, but the solar or the services it provides it is actually we, I benefit, and then the patient benefits. The community at large also benefits. Then whatever GIZ does should take it upon all of us. I should take it as this is also something that belongs to me. So, being part of the maintenance team, as a staff here, I feel that it is actually we who own, not the GIZ." (Siripi HC III, IPD In-Charge)

Enhancing ownership may strengthen healthcare worker's accountability to using the OGS PVS appropriately. One healthcare worker suggested the formation of an accountability group within the staff to ensure careful and appropriate use of the solar systems.

"Maybe the staff can come and check how you are the solar, whether you are using it for other appliances that consume a lot of power that will affect the solar system. They could participate in checking that." (Odoubu HC II, Midwife)

Capacity building for maintenance

Health facilities have not been capacitated to provide routine maintenance of the solar systems, even non-technical aspects such as routine cleaning of the solar panels, dusting of the indoor components, and basic visual inspection of the arrays and wires (Table 23). None of the health facilities (0/6) are able to name a designated staff member who has received training or support to learn how to maintain the solar system, and none (0/6) can produce an operations and maintenance manual on any of the existing OGS PVS. Typically, health facilities refer to the donors of the solar systems or diesel generators to provide external maintenance support.

"The maintenance and parts of these houses or structures like the general ward, like this one, it was from AIRD project and then maternity is it from CARE office." (Yinga HC III, Midwife)

"They [CARE] just come and ask us about the solar system and any other challenges that we may have. So we used to report solar, every time they come we tell them 'the solar is weak' and that was the first complaint and then other things were on plumbing. Someone came, an electrician from their side. He did assessment. He told us he was going to write a report, and then they will see what they can do about it. We are waiting for

them to do something. Then they handed over to IRC. I reported and I haven't gotten a response yet." (Ofua HC III, Midwife)

Community representatives and health facility staff alike recognize ownership of the OGS PVS as a first step to taking responsibility for it.

"We shall first start by owning the solar system and acknowledge that it's something that is going to help us, t hen we shall maintain it best." (Odoubu HC II, VHT members)

"You know when you do something and the sustainability plan is not there, it becomes a junk program because it needs the community to also own. And what we also need to do is we need to engage the facility health management committee to be part of the team, and also involve the staffs in the program so that once it is installed, it will be a routine thing with minor maintenance, like cleaning dust, especially on the batteries and the panels." (Siripi HC III, Clinical Officer)

Interviewed healthcare workers and HUMC members were receptive and willing to learn how to monitor and provide basic maintenance for the OGS PVS. They saw the advantage of having a capable person on the ground who can offer minor repairs when needed and ensure continuation of service delivery without having to wait for external support to come and restore power. Another advantage of an internal person skilled to work with the OGS PVS is so the health facility can have more flexibility to address the energy needs of the health facility. The disadvantages of relying on external support for maintenance is that one must wait for the outside partner to be available and the outside partner may be only willing to fix what another organization has budgeted for it to do (instead of meeting the actual needs faced by the health facility).

"It would be good because in case of any need they would not be calling GIZ when they are not here. The available person will just step in and help immediately so that services can continue running normally than waiting for them to first come and making phone calls." (Ocea HC II, Midwife)

"The advantage of maintaining the solar from the outside is that it cuts the budget of the facility because here as a facility we may not say something about it – they cater for the budget. When you look at the disadvantages, the burden of maintaining a solar outside is one, you will now bear their condition because like if they are to say 'please, today we don't have power' they will take their own time because they come on maybe procedure for coming. They take their own time to come, they may not come today or in a week, they will take their own time. And the other thing you will not know the cost of that maintenance since it is budgeted from them, only implemented by them, you cannot know their cost. And thirdly, you go by what they do, there is no option of saying 'Please, this one is like this' especially, recently when they came to replace the bulbs, we were like 'no at least you bring for us power here in the office so that at least we run our computer' but they were saying 'haa, this one we are not interested, we did not procure this one here, so we only do what is given to us.' So it means when they want to do their need, you need to accept their need, not basing on your need on ground, that is the disadvantage." (Yinga HC III, Data Assistant)

"GIZ should organize for a training for all the management team because we have here community, facility-based management, so GIZ should organize for a training so that the knowledge gap should be avoided. For minor maintenance we can even do it here locally, not to raise a concern to GIZ. Something like this one here – fixing a bulb, wiring, in case rats have disorganized some of the wires, we need not call GIZ office to send technical people to come. Maybe if it is something beyond our capacity, that is when we raise a concern. But at least through training, if some staff or the management team they are trained, then it would be of our pride and then you will even benefit in through the effort you have made at the facility, which is that we have established people to maintain it well." (Yinga HC III, Data Assistant)

Health care workers recognize the importance of having internal capacity to maintain the diesel generators and solar systems because they are familiar with donors leaving and no longer having access to support.

"There are disadvantages in that if the organization will phase off, there will be no maintenance of this thing, and it will go down, and there will be no power after the organization leaving, there will be no power for the facility." (Yinga HC III, Midwife and Facility-in-charge)

"They [CARE] came for some time because like after building and then people start using, they give you a period when they will be in charge of maintenance. And then after that period they fully handover. So even that period ended, they no longer came." (Ofua HC III, Midwife)

The HUMC and facility staff recommend careful selection and training of more than one person because so the facility does not lose capacity when a staff is rotated to another health facility, and that training and responsibility of maintenance should be given to staff who mainly reside within the catchment area. Some facilities recommended that the security guard or general maintenance repair person (especially the government funded one). Other facilities recommended that staff who hold responsibilities, such as the facility in-charge, store keeper, and laboratory technician be trained.

"It [training on maintenance] will be good, but now, the other thing is that for us, we are not permanent to this facility, we keep rotating. So, if the training is to happen, maybe if GIZ is going to put these solars in all the IRC facilities, such that even if I am trained from here, and I am transferred to another facility, I don't go with my knowledge and you go and sit on it the other side." (Ofua HC III, Midwife)

"I think first of all, the in-charge of the facility, the store keeper, and then we have clinicians – technically people who are around and then most probably the laboratory technician and then maybe department heads. Because I wouldn't wish to say everyone, no. At least people who have responsibility." (Ocea HC II, ART Clinical Officer)

"If they can empower and train a few that would be okay. Because these are people who stay here mostly. Then when they have that knowledge it will be easier actually to report, then if they are not empowered, they will also be like 'there is no power, what has happened?' So it would be okay. It would a good idea if one or two facility staff is part of the team." (Siripi HC III, IPD in-charge)

A District Health Officer said the district has four engineers – a district engineer, an electrical engineer, a mechanical engineer, and a road inspector. The electrical engineer is expected to maintain electricity-related equipment in health facilities within the district. In reality, the district-level electrical engineer does not do so. The problem could be related to both lack of fuel for transport and management. The District Health Officer thinks it is more cost-effective to train technicians at the regional level to ensure sustainability of the maintenance programme.

"The electrical engineer is expected to take care of these things. Move around and take care of these. But usually they have not been ably doing it. That is the truth. It is now an issue of supervision. Maybe because UNICEF doesn't raise these issues also. … Usually budgets are there but whether they are sufficient or not, they cannot say it." (Terego, District Health Officer)

"[It would be most cost effective to train someone onsite] but probably not per facility, maybe per district. Yes, per district. Because it becomes very difficult to train people per facility. Those are very many people, expensive, and then sustaining these people becomes challenging. If these are not a day-to-day issue, maybe a system breaks down in six months, something like that, one person in the district can be sufficient. Ideally, the person would be from the engineering department." (Terego, District Health Officer)

The District Health Officer noted that Arua Regional Referral Hospital's equipment maintenance unit has existing capacity and expertise on maintaining, repairing, and replacing solar components. It may be possible to leverage existing capacity within the region to support maintenance without having to transport someone from Kampala to Terego or Madi Okollo.

"But for maintaining power systems for equipment, regional referral has equipment maintenance unit. In it they have all these people, there are those who check electrical systems, there

are those who deal with the equipment, they go around repairing them. This is at the regional level." (Terego, District Health Officer)

Funding for maintenance, repair, and replacement of solar systems

To date, the primary source of funding for maintenance, repairs, and replacement of solar components is from the donor that installed the OGS PVS. Two sources of internal funding are available to health facilities under the managing authority of the MOH: the Primary Health Care (PHC) Fund and Results-Based Financing (RBF), and some of those funds could potentially be used for minor maintenance, repair, and replacement of OGS PVS equipment are.

We can ask the health facilities to use part of their budget to do that, also, if the partner can do a few follow-ups, the better. But at the district level, we don't have funds to do that because at various levels, there is a budget allocation of funds. Therefore, that can only be done at health facility in their budget, which is in most cases very little. The PHC is very small and that's their source of earning. And even the RBF can do that but it depends on the extent of the cost needed for the repair. Then they may need an intervention of partner or a well-wisher to help them put it back." (Madi Okollo, District Health Officer)

According to all healthcare workers and HUMC interviewed, the PHC fund is very limited. The vast majority of funds (~80-90%) are allocated for community-based outreaches (e.g., immunization activity, health education/ mobilization) and staff welfare. The remaining funds (~10-20%) are used to maintain the health facility compound and pay staff such as the cleaner, security guards, and a part-time gardener. What remaining funds are available are generally used for compound maintenance, such as cutting grass and replacing lightbulbs. The PHC fund would not be a realistic source of funding to ensure routine maintenance of the solar systems by a trained technician.

"That is what the PHC does, the bulb has broken down, it is bushy, you plan it within there." (Terego, District Health Officer)

"The PHC fund depends on the level of the health centre. On average, every quarter, they have about 10% for maintenance though am quite uncertain. The PHC fund is not adequate because if a facility may have 1 million for three months, or two million for instance for a health centre three, that definitely is very little money and all their activities are handled by that money." (Madi Okollo, District Health Officer).

"[The PHC funds are] for outreaches, they plan for staff welfare, there are also staff who paid using the PHC funds – like the cleaner." (Odoubu HC II, Midwife)

"Even if we are on the main power grid, the PHC funds that we give facilities cannot pay for that electricity for them. The PHC funds are too little to pay for electricity at our Ugandan rate. Health centers won't afford it. So the reliable sustainable power that can be there can be solar.
...
Putting those health facilities on a grid, they will not sustain. Given the current funding that I see, because a health centre IV receives around 11 million Ugandan shillings per quarter, that is for three months for everything including immunization and other issues, so making them pay for this electricity is impossible. *I: There is no special rate for such services like UMEME?* R: No, same rate. They charge the same rate, and they won't know whether you are a government entity or not. They don't know because the electricity regulatory authority operates as an independent parastatal away from other services. So for them, they charge their rates the way they are, regardless of whether they are service delivery entity or you are private, they don't consider that." (Terego, District Health Officer)

Results-based financing (RBC) is performance-based financing whereby a government health facility is awarded a grant every period they achieve select performance targets in health service delivery. RBF is only available to HC IIIs and above. According to a District Health Officer, the RBF agreement was signed with the district of

Arua. In order to functionalize RBF for eligible health facilities in Imvepi and Rhino Camp refugee settlements, new agreements will need to be drawn and signed with Madi Okollo and Terego districts.

"There are two types of funding here. First RBF we are not 100% because its result oriented and anytime it can phase so what we are assured of as a government facility is PHC and the volume of PHC is not enough. If you look at the solar we are talking about, this is a big facility where we are going to use more than ten batteries which cost more than two million per battery and in terms of financing that fund will not manage to maintain all those batteries, so maybe small budget can be drawn from PHC but it won't cater to do all this and that is why we are advocating for another option. We shall also have some small budget from result-based financing for routine maintenance of the panels." (Yinga HC III, HUMC member)

"The RBF has just come to the community and not all facilities have it. It's only the HC IIIs and IVs and the RBF has its own budget line on what it should be able to do. They may be able to maintain, but not solar, there are many other sorts of things. The truth is that they may be able to get the money, but it is not big enough to handle some of the major repairs." (Madi Okollo, District Health Officer)

"The district in most cases does not have the funds to maintain those gadgets unless the facilities can do a minor repair. But considering their budgets, the funds are inadequate to take care of that." (Madi Okollo, District Health Officer)

The District Health Officer identified two potential sources of funding electrification of health centres from the district health system: they are the Capital Development Fund and the District Development Equalization Grant.

I: What role does the district health team play in supporting health facilities with adequate electricity?
R: It is really very difficult for us because for now the Capital Development Fund was not there, that is the only way, when we get Capital Development Funds then we can say 'okay, maybe put one or two staff houses, this facility has inadequate power, put it there' but for now those budgets are not there.

...
R: Then, there is a general [fund] they give to the district, they call it DDEG, District Development Equalization Grant. This is where the district planning team allocates where our priorities may be. Health are we are giving this much, for education we are giving this much, for administration we are giving this much, community services, that is where you have freedom to allocate. So, in the team as the district, if they don't see the need for electricity is top most priority, they won't give it there for you. (Terego, District Health Officer)

The District Health Officer does not think these funds can realistically or comprehensively meet the energy needs of health facilities within its district. For the Capital Development Fund, the Ministry of Finance (central government) allocates a certain amount to the district – the figure is not based on priorities and needs identified by the district. Also, the fund is ringfenced so the district cannot reallocate the funds to other pressing needs and priorities. There is more flexibility in district allocation of funds for the District Development Equalization Grant. However, the funds are split across multiple sectors (health, education, community services, administration, planning, natural resources, and production) and it is difficult to prioritize funds to electrify a health centre. What funds are available for electrification are usually given to protect vaccines and the immunization program.

"Out of the supplementary budget, part of the things that we cannot touch, the DDEG came, around 700 million I think for the whole [Terego] district. This is where you have some flexibility to allocate according to your priority but, as a new district, the district started the priorities are; they need vehicles for LC V, they need money for the district environment, and as health, they only gave us 25 million, so what do we do with 25 million, we plan for a motorcycle, a laptop for the DHO's office, printers, only. There is nothing to allocate, for example, towards electricity at health facilities. This is how difficult it gets. So next year, maybe the money will come, and the district

will also look at another priority. Something that doesn't fall in health becomes very challenging to plan it that way." (Terego, District Health Officer)

"If government has a program, maybe, to construct staff houses in health facilities, usually it comes with the energy component. They instal solar and so on. But much of it has been to protect vaccines and the immunization program. Most of the solar systems you find are for that. But for running other services, lighting for example, in other departments or staff housing, it comes only once in a while periodically. Maybe once in five years they come up with a project and then they install some solar. But in-between here, if a facility runs short of energy, it is very difficult to address unless there is an IP in place that does that." (Terego, District Health Officer)

A District Health Officer raised the idea of asking healthcare workers to pay for electricity at the staff quarters as a strategy to ensure sustainable financing of OGS PVS services. However, an implementing partner disagreed with this idea and felt it would disincentivize staff from working in these remote, hard-to-reach settings.

"Now, for me, I will think about it this way. For service delivery points, certainly you can't charge any rate, but within the health facility and its surroundings, there are people who live, who can use this energy. For example, in the staff quarters, staff should know that energy as a consumptive service, is something you will pay for. They can be made to pay for. Yes, you provide it but they can be made to pay for this energy they are using in bits. So the resultant small money can be used to sustain these services. For example, bulbs, batteries, they run off. Then you can get to this fund you are collecting – use it to replace, it becomes sustainable.

...

But for the other service delivery points like lighting in OPD, equipment servicing, that one definitely is a service point which you can't charge for it. But the only way of sustaining when eventually we runoff is by doing something like this. I: You think they will agree? R: They can. Because many of these staff even have their homes in town and they know that energy is paid for. It might not be at the same rate like this one, it might be less, it might be like 50% of this rate. Yeah, but just to educate them to make them understand that now we have set up this system. In five year's time it will run down. These batteries will be no longer. These inverters may die. But to replace them this fund will take care. When you go with that education, they will agree especially if they have sufficient energy in their house such that they can charge their phones and they can use their laptops, they can watch TV. Why won't they? They will accept. If they can pay for the TV, why won't they pay for the energy? ... The only challenge I would see with it, if we make them pay for it, government might think we are collecting funds, there has to be tax on it. Now that may spoil it up." (Terego, District Health Officer)

As a result of limited funding opportunities and the recognition that repairs and replacements of solar components, such as batteries will exceed what is available from the PHC funds, HUMC, health facility staff, and district health officers feel that GIZ should budget funds to support the maintenance of OGS PVS.

"As a member of HUMC, I am still requesting GIZ to put for us something aside for maintenance, such that the PHC funds will just be able to be used to add on top of what they have given us." (Yinga HC III, HUMC member)

"We shall try lobbying among ourselves but in case we fail to raise the money which is expected, we shall call GIZ to give us back-up." (Ocea HC II, VHT members)

"As a facility is run by partners and not government, I know they have budgeted according to services they are delivering to the people and am sure lighting is in their budget." (Ofua HC III, RWC member)

"I: Who advocates for energy or address energy in this area?
R: GIZ has been the only one. Actually, at the beginning of the financial year, I think it was August when they called me and we had a meeting in the regional office about energy. Minus GIZ, I have not seen any other partner that is concerned with energy." (Terego, District Health Officer)

HUMC and healthcare workers are eager for support to initiate income-generating activities in order to generate funds to support the minor maintenance and repair of the solar systems. Each site had its own ideas of what would work in its setting (Table 24). For example, Yinga HC III would like to start a small canteen with excess energy, and charge the community to use its charging facilities, offer mobile money services, and sell cold drinks. Imvepi HC II would like to use the excess energy to operate a photocopier and generate funds through the photocopying services. Odoubu HC II would like to put up a pool table in its youth friendly services area and charge people as they come to play. Notably, these income-generating activities would need an injection of start-up capital in order to be functionalized.

"But with GIZ they had proposed to have energy, they called it energy kiosks. The main aim would be to benefit the health facilities, but also for sustainability of it. The energy created would be excess of what the facility needs, and they would sell out to the local community, and the small money that they would realize from there would be saved for future sustainability. It was a brilliant idea and I had told them the best way of discussing that would be with the sub-counties because the sub-counties are responsible for those facilities, not even us at the district. Even the accounts are managed by the in-charge of the health facility and the sub-county chief." (Terego, District Health Officer)

"To my understanding, GIZ should put for us a kiosk where we shall be generating money out of. In that canteen, we shall put refreshments with solar fridge, charging of phones at maybe 300-400 shillings, and that money will be used to maintain the solar. Then additionally, GIZ can start for us mobile money, then the little bonuses which we can also use for maintenance. After the transactions of depositing and withdrawing, we can get a bonus of 500,000 per month." (Yinga HC III, HUMC member)

"Our initial planning when we heard that GIZ was bringing for us solar – we had a plan of raising funds and also make someone accountable for the funds and the community members will come and audit and in case of any problem with batteries or inverter, we shall just fix it because we have the money. This money will be raised through putting up a canteen where phones will be charged at 500 and receipts have to be written for every phone charged and we shall keep that money for maintaining our solar system. Secondly, we thought of when GIZ brings the solar system given the fact that we usually go and photocopy our things from outside. So we were thinking of bringing our own photocopying machine and also bring some cold drinks in the canteen to raise more money." (Imvepi HC II, HUMC members)

Table 24 Ideas of income generating activities to sustain OGS PVS

Health facility	Proposed Income Generating Activities to sustain OGS PVS	Proposed Management of Income-Generating Activities
Yinga HC III	Canteen with excess energy to charge phones and power a refrigerator to sell cold drinks, also offer mobile money services HUMC can also sell some trees they own	HUMC
Imvepi HC II	Canteen with excess energy to charge phones, sell cold drinks, and power a photocopier so they can offer photocopying services	HUMC
Ocea HC II	Kiosk with excess energy to charge phones at a fee of 300 shs. Power a refrigerator to sell cold drinks, sell home-made bread in canteen, offer printing and photocopying services, start a saloon for shaving hair for men and women, put up a place to repair phones and computers, sell airtime,	No data
Siripi HC III	Charge phones at 300 shs, call upon RWC and community members to make contribution to solar systems, sell cold drinks in fridge, offer photocopying services, sell dry ratios, start mobile money services, ask GIZ to bring power banks for rental (similar to MoPo) so they can hire out the power banks for money	LCs and healthcare workers
Ofua HC II	Collect contributions from community members of about 100-500 per individual, work through "block leaders", borrow money from the saving group, use excess energy to charge phones of 500 UGX, sell cold drinks, sell mixed goods – soap, biscuits, books, pens, cosmetics, torches, and batteries	HUMC
Odoubu HC II	Use excess energy to buy a photocopier and printer, offer phone charging at 500 UGX, start a photo studio, put a pool table at the youth friendly services and charge people to play it, laundry services to wash and iron people's clothes, start a saloon for men and women, sell drinks and put a TV to entice people to come	HUMC and community leaders
DHO Terego	Charge healthcare workers residing in staff quarters with OGS PVS for the electricity	District level – DHO, CAO, and LCV Catchment area - Facility in-charges and sub-county chiefs as direct overseers of these health facilities Within health facility activity - HUMC chairperson

Recommendations

The United Nations Foundation and Sustainable Energy for All 2019 publication "Lasting Impact: Sustainable Off-Grid Solar Delivery Models to Power Health and Education" [24] and its Model Sustainability Framework offers a comprehensive, thoughtful, and pragmatic template to designing an OGS PVS implementation and sustainability plan applicable to the electrification of health centres in this project. The Framework centres on key factors that are fundamental to the sustainability of solar PV systems and its delivery in off-grid public health facilities. The Framework highlights fundamental "pillars" or dimensions of sustainability: organization, technical, and financing of OGS PVS, as well as implementation as played out in the continuum of the four main project cycles: inception, design, build and operations and maintenance.

Figure 8 Model Sustainability Framework (United Nations Foundation and Sustainable Energy for All, 2019)

Sustainability Framework Pillars	Organizational	Technical	Economic
Three "pillars" of sustainability—Organizational, Technical, and Economic	Arrange project stakeholders to preserve systems' long-term functionality	Make certain installed systems are robust and fit for purpose	Ensure financing and incentives are structured for the long haul

MODEL SUSTAINABILITY FRAMEWORK

Each pillar contains four project lifecycle phases—Inception, Design, Build, and Operation and Maintenance (O&M)	Define core goals and approach	Finalize facility siting, expected needs, and system sizing	Undertake procurement and execute installation contracts	Ensure system performance for its expected live
Project Lifecycle Phases	I. Inception	II. Design	III. Build	IV. O&M

The following provides a concise summary of the Framework and key learnings from OGS PVS case studies [24]:

- **Organizational sustainability**: How can project stakeholders be arranged to preserve OGS PV system functionality? Consider the division of responsibilities, ownership, and accountability; alignment of incentives; and capacity to carryout responsibilities. Consider who the project stakeholders are and their primary roles throughout the project life cycle.

Table 25 Organizational Sustainability

Phase	Questions (Q)	Lessons (L)
Inception	Q1: What are the characteristics of the project champion and how does this impact the project vision and management approach? Q2: What is the ultimate vision for system ownership, obligations, and resource management; and do all entities have sufficient capacity and motivation to deliver on their responsibilities?	L1: Project champion are often needed to mitigate the risk of a responsibility vacuum or budgetary hole when exiting during O&M phase (initial project champions typically devolved responsibility for O&M to local level but many long-term "backup support" from central entities were observed in practice") L2: Passing the champion role to local actors can be effective, but only if local actors have sufficient human and financial resources (local community generated income but it was not enough to fully cover O&M costs, resulting in limited productive use of energy to advance sustainability).
Design	Q3: How formally have responsibilities been allocated? Has adequate stakeholder consultation, sensitization, and buy-in taken place? Q4: How is the procurement process established? Who has responsibility for making system and financial design choices? What is the rationale?	L3: The design process should align perspectives of external and internal champions (misalignment can carry long-term material consequences for stakeholder responsible for O&M). L4: Centralized design and/or procurement may introduce delays but also long-term benefits (this approach seems to provide clarity on long-term responsibilities for assets maintenance, also, inclusion of a 5-year warranty period created an incentive to ensure quality and proper investment in resources)
O&M	Q4: Who is financially responsible for managing O&M costs over an expected lifetime of 10-15 years? Q5: What are the O&M providers' capabilities and costs? Are there mechanisms to monitor O&M? Q6: What mechanisms for the transfer of responsibilities and funds exist over expected lifetime assets, and how are O&M obligations enforced?	L5: Project champions should conduct O&M planning for a 10-15 year time horizon, inline with standalone PV system lifespans (although development partners typically support public facility electrification projects for a finite time, there is a need to plan for 10-15 year life span of PV system to ensure coordination in transfer of responsibility, including replacements when components fail prematurely or reach their end of life) L6: Well-incentivized and resourced 'central' organizations competent in PV O&M can successfully manage significant asset portfolios (project champions often cede O&M to local actors for practical reasons but local actors often lack human, technical, and financial capacity to deliver)

- **Technical sustainability:** How are installed systems fit for purpose (i.e. that they not just operate as intended but that they also meet the key energy needs of the facility for which they were designed)? Consider efforts made to assess current and expected energy needs, the technical design of systems to accommodate these needs (including quality standards for components), and efforts made to facilitate system maintenance through both technical means (e.g., remote monitoring) and technical training.

Table 26 Technical Sustainability

Phase	Questions (Q)	Lessons (L)
Design	Q1: What is the expected energy demand at host facilities? How might demand change during the project lifecycle? Q2: Are systems appropriately sized? Do system components meet quality standards? Does project procurement require flexibility in system size or design? Q3: Can users operate the system? Do system operators have access to adequate training materials and training program? Q4: Have system designers considered adopting latest innovation or technologies, such as system monitoring, energy efficient appliances, quality battery technologies, or back up technologies?	L1: Ensure facility energy needs are understood and reflected in the system design (conduct energy audits to ensure the right type of PV system and size of core components are selected for the system to operate well and meet loads long-term) L2: Understand behavioural and usage-pattern changes PV systems may cause (consider how PV system would affect user behaviour – both on staff behaviour and appliance usage) L3: Consider trade-offs between custom and standardized system packages (standard systems are simplify design and procurement but increase risk of mismatch with facility needs) L4: Deploy new technologies and flexible designs to counter early PV system failure (remote monitoring regime can help manage preventive maintenance and troubleshooting, assess system demand trends and demonstrate sustainable system use, detect early signs of component failure, and generate information for future project designers) L5: Enforce strict design and component quality standards backed by a competent oversight authority
Build	Q5: Have systems been installed properly, including control or backup systems, if applicable?	L6: Use qualified technicians for installation and independent third parties for certification.
O&M	Q6: Are system monitoring protocols being followed by the end users? Are users receiving ongoing support and training? Q7: Are systems being serviced regularly and as needed, in line with service contracts? Q8: Do users understand optimal system operations?	L7: Regular preventive maintenance protects system components and is good value for money (preventive maintenance is a low-cost measure that can have a high impact on sustainability by identifying and helping diagnose problems at an early stage; it also helps facility staff engage in system health and maintenance; remote monitoring can complement routine maintenance but should not be a substitute) L8: Follow O&M protocols, supported by intensive and sustained capacity building (capacity enhancement must be costed out and financing secured to ensure they are delivered; this supports local capacity to deliver on O&M protocols) L9: Remote monitoring can enhance O&M but its benefits are often limited by the capacity of those providing oversight (also need to also account for long-term mobile connectivity costs to ensure use of real-time system data)

- Economic sustainability: How can sufficient financing be made available to allow for the required maintenance of installed systems? Consider financing for installation, operation, and maintenance of installed systems to remain fully functional over the course of their planed lifetimes. Consider adequacy and reliability of O&M budgeting, especially for the replacement of failed components such as batteries. Consider economic incentives to ensure key actors deliver on critical responsibilities for long-term sustainability.

Table 27 Economic Sustainability

Phase	Questions (Q)	Lessons (L)
Inception	Q1: What are the trade-offs between scale and sustainability, given budgetary constraints? Q2: What is the expected allocation of upfront and operational costs over system lifetime? Q3: Are the unit economics of the site(s) well understood?	L1: Program budgets should be optimized for system sustainability, not the number of systems deployed (design choices that improve the chance of completing a 10-15 year lifecycle but reduce the number of facilities reached should be considered) L2: Project champions must account for, and consistently meet, financing needs over the expected life-span of the deployed energy solution (funding required for lifetime system maintenance is rarely assessed or secured; planning and O&M funding was limited to 5 years with no coverage for component replacement; projects require a clear sustainability plan and funding for lifetime O&M activities and component replacement).
Design	Q4: What are upfront and downstream budget allocations? Have tradeoffs in component quality costs been duly considered? Q5: Have appropriate financial incentives and penalties been designed for all obligations?	L3: Incentives for supply and install contractors are critical (put in place mechanisms to prevent contractors from abandoning their responsibilities following installation, this should be done in the design phase, give installers a clear financial interest to fulfil obligations such as warranty claims throughout coverage period, until a third party assumes O&M)
O&M	Q6: What is the budget for O&M activities over a project's lifecycle? Q7: How are O&M budget shortfalls managed? Q8: What is the budget for battery replacement?	L4: PV system revenues are unlikely to cover ongoing O&M costs (case studies found health clinics poorly suited to generate income from any surplus energy – they can defray costs but are unable to generate enough income to cover operations or battery replacement) L5: If O&M is decentralized, project champions must secure funding (local organizations are typically under-funded and cannot divert scarce funds to maintain systems) L6: O&M outcomes must be directly tied to economic benefits or penalties (government took security deposit from contractor to discourage failure to fulfil obligations; align payment milestones with O&M delivery)

Adoption of the guiding principles and questions of the Model Sustainability Framework is highly recommended.

1. **Ensure adequate sizing of solar systems to fully functionalize health service delivery**

    a. Consider energy needs specific to the ward/department/unit
        i. What are energy requirements are needed to fully functionalize health service delivery in outpatient? Inpatient? Maternity? Laboratory?
        ii. What are existing available and functional equipment currently not in use?
        iii. What are anticipated upgrades and their energy needs?

    b. Take into account user behaviour's impact on energy demands
        i. Anticipate how many staff will want to charge devices to the solar system
        ii. Identify electronic devices that staff have or would like to use, and what their energy requirements are
        iii. Anticipate what electronic devices staff will likely procure and start using when they experience excess energy

    c. Take into account varying functionality of solar batteries between dry and rainy seasons
        i. If possible, calculate conservatively by using the lowest output available from rainy season to ensure excess energy is available even during rainy season

2. **Develop and implement an operations and maintenance plan for each health facility**

    a. Develop a capacity building strategy that enables health facilities and regional district health teams and energy partners to be achieve knowledge and skills on how to operate and maintain the OGS PVS.
        i. This may involve a phased plan of initially contracting a company to be entirely responsible for the maintenance of the OGS PVS while there is knowledge and skills transfer and skills building with staff based within the community (e.g., HUMC) or health facility, and then transferring more responsibilities of operations and maintenance to the community-based personnel and health facility-based staff.
        ii. While the initial phase of maintenance may be under the responsibility of a contracted company, it is recommended that community-based personnel and facility-based staff are also engaged and taught on basic, relevant operations and maintenance procedures. This will support a long-term sustainability strategy – especially to enabling the locally based team to understand, budget, and plan for the costs of maintenance.

    b. Identify and engage relevant stakeholders to be responsible for operations and maintenance of the OGS PVS
        i. Discuss what are meaningful, feasible, and realistic roles and responsibilities for each stakeholder
        ii. Clarify roles and responsibilities for operations, maintenance, repair, and replacement
        iii. Create site-specific accountability groups to regular user behaviour

    c. Select staff from within the health facility, HUMC, district health team, implementing partner, and donor to undergo training on how to operate and maintain solar systems
        i. Local staff – frontline healthcare workers who lead each ward/ department, security guard, HUMC chairperson
        ii. Regional staff – district electrical engineer, district health team representatives, implementing partner and donor (inclusion of regional staff from the district health team ensures long-term sustainability of OGS PVS capacity)

d. Train local and regional staff on operations and basic maintenance of OGS PVS
    i. Hands-on, in-person training
    ii. Include both didactic and practical sessions

e. Prepare a step-by-step operations and maintenance manual with clear, easy to understand instructions and pictographs to facilitate comprehension
    i. Should include guidance on what are compatible products (including appropriate voltages per device) that can be used for each solar system in the ward/ unit/ department (e.g., use LED lightbulb with a maximum of x-volts)
    ii. Consider and utilize locally available products within Arua Town to ensure maximum sustainability

f. Prepare a routine maintenance checklist for facility staff ensuring routine cleaning and basic maintenance and for the solar energy company technician to provide more in-depth assessments on functionality and maintenance
    i. Adapt existing resources, such as USAID's Solar PV System Maintenance Guide: Guyana Hinterlands Stand-Alone Solar PV Installations: Solar System Maintenance Schedule (maintenance tasks weekly, monthly, and every 3 months; panel maintenance log sheet for every 3 months; weekly battery inspection log sheet for "deep cycle flooded" lead acid battery; and weekly battery inspection log sheet for AGM and GEL batteries) [25]

g. Prepare a contact information sheet with relevant names, phone numbers, and WhatsApp contacts so health facilities can reach out to the correct individual for support, questions, and repair. Similarly, ensure GIZ and energy company have the relevant health facility staff's contact information.

h. Ensure health facilities have the protective and maintenance equipment needed to perform routine, preventive maintenance

i. Provide routine supportive supervision (e.g., monthly or quarterly) to the designated individuals within the health facility and district health teams on how to operate and maintain the solar systems
    i. This can build a practice of routine preventive maintenance
    ii. On-site supportive supervision helps to build and reinforce skills
    iii. Assess capacity at each visit and adjust level of support accordingly

j. Prepare a laminated simple, visual aide for each location (e.g., wall socket, lighting per ward/unit/ department) to remind users on what devices can be powered, what devices cannot be powered, times of days when socket can be used (or no restrictions) to ensure the solar batteries are not overused

k. Work with HUMC to form an accountability group with designated individuals responsible for checking appropriateness of electrical usage
    i. Check in and provide relevant feedback to the accountability group/ individuals on appropriate use of solar energy

3. **Develop and implement a sustainability plan for each health facility**

a. Identify and engage relevant stakeholders
   i. Stakeholders should include health facility staff, HUMC, sub-county chief, and GIZ OGS PVS and income generating activity technical staff
   ii. Health facility staff, HUMC, and sub-county chief

b. Clarify roles and responsibilities for operations, maintenance, repair, and replacement of OGS PVS
   i. Educate stakeholders on the lifespan of different solar components and their expected costs
   ii. What are considered minor repairs? Major repairs and replacements?
   iii. What can be realistically handled by the community/ health facility? What will need external support? According to case studies from Powering Health 2019, ownership passed to local community with the vision that the community would fund operations and maintenance through income-generating uses of the system beyond activities at the public facilities were not realized because income generated was not enough to fully cover operations and maintenance costs [24].
      1. If repair or replacement of certain solar components will be beyond the means of the health facility, then ensure this line item is included in the district health team, donor or implementing partner's budget for maintenance
      2. If there will be transition of implementing partners in the health sector, then ensure the need for these "big ticket items" are communicated to the next implementing partner

c. Work with relevant stakeholders to develop a context-specific sustainability plan
   i. Allow income-generating strategies and implementation methods to vary, depending on the context of each catchment population (available manpower, resources, capacity, goods or services that could generate income)
   ii. Consider expected costs for repairs and replacement, and amount of start-up capital GIZ is willing and able to provide in order to develop feasible strategies that can potentially generate enough income to meet these needs
   iii. Provide technical support for each facility to come up with the following:
      1. a business plan with the details on the business description and structure, market research and strategies, management and personnel, financial documents
      2. an accountability structure and plan on how to secure the funds generated and make decisions on how the funds will be used

d. Ensure communication and coordination between personnel responsible for the maintenance of OGS PVS with personnel responsible for managing and implementing the income-generating activity
   i. To know what upcoming maintenance needs and their related costs
   ii. To discuss how the funds will be used for routine maintenance, repairs, and replacement

4. **Leverage health system strengthening opportunities with the anticipated improvement in availability and reliability of electricity**

    a. Electricity is a necessary precondition to effective health service delivery. However, electricity alone cannot improve health services or health outcomes.

    b. Improved health outcomes can be achieved with preconditions are met with targeted health system strengthening (technical, equipment, supply chain, and human resource).

    c. Energy and health sector partners should work together to leverage expected adequate and reliable electricity for select health system strengthening interventions
        i. HUMC, donors, and partners should understand what energy will be available, including excess energy, and plan accordingly for procurement or upgrades of electronic equipment (if needed)
            1. Energy-related donors and partners have both the financial resource and technical capacity to determine what energy, including excess energy, will be available from the installed OGS PVS. This information should be clearly communicated to the HUMC and other bodies of health facility management to ensure accountability in daily energy use, planning for health system strengthening opportunities (e.g., other equipment that can be used), and how excess energy may be used reliably for income generating activities to support funds for the maintenance of OGS PVS.
        ii. Utilize 2021 collected baseline health facility data to identify areas of weaknesses (e.g., stock-outs, lack of essential equipment) and strengthen programming
        iii. Potential areas of impact: diagnostics, blood transfusion

5. **Measuring impact**

   a. Document indicators and impacts using the domains identified in the theory of change
      i. Consider adapting Energy for All (SEforALL) Monitoring, Evaluation, and Learning Framework's standardized indicators for inputs and outputs [26]
         1. See Annex 3: Activity Monitoring Indicators

Figure 9 SE4ALL Annex 3: Activity Monitoring Indicators (SE4ALL Monitoring, Evaluation and Learning Framework, 2017)

ANNEX 3:

ACTIVITY MONITORING INDICATORS

Communication	Policy	Partnership
• Concept Notes	• Stakeholder analyses done	• Concept notes
• Stakeholder analyse done	• Number of papers/analytical reports produced	• Stakeholder analyses done
• Number of website hit rates (by category, e.g., on stories, policy notes, own publications, maps)	• Number of initiatives resulting in contributions to other's analyses/reports	• Number of delivery agreements
• Downloads/Access (by category of documents, e.g., policy notes, own publications, data maps)	• Number of conference presentations	• Number of private sector actors/ philanthropists engaged
• Comment rate/interactive engagement on web content (by category, e.g., on stories articles, maps, "going live")	• Conference presentations that make specific reference to gender dimensions in energy access	• Number of partnerships by category (NGO, Government, private sector, etc.)
• Number of press briefings/speeches by category of engagement	• Workshop/events convened on evidence/ policy	• Number of Hub/Accelerator/Regional Meetings
• Number of articles written by category	• Attendees at workshops convened, including women attendees	• Measure partnership (specialist evaluation)
• Number of success stories written and shared, including number of stories featuring female leadership	• Number of events attended	• BTORS from travels/events mentioning key partners/reports positioned, etc.
• Number of events attended and social media coverage thereof	• to strategically engage with specific organizations	• BTORS
• Number of calls/discussions with other media representatives	• Citations (total number and by category, e.g., on own reports, on co-authored reports)	• CRM in place and up to date
• Citations/Media tracking (on/with gender reference)	• Number of gap analyses done	• Number of female led partnerships/ initiatives
• Number of interviews with SEforALL partners	• Number of documents that include information on what works	
• BTORS	• BTORS from travels/events mentoring key partners/reports positioned, etc.	
• CRM in place and up to date	• CRM in place and up to date	
	• Feedback sheets from event participants analyzed and key recommendations developed	
	• Learning notes	

2. See Annex 4: Output Indicators

Monitoring Question	Judgment Criteria	Indicators
1. Are SEforALL interventions well designed?	1.1 The intervention activities are aligned directly or indirectly to intermediate outcomes.	1.1.1 Intervention activities are clearly linked, directly or indirectly to leader (participant/counterpart) awareness, motivation, and/or opportunity to broker partnerships Intervention activities are clearly linked, directly or indirectly to leader (participant/counterpart) awareness, motivation and/or opportunity to unlock finance
	1.2 The intervention targets and engages a strategic/ strategically chosen group of leaders.	1.2.1 Clear evidence that intervention is designed for, and marketed to, a target audience. 1.2.2 Intervention engages its target audience.
2. Are SEforALL's interventions delivered as originally designed and/or intended?	2.1 Intervention fidelity	2.1.1 Intervention delivery is consistent with its concept note and/or work plan.
	2.2 Challenges and risks managed appropriately	2.2.1 Evidence of preventative measures to ensure challenges and risks are managed appropriately 2.2.2 Timely and corrective action to mitigate unforeseen challenges and risks is taken when necessary
	2.3 The intervention achieves its intended objectives	2.3.1 Objectives met
3. Are SEforALL's intervention inputs translated to outputs in a timely, efficient manner?	3.1 The intervention is appropriately resourced.	3.1.1 Sufficient funding to achieve the stated objective
		3.1.2 Sufficient staffing to achieve the stated objective
		3.1.3 Sufficient management time to achieve stated objectives
	3.2 The intervention is implemented efficiently.	3.2.1 Use of resources
	3.3 The intervention delivers its outputs on time.	3.3.1 Compliance with work plan deadlines

b. Collect the same measures used in the baseline survey over time
   i. Repeat reliability of electricity measures over time and assess changes in availability and reliability of electricity
   ii. Compare WHO SARA outcomes and the UNHCR Balanced Score Card data over time to assess for changes in performance of health service delivery – particularly, focus on diagnostics and blood transfusion

Appendices – Data Collection Tools

I. Semi-structured health facility survey

II. Reliability of electricity data collection form

III. In-depth interview guide for Healthcare Workers

IV. In-depth interview guide for District Health Officers

V. Focus group discussion guide for Community Representatives

VI. Socio-demographic form for Community Representatives

VII. Informed consent form for healthcare workers

VIII. Informed consent form for community representatives

Appendix I: Semi-Structured Health Facility Survey

Section 1. General Information

No.	Question	Response Categories	Skip Pattern
1.	Health centre name		
2.	Village		
3.	Parish		
4.	Sub-county		
5.	County		
6.	District	01 Terego 02 Madi Okollo	
7.	Refugee settlement	01 Rhino Camp 02 Imvepi	
8.	Zone within refugee settlement		
9.	Catchment size of refugee settlement	Total: __ __ __ __ __ __ Refugee: __ __ __ __ __ __ Host: __ __ __ __ __ __	
10.	Country of origin Rank in order of greatest numbers	01 _____ 02 _____ 03 _____ 04 _____ 05 _____ 06 _____	
11.	Name of interviewer		
12.	Date of interviewee	__ __ / __ __ / __ __ (dd/mm/yy)	
13.	Title of interviewee		
14.	Name of interviewee		
15.	Mobile contact of interviewee		

Section 2. Health Facility Characteristics

No.	Question	Categories	Skip Pattern
1.	Health facility level	01 HC II 02 HC III 03 HC IV	
2.	Managing authority	01 Government/ public 02 NGO/ not for profit 03 Private for profit 04 Mission/ faith based 66 Other, specify	
3.	Years in service	__ __ years	
4.	Please list the clinics/units/departments that are present in this health facility	**Outpatient** 01 General outpatient 02 Paediatric outpatient 03 Antenatal care 04 Family planning 05 Delivery (outpatient) 06 Tuberculosis 07 HIV counselling and testing 08 PMTCT 09 Specific HIV/AIDS only (maybe the ART clinic) 10 Specific diagnoses 11 STI 12 Gynaecology 13 Urology 14 Emergency/casualty 15 Social services department/home-based care/ community services (not HIV/AIDS specific) 16 Social services department/home-based care/ community services (HIV/AIDS specific) 17 Service statistics/medical records/HMIS 18 Laboratory (OPD and/or IPD) 19 Pharmacy 20 MCH clinic 21 Mental health and psychosocial support 22 Nutrition (screening, treatment) 23 Epidemic preparedness and response 24 Other OPD, specify **Inpatient** 25 Inpatient medical (adult or adult + paediatric) 26 Inpatient medical/ surgical (Adult or adult + paediatric) 27 Inpatient surgical (adult or adult + paediatric) 28 Inpatient paediatric 29 HIV/AIDS only inpatient 30 Specific diagnoses (including HIV/AIDS) 31 Tuberculosis 32 Delivery (inpatient) 33 Hospice 34 Nutrition treatment 35 Epidemic preparedness and response 36 Other IPD, specify	
5.	How many days each week is the facility routinely open for outpatient curative services?	Record number of days __ __ 88 Don't know	

No.	Question	Categories	Skip Pattern
6.	What hours the facility is routinely open for outpatient curative services?	Mon: __ __ AM to __ __ PM Tue: __ __ AM to __ __ PM Wed: __ __ AM to __ __ PM Thu: __ __ AM to __ __ PM Fri: __ __ AM to __ __ PM Sat: __ __ AM to __ __ PM Sun: __ __ AM to __ __ PM	
7.	On average, how many hours per day is this facility open?	01 4 hours or less 02 5 to 8 hours 03 9 to 16 hours 04 17 to 23 hours 05 24 hours	
8.	Does a trained health provider live on the facility premise?	01 Yes 02 No 88 Don't know	
9.	Is there a trained health provider assigned to and present at the facility at all times (24 hours a day) for emergencies?	01 Yes 02 No 88 Don't know	01 → Q12 02 → Q10 88 → Q10
10.	Is there a trained health provider available away from the facility but officially on call, at all times (24 hours a day) for emergencies?	01 Yes 02 No 88 Don't know	
11.	Is this facility part of a network, where one of the network facilities always offer 24-hour emergency services?	01 Yes 02 No 88 Don't know	
12.	Does this facility have a functioning landline telephone that is available to call outside at all times client services are offered? Clarify that if facility offers 24 hour emergency services, then this refers to 24 hour availability.	01 Yes 02 No 88 Don't know	
13.	Does this facility have a functioning cellular telephone or a private cellular phone that is supported by the facility?	01 Yes 02 No 88 Don't know	
14.	Does this facility have a functioning shortwave radio for radio calls?	01 Yes 02 No 88 Don't know	
15.	Does this facility have a functional ambulance or other vehicle for emergency transportation for clients that is stationed at this facility operates from this facility?	01 Yes 02 No 88 Don't know	01 → Q17 02 → Q16 88 → Q16
16.	Does this facility have access to an ambulance or other vehicle for emergency transport for clients that is stationed at another facility or that operates from another facility in near proximity?	01 Yes 02 No 88 Don't know	01 → Q17 02 → Q18 88 → Q18
17.	Is fuel for the ambulance or other emergency vehicle available today?	01 Yes 02 No 88 Don't know	

No.	Question	Categories					Skip Pattern
18.	Does this facility routinely provide in-patient care?	01 Yes 02 No 88 Don't know					01 → Q19 02 → Q21 88 → Q21
19.	Excluding any delivery beds, how many overnight/ inpatient beds in total does this facility have, both for adults and children?	__ __ __ __ overnight/ inpatient beds					
20.	Of the overnight/ inpatient beds in this facility, how many are dedicated maternity beds? This does not include delivery beds.	__ __ __ maternity beds					
21.	Please tell me how many staff with each of the following qualifications are currently assigned to, employed by, or seconded to this facility. Please count each staff member only once, on the basis of the highest technical or professional qualification. I would like to know how many are full-time or part-time at this facility.	Cadre	FT	PT	Present Today	Government Supported	Project Supported
		Anaesthesiologist					
		Clinical officer Anaesthesiologist					
		Nurse anaesthesiologist					
		OB/gynaecologist					
		Surgeon					
		Paediatrician					
		Other physician specialist					
		Medical officer					
		Clinical officer					
		Enrolled nurse					
		Enrolled midwife					
		Registered nurse					
		Registered midwife/ DBL trained nurse					
		Comprehensive nurse					
		Public health nurse					
		Nursing assistant					
		Nursing aide					
		Pharmacist					
		Pharmacy dispenser					
		Lab technologist					
		Lab technician					
		Lab assistant					
		Nutritionist					
		Health educator					
		Statistician					
		Records clerk					
		Hospital admin					
		Social worker					
		HIV/AIDS counsellor					
		Other counsellor					
		Pathologist					
		Other clinical staff, specify					
		Supplies officer					
		Stores assistant					
		Translator					
		Cleaner					
		Security guard					
		Community health worker					
		Nutrition assistant					
		Environmental health assistant					

Section 3. Status of Electrification

Print as many copies of Section 3 as there are unique sources of power for each health facility.

No.	Question	Categories	Skip Pattern
	Overview		
	How many sources of power do you have providing electricity to buildings (permanent, semi-permanent, and temporary) in this health facility?	__ __ sources	
	Which buildings do NOT have any source of power? (e.g., storeroom, isolation tent, staff quarters)	List buildings:	
	List the buildings that the FIRST source of power provides electricity for:	List buildings:	
	Sources of Power		
1.	Does your unit/ward/department have electricity from any source (e.g., electricity grid, generator, solar, or other) including for standard-alone devices (EPI cold chain)	01 Yes 02 No 88 Don't know	01 → Q2 02 → next section 88 → next section
2.	What is the electricity used for in this unit/ward/department?	01 Only stand-alone electric medical devices/ appliances (e.g., EPI cold room, refrigerator, suction apparatus, etc.) 02 Electric lighting (excluding flashlights) and communication 03 Electric lighting, communications and 1 to 2 electric medical devices/ appliances 04 All electrical needs of facility	
3.	What is the unit/ward/ department's main source of electricity?	01 Central supply of electricity (e.g. national or community grid) 02 Generator (fuel or battery operated generator) 03 Solar system 66 Other, specify _____ 88 Don't know	
4.	Other than the main or primary source, does the unit/ward/ department have a secondary or backup source of electricity? If yes, what is the secondary source of electricity?	01 No secondary source 02 Central supply of electricity (national or community grid) 03 Generator (fuel or battery operated generator) 04 Solar system 66 Other, specify _____ 88 Don't know	
	Reliability of Power		
5.	During the past 7 days, was electricity at all times from the main or any back source when the facility was open for services?	01 Always available (no interruptions) 02 Often available (interruptions of less than 2 hours per day) 03 Sometimes available (frequent or prolonged interruptions or more than 2 hours per day)	01 → Q7 02 → Q6 03 → Q6
6.	How many days during the past week was electricity not available for at least 2 hours during a time the facility was open for services? This includes emergency services.	__ Number of days NOT AVAILABLE past week	

No.	Question	Categories	Skip Pattern
	Diesel Generator		
7.	**[Self] Check Q3 to see if unit/ward/ department has a generator**	01 Yes 02 No	01 → Q8 02 → Q20
8.	Is the generator functional? *If the facility does not have generator, circle 02.*	01 Yes 02 No	01 → Q9 02 → Q13
9.	Is there fuel available today?	01 Yes 02 No 88 Don't know	
10.	On average how many litres of diesel fuel are needed to keep the generator running for service delivery every day?	__ __ __ litres 888 Don't know	
11.	What is average budget your unit/ward/department has allocated to fuel the diesel generator each month?	__ __ __ __ __ __ __ __ UGX per month 8888888 Don't know	
12.	Is the allocated budget for fuel or litres of fuel enough to keep the unit/ward/department's generator working?	01 Yes 02 No 88 Don't know	
13.	What year was the diesel generator installed in this unit/ward/department?	__ __ __ __ (year) 8888 Don't know	
14.	Does this unit/ward/department have a programme for routine preventive maintenance for the generator. This means the equipment is checked periodically even if there is no problem.	01 Yes 02 No 88 Don't know	01 → Q15 02 → Q17 88 → Q17
15.	When was the last time the diesel generator and its related parts received routine maintenance?	__ __ / __ __ __ __ (mm / yyyy) 88 / 8888 Don't know 99 / 9999 Never	
16.	Is this person responsible for routine preventive maintenance for the generator assigned to the facility or from outside the facility?	01 Yes, onsite staff 02 Yes, outside support 03 Yes, both onsite and outside support	
17.	What is the system for repairing or replacing the generator? Probe and circle all the apply.	01 Onsite maintenance 02 Petty cash for purchase replacement or repair 03 Send elsewhere for repair 04 Replaced by MOH/donor 05 No system 66 Other, specify 88 Don't know	
18.	Has any staff member at the facility received training or support to learn how to maintain the diesel generator?	01 Yes 02 No 88 Don't know	
19.	Does the unit/ward/ department have a manual on how to maintain the diesel generator?	01 Yes 02 No 88 Don't know	

No.	Question	Categories	Skip Pattern
	Solar System		
20.	**[Self] Check Q3 to see if unit/ward/ department has a solar system**		01 → Q21 02 → next section
21.	Is the solar system functional? *If the facility does not have a solar system, circle 3.*	01 Yes, functioning 02 Partially, battery needs servicing/ replacement 03 No, not functioning 88 Don't know	
22.	What year was the solar system installed in this unit/ward/department?	__ __ __ __ (year) 8888 Don't know	
23.	Make a quick drawing of the solar system configuration indicating at least: solar panels, solar charge controllers, battery bank, solar inverter		
24.	Please list the brand and model of each component of the system (brand + model)	Component / Brand / Model Solar panel Charge controller Battery Inverter Specify other	
25.	Does this unit/ward/department have a programme for routine preventive maintenance for the solar system. This means the equipment is checked periodically even if there is no problem.	01 Yes 02 No 88 Don't know	01 → Q26 02 → Q27 88 → Q27
26.	Is this person responsible for routine preventive maintenance for the solar system assigned to the facility or from outside the facility?	01 Yes, onsite staff 02 Yes, outside support 03 Yes, both onsite and outside support	
27.	When was the last time the solar battery (the device used to store electrical charge) has been inspected for cracks, electrolyte leaks and cleaned of any corrosion?	__ __ / __ __ __ __ (mm / yyyy) 88 / 8888 Don't know 99 / 9999 Never	
28.	When was the last time the solar battery*'s electrolyte level has been checked? *If not gel batteries	__ __ / __ __ __ __ (mm / yyyy) 77 / 7777 Not applicable (gel batteries) 88 / 8888 Don't know 99 / 9999 Never	
29.	When was the last time the solar battery was checked for a high state of charge?	__ __ / __ __ __ __ (mm / yyyy) 88 / 8888 Don't know 99 / 9999 Never	

No.	Question	Categories				Skip Pattern
30.	Does the unit/ward/department have any of the following equipment to carryout battery maintenance?	Equipment	01 Yes	02 No	88 DK	
		Safety goggles				
		Protective, chemical resistant gloves				
		Water and bicarbonate soda solution for acid spillage				
		Tools with insulated handles				
		Volt meter				
31.	When was the last time the solar array (the number of solar panels connected together) has been cleaned?	__ __ / __ __ __ __ (mm / yyyy) 88 / 8888 Don't know 99 / 9999 Never				
32.	What was used to clean the solar panels? (ask open-ended, don't provide options, but record)	01 Correct: washed with water, rubbed grime with sponge 02 Incorrect: used metal brush, detergents 88 Don't know				
33.	When was the last time the solar panels were inspected for cracks, chips, delamination, fogging, water leaks, and discoloration?	__ __ / __ __ __ __ (mm / yyyy) 88 / 8888 Don't know 99 / 9999 Never				
34.	When was the last time the solar array mounting frame, bolts, and junction boxes were checked that they were not rusting, secure, and wires not chewed by rodents or insects?	__ __ / __ __ __ __ (mm / yyyy) 88 / 8888 Don't know 99 / 9999 Never				
35.	When was the last time the inverter/ battery charger and charge controller dusted?	__ __ / __ __ __ __ (mm / yyyy) 88 / 8888 Don't know 99 / 9999 Never				
36.	When was the last time the inverter/ battery charger and charge controller visually inspected to ensure the indicators, such as the LED lights and wires leading to and from the device were not loose?	__ __ / __ __ __ __ (mm / yyyy) 88 / 8888 Don't know 99 / 9999 Never				
37.	When was the last time the wiring installation of the solar system checked for any cracks, breaks or deterioration in the insulation/ conduits?	__ __ / __ __ __ __ (mm / yyyy) 88 / 8888 Don't know 99 / 9999 Never				
38.	Has any staff member at the facility received training or support to learn how to maintain the solar system?	01 Yes 02 No 88 Don't know				
39.	Does the unit/ward/ department have a manual on how to maintain the solar system?	01 Yes 02 No 88 Don't know				
40.	What is the system for repairing or replacing parts for the solar system? Probe and circle all the apply.	01 Onsite maintenance 02 Petty cash for purchase replacement or repair 03 Send elsewhere for repair 04 Replaced by MOH/donor 05 No system 66 Other, specify 88 Don't know				

Section 4. Health Service Provision

Immunization

No.	Question	Categories	Skip Pattern
1.	Does this facility offer immunization services? *Ask to be shown the location in the facility where immunization services are provided. Find the person most knowledgeable about immunization services in the facility.*	01 Yes 02 No	01 → Q2 02 → next section "Diagnostics"
2.	Is this facility providing immunization services today?	01 es 02 No	
	Does this facility provide any of the following immunization services in the facility only, as outreach at fixed post only, or both?		
3.	Birth doses (e.g., hepB0, BCG, OPV0, …)	01 Both in the facility and as outreach 02 In the facility only 03 Outreach only 04 Service not offered	
4.	Infant vaccines (under 1 year)	01 Both in the facility and as outreach 02 In the facility only 03 Outreach only 04 Service not offered	
5.	Adolescent/adult vaccines (e.g., HPV, tetanus, flu)	01 Both in the facility and as outreach 02 In the facility only 03 Outreach only 04 Service not offered	
6.	How often does this facility offer routine full child immunization services at the facility?	01 Daily 02 Weekly 03 Monthly 04 Quarterly 66 Other, specify	
7.	How often does this facility offer routine full child immunization services as outreach?	01 Daily 02 Weekly 03 Monthly 04 Quarterly 66 Other, specify	
8.	Do you have the national guidelines for routine child immunization available in this facility today? If available, ask to see the document.	01 Yes, observed 02 Yes, reported not seen 03 No	

No.	Question	Categories	Skip Pattern
	Have you, or any provider(s) of immunization service delivery received any training in any of the following child immunization services in the last 2 years? If yes, please specify if it was through formal training or supportive supervision.		
9.	Immunization service delivery (immunization in practice or any similar)	01 Yes, formal training 02 Yes, supportive supervision 03 No training	
10.	Vaccine management/ handling and cold chain	01 Yes, formal training 02 Yes, supportive supervision 03 No training	
11.	Data reporting and monitoring of service delivery (e.g., data quality self-assessment DQS)	01 Yes, formal training 02 Yes, supportive supervision 03 No training	
12.	Disease surveillance and reporting	01 Yes, formal training 02 Yes, supportive supervision 03 No training	
13.	Injection safety and waste management	01 Yes, formal training 02 Yes, supportive supervision 03 No training	
14.	RED (Reaching Every District)	01 Yes, formal training 02 Yes, supportive supervision 03 No training	
15.	Training on new vaccine prior to introduction	01 Yes, formal training 02 Yes, supportive supervision 03 No training	
	I would like to know if the following items for immunization are available in this service area today. For each item, please tell me if it is available today.		
16.	Auto-disposable syringes	01 Observed 02 Reported, not seen 03 Not available	
17.	Sharps container/ safety box	01 Observed 02 Reported, not seen 03 Not available	
18.	Vaccine carrier(s) / cold box	01 Observed 02 Reported, not seen 03 Not available	
19.	Set of ice packs for vaccine carriers (Note 4-5 ice packs make one set)	01 Observed – gel based ice 02 Observed – water based ice 03 Reported, not seen 04 Not available	
20.	How is the ice maintained?		

No.	Question	Categories			Skip Pattern
21.	Immunization cards (or child health booklet)	01 Observed 02 Reported, not seen 03 Not available			
22.	Official immunization tally sheets or integrated tally sheet	01 Observed 02 Reported, not seen 03 Not available			
23.	Official immunization registers or equivalent	01 Observed 02 Reported, not seen 03 Not available			
24.	Does this facility have a refrigerator available and functioning for the storage of vaccines? Note: For a refrigerator to be functional, it must have sufficient capacity to accommodate all needed vaccines.	01 Available and functional 02 Available, not functional 03 Available, don't know if functioning 04 Not available			
25.	What type of energy source is used for the vaccine refrigerator?	01 Electricity (grid or generator) 02 Solar (with or without batteries) 03 Gas 04 Kerosene 05 Mixed (Electric with gas kerosene) 66 Other, specify 88 Don't know			
26.	Does this energy source supply power to the refrigerator for 24 hours a day and for 7 days in the week?	01 Yes 02 No			
27.	Which of the following devices for monitoring refrigerator temperature are available and functioning in the refrigerator today: Available: 01 Observed 02 Reported not seen 03 Not available Functioning: 01 Yes, 02 No, 88 DK	Devices	Available	Functioning	
		Thermometer			
		Continuous temperature recorder/logger		NA	
28.	Is the temperature of the refrigerator monitored twice daily? If yes, please ask to see the log used to record the temperature.	01 Yes, log observed 02 Yes, log reported not seen 03 No			
29.	Has the temperature log been completed for the last 30 days? Please review log and check for completeness (temperature recorded 2 times/ day during the last 30 days)	01 Yes 02 Yes, partially 03 No			
30.	Has the temperature been out of the range 2 to 8°C inclusive in the last 30 days? Please check the temperature record and verify the temperature for the last 30 working days in order to answer the questions.	01 Observed in range 02 Reported in range but not seen 03 Out of range 04 Record not available			

No.	Question	Categories	Skip Pattern
	Are any of the following vaccines available in this service site today? [when analysis, cross with validity based on functional refrigeration for storage of vaccines]		
31.	Measles vaccine and diluent	01 Observed available 02 Reported available not seen 03 Not available today 04 Never available	
32.	DPT-Hib-HepB (pentavalent)	01 Observed available 02 Reported available not seen 03 Not available today 04 Never available	
33.	Oral polio vaccine	01 Observed available 02 Reported available not seen 03 Not available today 04 Never available	
34.	BCG vaccine and diluent	01 Observed available 02 Reported available not seen 03 Not available today 04 Never available	
35.	Rotavirus vaccine	01 Observed available 02 Reported available not seen 03 Not available today 04 Never available	
36.	Pneumococcal vaccine	01 Observed available 02 Reported available not seen 03 Not available today 04 Never available	
37.	IPV (Inactivated polio vaccine)	01 Observed available 02 Reported available not seen 03 Not available today 04 Never available	
38.	HPV (human papillomavirus vaccine)	01 Observed available 02 Reported available not seen 03 Not available today 04 Never available	

No.	Question	Categories	Skip Pattern
	In the past 3 months were you unable to give any of the vaccines listed below because of unavailable stock?		
39.	Measles vaccine and diluent	01 Yes stock out 02 No stock out 03 Not indicated 04 Product not offered 05 Facility record not available	
40.	DPT-Hib-HepB (pentavalent)	01 Yes stock out 02 No stock out 03 Not indicated 04 Product not offered 05 Facility record not available	
41.	Oral polio vaccine	01 Yes stock out 02 No stock out 03 Not indicated 04 Product not offered 05 Facility record not available	
42.	BCG vaccine and diluent	01 Yes stock out 02 No stock out 03 Not indicated 04 Product not offered 05 Facility record not available	
43.	Rotavirus vaccine	01 Yes stock out 02 No stock out 03 Not indicated 04 Product not offered 05 Facility record not available	
44.	Pneumococcal vaccine	01 Yes stock out 02 No stock out 03 Not indicated 04 Product not offered 05 Facility record not available	
45.	IPV (Inactivated polio vaccine)	01 Yes stock out 02 No stock out 03 Not indicated 04 Product not offered 05 Facility record not available	
46.	HPV (human papillomavirus vaccine)	01 Yes stock out 02 No stock out 03 Not indicated 04 Product not offered 05 Facility record not available	

Diagnostics

No.	Question	Categories	Skip Pattern
1.	Does this facility conduct any diagnostic testing including any rapid diagnostic testing? *Ask to be shown the main laboratory or location in the facility where most testing is done to start data collection.*	01 Yes 02 No	01 → Q2 02 → next section "Blood Transfusion"
	I would like to know if the following diagnostic tests and associated equipment are available today in this facility. Does this facility offer any of the following tests on-site?		
2.	Rapid syphilis testing	01 Yes 02 No	
3.	HIV rapid testing	01 Yes 02 No	
4.	Urine rapid tests for pregnancy	01 Yes 02 No	
5.	Urine protein dipstick testing	01 Yes 02 No	
6.	Urine glucose dipstick testing	01 Yes 02 No	
7.	Urine ketone dipstick testing	01 Yes 02 No	
8.	Dry blood spot (DBS) collection for HIV viral load or EID	01 Yes 02 No	
9.	Malaria rapid diagnostic testing	01 Yes 02 No	
	Does this facility conduct the following tests onsite or offsite?		
10.	Blood glucose tests using a glucometer	01 Yes onsite 02 Yes offsite 03 Don't conduct the test	
11.	Haemoglobin testing	01 Yes onsite 02 Yes offsite 03 Don't conduct the test	
12.	General microscopy/ wet-mounts	01 Yes onsite 02 Yes offsite 03 Don't conduct the test	
13.	Malaria smear tests	01 Yes onsite 02 Yes offsite 03 Don't conduct the test	
14.	HIV antibody testing by ELISA	01 Yes onsite 02 Yes offsite 03 Don't conduct the test	

No.	Question	Categories			Skip Pattern
15.	I would like to know if the following general equipment items are available and functional today Available 01 Yes, 02 No Functional 01 Yes, 02 No, 88 DK	Equipment	Available	Functional	
		Light microscope			
		Glass slides and cover slips		NA	
		Refrigerator			
		Glucometer			
		Glucometer test strips with valid expiration date			
		Colorimeter or hemoglobinometer			
		HemoCue			
		Wright-Giemsa stain or other acceptable malaria parasite stain (Field Stain A and B)		NA	
		ELISA washer		NA	
		ELISA reader		NA	
		Incubator			
		Specific assay kit- HIV antibody testing by ELISA		NA	
16.	Does this facility have an accredited/ certified microscopist?	01 Yes 02 No			
17.	Does this facility offer TB services?	01 Yes 02 No			01 → Q18 02 → Q22
18.	Does this facility do Ziehl-Neelsen testing for TB (AFB) onsite or offsite?	01 Yes onsite 02 Yes offsite 03 No			01 → Q19 02 → Q20 03 → Q20
19.	I would like to know if the following equipment items for TB testing are available and functional today. Available: 01 Yes, 02 No Functional 01 Yes, 02 No, 88 DK	Equipment	Available	Functional	
		Fluorescence microscope (FM)			
		Ziehl-Neelsen stain		NA	
		Auramine Rhodamine stain for fluorescent microscopy		NA	
20.	Does this facility conduct Xpert MTB/ RIF diagnostic testing for TB onsite or offsite?	01 Yes onsite 02 Yes offsite 03 No			01 → Q21 02 → Q22 03 → Q22
21.	Please tell me if the following equipment items for Xpert MTB/RIF diagnostic testing for TB are available and functional today. Available: 01 Yes, 02 No Functional 01 Yes, 02 No, 88 DK	Equipment	Available	Functional	
		GeneXpert 4 module unit with laptop			
		TB rapid test cartridge			

No.	Question	Categories			Skip Pattern
	Does this facility conduct the following liver and renal function tests onsite or offsite?				
22.	ALT testing	01 Yes onsite 02 Yes offsite 03 Don't conduct the test			
23.	Other liver function test (such as bilirubin)	01 Yes onsite 02 Yes offsite 03 Don't conduct the test			
24.	Serum creatinine testing	01 Yes onsite 02 Yes offsite 03 Don't conduct the test			
25.	Other renal function (such as urea nitrogen)	01 Yes onsite 02 Yes offsite 03 Don't conduct the test			01 → Q26 02 → Q27 03 → Q27
26.	If site conducts liver function/ renal function tests onsite, then tell me if the following equipment items and reagents for liver and kidney function testing are available and functional today. Available: 01 Yes, 02 No Functional 01 Yes, 02 No, 88 DK	Item	Available	Functioning	
		Biochemistry analyser			
		Centrifuge			
		Specific assay kits – liver function test		NA	
		Specific assay kits – renal function tests		NA	
27.	Does this facility do full blood count and differential testing onsite or offsite?	01 Yes onsite 02 Yes offsite 03 No			01 → Q28 02 → Q29 03 → Q29
28.	Please tell me if the following equipment items and reagents for full blood count testing are available and functional today. Available: 01 Yes, 02 No Functional 01 Yes, 02 No, 88 DK	Item	Available	Functioning	
		Haematology analyser (for full blood count)			
		Stains for full blood count and differential		NA	
29.	Does this facility do CD4 count (absolute and percentage) testing onsite or offsite?	01 Yes onsite 02 Yes offsite 03 No			
30.	Please tell me if the following equipment items for CD4 testing are available and functional today. Available: 01 Yes, 02 No Functional 01 Yes, 02 No, 88 DK	Item	Available	Functioning	
		CD4 counter			
		Specific assay kit – CD4 test		NA	
31.	Does this facility conduct blood group serology onsite or offsite?	01 Yes onsite 02 Yes offsite 03 No			01 → Q32 02 → Q32 03 → Q33

No.	Question	Categories				Skip Pattern
32.	Does this facility conduct the following blood group serology tests onsite or offsite?	Test	Yes, onsite	Yes, offsite	Don't conduct the test	
		ABO blood group testing	1	2	3	
		Rhesus blood grouping testing	1	2	3	
		Cross-match testing by direct agglutination	1	2	3	
		Cross-match testing by indirect anti-globin testing or other test with equivalent sensitivity	1	2	3	
33.	Please tell me if the following equipment items and reagents for blood typing and cross match are available and functional today. Available: 01 Yes, 02 No Functional 01 Yes, 02 No, 88 DK	Item	Available		Functioning	
		Centrifuge				
		37°C incubator				
		Grouping sera			NA	
34.	Does this facility conduct the following tests onsite or offsite?	Test	Yes, onsite	Yes, offsite	Don't conduct the test	
		Serum electrolyte testing	1	2	3	
		Urine microscopy testing	1	2	3	
		Syphilis serology testing	1	2	3	
		Gram stain testing	1	2	3	
		CSF/ body fluid counts	1	2	3	
		Cryptococcal antigen testing	1	2	3	
		Molecular biological technique for HIV viral load or HIV early infant diagnosis (PCR)	1	2	3	
35.	Please tell me if the following equipment items and reagents are available and functional today. Available: 01 Yes, 02 No Functional 01 Yes, 02 No, 88 DK	Item	Available		Functioning	
		Specific assay kit – serum electrolyte test			NA	
		Specific assay kit – syphilis serology			NA	
		Gram stains			NA	
		White blood counting chamber				
		Specific assay kit – cryptococcal antigen test			NA	
		Assay specific automated system for estimating HIV viral load			NA	
		Centrifuge				
		Vortex mixer				
		Pipettes				
		Biochemistry analyser				

<table>
<tr><th>No.</th><th>Question</th><th>Categories</th><th>Skip Pattern</th></tr>
<tr><td>36.</td><td>In the last 30 days, have you needed to use any of the electric diagnostic equipment but could not do so because you did not have electricity?</td><td>01 Yes, at least once
02 No, do not rely on any electric diagnostic equipment
03 No, no electric outages
88 Don't know</td><td></td></tr>
<tr><td>37.</td><td>Does this facility perform diagnostic x-rays, ultrasounds, or computerized tomography?</td><td>01 Yes
02 No</td><td>01 → Q38
02 → next section "Blood transfusion"</td></tr>
<tr><td>38.</td><td>Please tell me if the following imaging equipment items are available and functional today.
Available:
01 Yes, 02 No
Functional
01 Yes, 02 No, 88 DK</td><td><table><tr><td>Item</td><td>Available</td><td>Functioning</td></tr><tr><td>X-ray machine</td><td></td><td></td></tr><tr><td>Ultrasound equipment</td><td></td><td></td></tr><tr><td>CT scan</td><td></td><td></td></tr><tr><td>ECG</td><td></td><td></td></tr></table></td><td></td></tr>
<tr><td>39.</td><td>In the last 30 days, have you needed to use any of the imaging equipment but could not do so because you did not have electricity?</td><td>01 Yes, at least once
02 No, do not rely on any electric items
03 No, no electric outages
88 Don't know</td><td></td></tr>
</table>

Blood Transfusion

<table>
<tr><th>No.</th><th>Question</th><th>Categories</th><th>Skip Pattern</th></tr>
<tr><td>1.</td><td>Does this facility offer blood transfusion services?</td><td>01 Yes
02 No</td><td>01 → Q2
02 → next section "Sterilization"</td></tr>
<tr><td></td><td>Ask to be shown the location in the facility where blood is collected, processed, tested, stored, or handled prior to transfusion. Find the person most knowledgeable about blood transfusion services in the facility.</td><td></td><td></td></tr>
<tr><td>2.</td><td>Have there been any interruptions in the blood availability during the past 3 months?</td><td>01 Yes
02 No</td><td></td></tr>
<tr><td>3.</td><td>Does this facility obtain blood from a national or regional blood centre?</td><td>01 Yes
02 No</td><td></td></tr>
<tr><td>4.</td><td>Does this facility obtain any blood from sources other than the national or regional blood centre?</td><td>01 Yes
02 No</td><td></td></tr>
<tr><td>5.</td><td>Does any place in this facility do blood screening for infectious diseases prior to transfusion?</td><td>01 Yes
02 No</td><td>01 → Q6
02 → Q7</td></tr>
<tr><td>6.</td><td>Please tell me if the blood that is transfused in the facility is "always", "sometimes", "rarely", or "never" screened for any of the following infectious diseases.</td><td><table><tr><th>Disease</th><th>Always</th><th>Sometimes</th><th>Rarely</th><th>Never</th></tr><tr><td>HIV</td><td>01</td><td>02</td><td>03</td><td>04</td></tr><tr><td>Syphilis</td><td>01</td><td>02</td><td>03</td><td>04</td></tr><tr><td>Hep B</td><td>01</td><td>02</td><td>03</td><td>04</td></tr><tr><td>Hep C</td><td>01</td><td>02</td><td>03</td><td>04</td></tr></table></td><td></td></tr>
<tr><td>7.</td><td>Does this facility have a refrigerator available and functioning in this service area for the storage of blood?</td><td>01 Available and functional
02 Available not functional
03 Available don't know if functional
04 Not available</td><td>01 → Q8
02 → Q11
03 → Q11
04 → Q11</td></tr>
<tr><td>8.</td><td>Does this facility have a refrigerator available and functioning for the storage of blood?
Note: For a refrigerator to be functional, it must have sufficient capacity to accommodate all needed blood.</td><td>01 Available and functional
02 Available, not functional
03 Available, don't know if functioning
04 Not available</td><td></td></tr>
<tr><td>9.</td><td>What type of energy source is used for the blood refrigerator?</td><td>01 Electricity (grid or generator)
02 Solar (with or without batteries)
03 Gas
04 Kerosene
05 Mixed (Electric with gas kerosene)
66 Other, specify
88 Don't know</td><td></td></tr>
</table>

No.	Question	Categories	Skip Pattern
10.	Does this energy source supply power to the refrigerator for 24 hours a day and for 7 days in the week?	01 Yes 02 No	
11.	Has the temperature been out of the range of 2 to 6°C inclusive in the last 30 days? Please check the temperature record and verify the temperature for the last 30 days in order to answer the question.	01 Observed in range 02 Reported in range but not seen 03 Out of range 04 Record not available	
12.	Do you have any guidelines on the appropriate use of blood and safe transfusion practices?	01 Yes, observed 02 Yes, reported not seen 03 No	
13.	Have any provider(s) of blood transfusion services received any training in the appropriate use of blood and safe transfusion practices in the last two years?	01 Yes 02 No	

Processing Equipment for Reuse (Sterilization)

No.	Question	Categories			Skip Pattern
1.	Please tell me if the following items used for processing of equipment for reuse are available and functional in the facility today. Available: 01 Yes, 02 No Functional 01 Yes, 02 No, 88 DK	Item	Available	Functioning	
		Electric autoclave (pressure & wet heat)			
		Non-electric autoclave			
		Electric dry heat sterilizer			
		Electric boiler or steamer (no pressure)			
		Non-electric pot with cover for boiling/steam			
		Heat source for non-electric equipment		NA	
2.	In the last 30 days, have you needed to use any of the electric items for processing of equipment for reuse but could not do so because you did not have electricity?	01 Yes, at least once 02 No, do not rely on any electric items 03 No, no electric outages 88 Don't know			

Obstetric and Newborn Care Services

No.	Question	Categories	Skip Pattern
1.	Does this facility offer delivery (including normal delivery, basic emergency obstetric care, and/or comprehensive emergency obstetric care) and/or newborn care services?	01 Yes 02 No	01 → Q2 02 → End
	Ask to be shown the location in the facility where obstetric and newborn care services are provided. Find the person most knowledgeable about obstetric and newborn care services in the facility. Please tell me if the following interventions are routinely carried out by providers of delivery services in this facility:		
2.	Administration of oxytocin injection immediately after birth to all women for the prevention of postpartum haemorrhage	01 Yes 02 No	
3.	Monitoring and management of labour using partograph	01 Yes 02 No	
4.	Immediate and exclusive breastfeeding	01 Yes 02 No	
5.	Hygienic cord care (Cut with sterile item and apply disinfectant to tip and stump, and no application of other substances)	01 Yes 02 No	
6.	Thermal protection (drying baby immediately after birth and wrapping)	01 Yes 02 No	
	Please tell me if any of the following interventions for the management of complications during and after pregnancy and childbirth have been carried out in the last 12 months by providers of delivery services as part of their work in this facility.		
7.	Parenteral administration of antibiotics (IV or IM) for mothers	01 Yes 02 No	
8.	Parenteral administration of oxytocic for treatment of postpartum haemorrhage (IV or IM)	01 Yes 02 No	
9.	Parenteral administration of magnesium sulphate for management of preeclampsia and eclampsia (IV or IM)	01 Yes 02 No	
10.	Assisted vaginal delivery	01 Yes 02 No	
11.	Manual removal of placenta	01 Yes 02 No	
12.	Removal of retained products of conception	01 Yes 02 No	

No.	Question	Categories			Skip Pattern
13.	Neonatal resuscitation with bag and mask	01 Yes 02 No			
14.	Caesarean section	01 Yes 02 No			
15.	Blood transfusion	01 Yes 02 No			
16.	Antibiotics for preterm or prolonged PROM (premature rupture of membranes) to prevent infection	01 Yes 02 No			
17.	Corticosteriods in preterm labour	01 Yes 02 No			
18.	KMC (Kangaroo mother cre) for premature/ very small babies	01 Yes 02 No			
19.	Injectable antibiotics for neonatal sepsis	01 Yes 02 No			
20.	I would like to know if the following basic equipment items are available in the service area today. For each equipment or item, please tell me if it is available today and functioning. Available 01 Yes, 02 No Functioning 01 Yes, 02 No, 77 DK	Item	Available	Functioning	
		Examination light (flashlight ok)			
		Delivery pack		NA	
		Cord clamp			
		Episiotomy scissors			
		Scissors or blade to cut cord			
		Suture material with needles		NA	
		Needle holder			
		Manual vacuum extractor			
		Incubator			
		Disposable latex gloves		NA	
		Blank partograph		NA	
		Delivery bed			
		Resuscitation table with heat source for newborn resuscitation			
		Newborn bag and mask size 1 for term babies			
		Newborn bag and mask size 0 for preterm babies			
		Electric suction pump			
		Suction catheter		NA	
		Suction bulb, single use			
		Suction bulb, sterilization multi-use			
		Speculum			
		Infant weighing scale			
		Blood pressure apparatus (may be digital or manual sphygmomanometer with stethoscope)			
		Clean running water (piped, bucket with tap, or pour pitcher)		NA	
		Hand-washing soap/liquid soap		NA	
		Alcohol based hand rub		NA	
21.	Does this facility stock any medicines for obstetric care in this service site?	01 Yes 02 No			01 → Q22 02 → End

No.	Question	Categories	Skip Pattern
	Are any of the following medicines and commodities available in this service site today?		
22.	Antibiotic eye ointment for newborn	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
23.	Gentamicin injection	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
24.	Ampicillin powder for injection	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
25.	Hydralazine injection	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
26.	Metronidazole injection	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
27.	Azithromycin cap/tab or oral liquid	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
28.	Cefixime cap/tab	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
29.	Benzathine benzylpenicillin powder for injection	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
30.	Nifedipine cap/tab (10mg)	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	

No.	Question	Categories	Skip Pattern
31.	Methyldopa tab	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
32.	Calcium gluconate injection	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
33.	Magnesium sulphate injectable	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
34.	Skin disinfectant	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
35.	Intravenous solution with infusion set	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
36.	Sodium chloride injectable solution	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
37.	Betamethasone injection	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
38.	Dexamethasone injection	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	
39.	Oxytocin injection	01 Available, observed 02 Reported, but not seen 03 Not available today 04 Never available	01 → Q40 02 → Q40 03 → End 04 → End
40.	Is the oxytocin stored in cold storage	01 Yes 02 No	

Appendix II: Reliability of electricity data collection form

Record the date (dd/mm) and mark "1" if there is any known electricity outage and "0" it there is not any electricity autage.

Day	Date	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	24:00	1:00	2:00	3:00	4:00	5:00
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Health Facility Name: .....

Ward/Unit/Department: .....

Appendix III: In-depth interview guide for Healthcare Workers

Thank you for participating in this interview. Let us begin.

Introduction

1. Tell me about your role in this health facility.
2. What health services are provided in this health facility?

Reliability of electricity

3. What are the main sources of power at this health facility?
4. What are the regular operating days of this health facility?
5. How many times does the electricity run out at least once in a typical working week?
6. For how many days does the electricity run out for?
7. How many times does the electricity run out at least once in a typical working day?
8. For how many hours does the electricity run out for?
9. Under what circumstances do electricity run out at this health facility?
   Probe further: What factors shape availability of electricity at this health facility?
   Ex. How does health facility planning shape availability of fuel for the diesel generator? What factors are within the health facility's control? What factors are not within the health facility's control?

Maintenance

(for facilities with off-grid solar systems)

10. Is the current off-grid solar system maintained at all at this health facility?

If yes, then ask:

11. How is the current off-grid solar system maintained at this health facility?
12. Who is responsible for providing routine maintenance for the off-grid solar system?
13. What makes it easier to maintain the off-grid solar system? (Probe: in-house or external provider)
14. What makes it harder to maintain the off-grid solar system?

For all, ask:

15. What suggestions or recommendations do you have to make sure such a system is routinely maintained?
    Probe: Who, how, what systems, available training, resources required

Capacity and availability of services requiring electricity

16. What health services or infrastructure require electricity in this health facility?
    Probe further on each example. E.g., sterilization, vaccine or drugs, equipment, diagnostics
17. What health services are you able to provide because you have electricity?
18. What health services are you not able always provide because you do not have electricity?
    Probe for specific examples for HCs. (May probe further on blood bank for HC IV)

When there is no electricity

19. What happens when there is no electricity?
    Probe: Is there a system to request for back-up fuel, money for grid electricity?
20. How are services provided at night?
21. Tell me about a time when there was no electricity and you had a woman in labour … (or another relevant example)
22. What do you think about security of the health facility compound when there is no electricity at night? Probe if it affects female staff more or not

How can electricity improve work, quality of care, motivation, quality of life/ retention

23. How can electricity improve the way you do your work at this health facility? Probe: facility operations – use of phones and computers to carry out administrative work and reporting to health service provision
24. How can electricity improve quality of care for patients?
25. How can electricity expand the health services provided at this health facility? Probe for specifics, including from other service providers such as INGOs, e.g., adolescent SRH
26. How does electricity provide quality of life living here (at staff quarters)?
27. How can improved or increased access to energy improve your quality of life living here?

Thank you for sharing and for your time. Do you have any questions for me?

Appendix IV: In-depth interview guide for District Health Officers

Warm up

1. How many years have you been a DHO at this place?
2. Tell me about your role as a DHO.
3. How have refugees impacted your daily role as a DHO?
4. What has the impact of refugees been on the health sector of your district? (probe for specific examples)
   I. Electricity and health service delivery
5. How does electricity affect health service delivery in your district? (probe for at least 3 specific examples)
6. How does electricity affect healthcare worker motivation in your district? (probe for specific examples)
7. What role does the District Health Team play in ensuring health facilities have adequate electricity for health service delivery? (probe for specific examples)
8. What interventions have been put in place to address energy deficits in health facilities?
9. How well have these interventions worked? (Probe: why do you think these interventions worked? Why do you think these interventions have not worked well?)

Maintenance/ Sustainability

10. What do you think is needed to address the energy needs of a health facility sustainably? (probe for specific examples)
11. What role does the district play in supporting health facilities to routinely maintain or repair generators or solar systems at government health centres? (probe for specific available cadres, system for triggering routine maintenance or repair, payment systems for maintenance and repair)
12. What resources do government health facilities have available to maintain or repair things like diesel generators or batteries of solar systems? (probe on size of PHC funds, how adequate PHC fund is, RBF – results based financing)
13. How can a donor or an implementing partner collaborate with the District Health Team to ensure sustainability of an intervention like placing solar systems in health centres?

Ending

14. Is there anything else related to electricity and health service provision that we have not yet touched upon that you would like me to think about?

Appendix V: Focus group discussion guide for Community Representatives

Thank you for participating in this group interview.
Collect socio-demo for FGD: age, sex, education attained, occupation, refugee/ host status

- Sex: male/ female
- Age (years)
- Number of years of schooling completed
- Current occupation
- Refugee or host status
- VHT, RWC, HUMC

Ground Rules

<set ground rules together>

Warm up

1. What kind of services do the community come to this health facility for? Probe: any other? (See if these health services match up with what HCW provides)
2. In general, how comfortable/happy is the community with seeking health services at this health facility at night? Why or why not?
3. What does a community member think about getting health services from a facility that does not have electricity at night?

Accessing health services at night

Now we would like to understand what accessing health services is like at night. We will go over three different scenarios, and we would like you to tell us what typically happens in your community. Feel free to discuss within your group what happens and share examples.

4. Imagine a woman goes into labour at 9pm. She gets help from the traditional birth attendant but the baby is stuck. What happens next? See if the community identifies this health facility or not, if not, why not.
5. Imagine a young man is knocked by a car in the evening hours. Tell me what happens next. Probe: Where does the community go for help at night if someone has an accident that cannot wait until the next day? See if the community identifies this health facility or not, if not, why not.
6. Imagine a mother and father works all day outside of the home. The children are left alone until evening time. When the mother comes home, she finds her young boy crying. He has a fever. He is lethargic and refuses to eat dinner. What happens next?

For each of the scenario, probe when there is no electricity/consequences

- What happens to a patient when is no electricity at the health centre? Probe: are services provided? Is patient turned away? Is patient referred to another facility?
- Tell me what happens if a patient is not able to get the services he or she needs at this health centre. Probe: where does she go? What transport is used? How are the funds raised? How far away is this other facility? What alternative is used if the family isn't able to raise funds?

Market Approach

As we mentioned in the introduction, GIZ will be supporting this health facility with a solar system to get reliable and adequate electricity. We are trying to think of different ways a health facility can generate funds to pay for the maintenance of the solar system.

7. One idea is to maybe have a kiosk where people can pay to charge their phones. What do you think of this idea?
   Probe: Do you think your community would come to the health facility canteen to get their phone charged [or for other services – in case they opt for another idea]?
   Probe: Are there any other kiosks or individuals offering the same services in your community already? How many (maybe by kiosk or individuals)?
   Probe: How much do you think people are willing to pay to charge up their phone?
   Probe: which steps are necessary to put your idea in place (e.g. setting up a canteen?)

Health expenditure

8. Imagine a young woman is about to give birth. She wants to give birth at a health facility. She walks to the health facility but the midwife tells her she must come with a mama kit or they cannot give her the service. What will she do next?
   Probe: Although health services are supposed to be free of charge in Uganda patients often have health-related costs, such as transport to the health facility, need to pay for medicines or supplies if they are not available. What kind of health-related costs does your community typically face? How do individuals or families pay for health-related costs if they do not have cash? Probe: in-kind, raise money between households or saving groups, friends. What would individuals or families do with their resource if they did not have to spend it on transport to the health facility?

Sickness-related absenteeism

9. Think of a time before COVID-19. Imagine a school-aged child wakes up one morning and has a fever. Tell me what happens. Probe: will she go to school? How many days of school will she miss? What will she do at home? What will her parents/caregivers do?
10. Imagine a young woman is sick with fever and a headache. Tell me what happens next. Probe: what will she do? Who will look after her? What will happen to her groundnuts/ sorghum/ maize/ cassava if she is sick for a few days? Probe: does it affect her livelihood? What about her saving of the week (very many farmers' groups are engaged in the local Village Savings and Loan Association) (choose a relevant livelihood to refugee settlement).

Appendix VI: Socio-demographic form for Community Representatives

Focus Group Discussion with Community Representatives

1. Date of interview: January _____ 2021

2. Time of interview: _____

3. Name of interviewer: _____

4. Name of translator: _____

5. Record type of community representatives
   - ☐ Village Health Team
   - ☐ Refugee Welfare Committee
   - ☐ Health Unit Management Committee

6. Record name of health centre associated with community representatives

   _____

7. Record location of interview

   - Village: _____
   - Parish: _____
   - Sub-county: _____
   - County: _____
   - District: _____

8. Collect the following information from each FGD participant

Name	Age (years)	Sex (M/F)	Refugee or Host (R/H)	Occupation	KM from health centre	Length of time in Group (years)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						

Appendix VII: Informed consent form for in-depth interviews

Informed Consent

Purpose

I am Sharon. I am a consultant researcher for GIZ's energy program. The purpose of the study is to understand how electricity affects health service access and delivery. You are invited to take part in a research study.

Procedures

We are asking key informants such as frontline healthcare providers, District Health Officers, or representatives of UNHCR and IRC if they would like to participate in an in-depth interview.
During the discussion, you will be asked questions about the role of electricity and health service delivery, quality of care, and healthcare worker motivation.
With your permission, I will record the interview with a recorder. I expect the interview will take no more than one hour of your time.

Possible risks/discomforts

Being part of this study is not likely to create any harm for you. I will ask you questions about sources and reliability of electricity at this health centre and how electricity affects health service delivery, quality of care, and healthcare worker motivation. You do not have to answer any questions you would prefer not to answer, and you are free to leave the interview. Your answers will not affect your employment at this health facility.
I will protect the information you share with me. I will not use your name in any report. The recording and notes from this interview will be stored on a password protected computer. Only members of the research team will have access to this information, and they will not be allowed to share it will anyone else.

Possible benefits

There is no direct benefit to you from participating in this study. The discussion and findings from this study will help GIZ's energy program to develop a better program to support the health centre and the patients served by the health centre. You will receive a soda and snack as compensation for your time.

Voluntary participation

You do not have to agree to be in this study and you may change your mind at any time.

Permission to proceed

Is it okay to proceed with the interview?

Name	Signature/Thumbprint	Date

Health centre name: _____

Appendix VIII: Informed consent form for community representatives

Informed Consent

Purpose

We are Esther, Mourin, and Sharon. We are consultant researchers for GIZ's energy program. We are here to understand how electricity affects health service access and delivery. You are invited to take part in a research study. The purpose of this study is to explore community experiences accessing health services at night, health-related costs, how a solar system can affect health services at this health centre, and the impact of missing school and work because of sickness.

Procedures

We are asking community representatives who are a member of a Village Health Team, Refugee Welfare Committee, of Health Unit Management Committee if they would like to participate in a group discussion.

During the discussion, you will be asked questions about your experiences with accessing health services at night, health-related costs, and the impact of missing school and work because of sickness. You will also be asked what you think about this health facility having a solar system.

With your permission, we will record the discussion with a recorder. We expect the group discussion will take no more than one to two hours of your time.

Possible risks/discomforts

Being part of this study is not likely to create any harm for you. We will ask you questions about your/your community's experiences with healthcare access at night. You do not have to answer any questions you would prefer not to answer, and you are free to leave the group. Your answers will not affect your healthcare access at this health facility.

We will protect the information you share with us. We will not use your names or job titles in any reports. The recording and notes from this group discussion will be stored on a password protected computer. Only members of the research team will have access to this information, and they will not be allowed to share it will anyone else.

Possible benefits

There is no direct benefit to you from participating in this study. The discussion and findings from this study will help GIZ's energy program to develop a better program to support the health centre and the patients served by the health centre. You will receive a soda, snack, and a transport refund of 15,000 UGX as compensation for your time.

Voluntary participation

You do not have to agree to be in this study and you may change your mind at any time.

Permission to proceed

Is it okay to proceed with the group discussion?

Name	Signature/ Thumbprint	Date

Focus group discussion type:
- ☐ Village Health Team
- ☐ Refugee Welfare Committee
- ☐ Health Unit Management Committee

Health centre name: _____

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