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COOPERATION REPUBLIC OF UGANDA FEDERAL REPUBLIC OF GERMANY

Promotion of Renewable Energy and Energy Efficiency Programme (PREEEP)

IMPACT ASSESSMENT OF THE SOLAR ELECTRIFICATION OF HEALTH CENTRES

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The Promotion of Renewable Energy and Energy Efficiency Programme (PREEEP), a joint project of the Ministry of Energy and Mineral Development (MEMD) and German Technical Cooperation (GTZ), in collaboration with District Health Offices representing the Ministry of Health and local solar companies undertook the electrification of rural Health Centres including staff quarters with solar (PV lighting and refrigeration systems). Following two years since installation of the systems at Health Centres and staff quarters in Jinja and Kayunga Districts, this report assesses the impact of the use of electricity on the quality of delivery of medical services at Health Centres II and the living conditions of medical staff residing at Health Centre staff quarters. All aspects considered, the overall conclusions of the study are that:

- The use of electricity at Health Centres II enhances the delivery of medical services through the provision of quality light during treatment of nighttime emergencies, emergency deliveries and for security purposes at the main building and staff quarters.

- The use of solar fridges, if working properly, has facilitated the service of instant immunization of children at Health Centres that previously did not have fridges. In Health Centers where the solar fridge replaced formerly used gas fridges, the reliability of immunization services increased as gas supply in Uganda faces shortages a few times in a year. In cases where the solar fridge has shown technical problems the reliability of service decreased as no technical knowledge to repair the fridges is available with as consequence that no vaccines can be stored.

- Health Centres II without staff quarters mainly operate during the day hence under-utilize the installed lighting systems which are mainly used for security lighting.

- Whereas Health Centres continue to use traditional sources of energy- notably kerosene for waste burning, charcoal for sterilization of medical equipment and for cooking at the staff quarters- solar electricity, if working properly, reduces expenditure on energy sources for lighting and gas (replaced by solar fridges).

- Although the availability of solar is not a decisive factor for the readiness of health staff to take up positions in rural health centres, it is likely to increase motivation and morale of health staff whose living standards are improved by access to cheaper and quality light to complete work at night and a facility to charge cell phones, especially in remote rural areas with no access to grid power.

- Solar has facilitated private and work related communication between health workers in far off locations, through the provision of electricity for phone charging, thereby enhancing efficiency in medical service delivery.

To enhance the impact of solar in the health sector, the installation of PV systems should prioritize Health Centres that have staff quarters, as these are more likely to effectively utilize the systems by opening for nighttime emergencies. PV system installation should also prioritize Health Centres which routinely operate at night (health centres III and above). The lighting systems installed at the Health Centres II also should not be too sizeable considering that not all rooms at the Health Centres are utilized during nighttime emergencies. Solar fridges should also be supplied to Health Centres as part of the PV system package as –if well functioning- they are more reliable than grid powered and gas fridges whose efficiency is affected by the intermittent supply of grid power and gas. Care should however be taken to install fridges that are durable and can be easily repaired by the local cold chain engineers. Sound technical training of cold chain engineers should be an integral part of solar programs for Health Centers.

ABBREVIATIONS AND ACCRONYMNS

DHO	-	District Health Office
HC	-	Health Centre
HSD	-	Health Sub District
NRH	-	National Referral Hospital
PREEEP	-	Promotion of Renewable Energy and Energy Efficiency Programme
PV	-	Photovoltaic
RRH	-	Regional Referral Hospital
UNEPI	-	Uganda National Expanded Program on Immunization
UNMHCP	-	Uganda National Minimum Health Care Package
VHT	-	Village Health Team

I. INTRODUCTION

The Promotion of Renewable Energy and Energy Efficiency Programme (PREEEP), a joint project of the Ministry of Energy and Mineral Development (MEMD) and German Technical Cooperation (GTZ), seeks to promote access to modern and sustainable energy services by the Ugandan poor. Under the Rural Electrification component, undertook the electrification of Health Centres in rural areas with photovoltaic (PV) lighting systems and solar fridges to enhance their ability to deliver timely and quality medical services.

This report assesses the impact of the solar electrification of Health Centres II in Jinja and Kayunga districts, supported by PREEEP. The assessment follows more than two years of the use of solar products (PV lighting systems and/or solar fridges) by the Health Centres and staff residing in Health Centre staff quarters.

1.0 Background of PREEEP and Health Centres

In its bid to promote the provision of better services in Uganda’s health sector, PREEEP partnered with the District Health Offices of Kayunga and Jinja respectively and local solar (import) companies to electrify rural Health Centres and Health Centre staff quarters with solar electricity. In each district, PREEEP signed a Memorandum of Understanding with the respective District Health Office and selected a local solar company (Energy Systems Limited or Solar Energy Uganda) through competitive bidding to supply and install the systems.

The Memoranda of Understanding between GTZ and the two districts differed in content. The contract with the Jinja District Health Office involved the installation of PV lighting systems and solar fridges at mainly Health Centres II, with GTZ funding- on average- 85% of the PV system cost while the district contributed the remaining 15%. The contract with Kayunga District on the other hand involved the installation of only PV lighting systems and GTZ’s contribution was 80%, while the district contributed 20%. The PV systems were installed at Health Centres II and staff quarters by Energy Systems Ltd (in Jinja District) and by Solar Energy Uganda (in Kayunga District). This impact assessment has been conducted two years after installation of the systems in Jinja and after one year for the systems in Kayunga.

1.1 Objectives of the Impact Assessment

The main objective of the assessment is to establish the impact of the installed PV systems at Health Centres II (HCs II) and staff quarters on the quality of delivery of medical services and the living and working conditions of the Health staff.

The purpose of the assessment is therefore to:

- Evaluate the impact of the use of solar PV by non-grid electrified HCs II with the focus on the quality of delivery of medical services.
- Assess the impact of the use of solar PV on the living conditions of the Health staff residing at the HCs II with a focus on job satisfaction.
- Evaluate the impact of the availability of solar electricity in previously non-electrified Health Centres on the patients that receive medical services.

1.2 Methodology

The methodology adopted for the assessment was a comparative analysis of solar-electrified HCs II (*the treatment group)* with non-electrified and grid electrified HCs II respectively (*the control group)*. In order to select the sample of Health Centres for the study, a list of all HCs II in the districts of Jinja and Kayunga was generated. Out of this list, all the HCs II that received PV systems with GTZ support were identified and selected. For comparison purposes, an equivalent number of HCs II without solar electricity was selected in the same districts, with priority placed on those without any electricity source. In addition, some HCs II that are electrified with grid power were also visited.

In total, 38 HCs II were visited; 29 of which are in Jinja and 9 in Kayunga (*See Appendix I*). At each HC, three interviews were held with the In-charge, staff residing in Health Centre quarters (where applicable) and patients visiting the Health Centre as summarized in the table below.

Table 1: Summary of Health Centre II resource persons interviewed representing the number of Health Centres and Staff Quarters

		Not electrified	SHS Users	Grid Users	Total (N)
	In-charges	14	18	6	38
	Staff	2	9	1	12
	Patients	5	27	1	33

II. OVERVIEW OF THE HEALTH SECTOR

2.0 Situational Analysis of the Health Sector in Uganda

Uganda's population is currently estimated at 33 million (51% female and 49% male) with a population growth rate of 3.3%. The life expectancy is 53 years for men and 54 years for women, while the Under 5 mortality rate is 137 deaths per 1,000 live births and the maternal mortality rate is 435 deaths per 100,000 live births[1]. The leading causes of morbidity and mortality in Uganda are malaria, malnutrition, acute respiratory infections, HIV/AIDS, diarrhoea and tuberculosis. Aside from these infectious diseases, other causes of mortality are non communicable diseases such as hypertension, cancer, diabetes, mental illness and chronic heart disease.

In Uganda, health services are provided by both the public and private sector, with each sector estimated to cover about 50% of the reported outputs. The National Health Delivery System is governed in accordance with the Constitution and the 1997 Local Government Act. It is decentralized to districts. Each district health system is expected to serve 500,000 people, while smaller districts are managed under Health Sub Districts (HSDs) that serve 100,000 people. The HSDs are functional sub divisions of the district health system aimed at further decentralization of organization and management from the District Health Office to lower levels for efficiency and better service delivery. The organization and management of activities of the health sector are guided by the National Health Policy and Health Sector Strategic Plan which are periodically reviewed to address emerging developments.

The structure of the National Health System comprises of three levels namely; the district health system, regional and national referral hospitals. The district health system is composed of Village Health Teams (Health Centres I), Health Centres II, Health Centres III and Health Centres IV, all managed by the respective District Local Governments. The Regional Referral Hospitals and National Referral Hospitals on the other hand are self accounting and autonomous institutions.

[1] Source: The 2009 State of the World Population Report- UNFPA and Draft National Health Policy II-Ministry of Health, Government of Uganda

The roles of the local district authorities include: management of health service delivery; recruitment and management of personnel for district health services; passing of district by-laws related to health; and planning, budgeting, resource mobilization and allocation for health services in the district. The table below illustrates the structure of the National Health System.

Table 2: Structure and health infrastructure of the National Health System[2]

Health unit	Physical structure/ services	Beds	Location	Target population
HC I (VHT)	None	0	Village	1,000
HC II	Outpatient services only	0	Parish	5,000
HC III	Outpatient services, maternity, general ward and laboratory	8	Sub county	20,000
HC IV	Outpatient services, wards, theatre, laboratory, blood transfusion	25	County	100,000
General Hospital	Hospital, laboratory, X-ray	100	District	100,000 to 1 million
RRH	Specialist services	250	Region (3 – 5 districts)	1 - 2 million
NRH	Advanced tertiary care	450	National	Over 20 million

The main focus of the National Health System is to strengthen district capacity to deliver the Uganda National Minimum Health Care Package (UNMHCP) which broadly includes nutrition and health promotion, disease prevention, early diagnosis and treatment. In line with the National Health Policy, each level of health unit has its minimum health care package on which the delivery of health services is based.

2.1 Health Centre II Attributes

Under the District Health System, HCs II are the second level health unit after VHTs. Unlike VHTs, the HC IIs have physical premises at parish level comprising of one building and - in some cases - staff quarters which are adjacent to the main Health Centre. A typical HC II has a building with 4 to 12 rooms, including a dispensing

[2] *Adapted from The Health Sector Strategic Plan 2000/01 – 2004/05; Ministry of Health- Government of Uganda*

room, examination room, treatment/ injection room and a store. Depending on the district policy, HC IIs are typically open for 6 days in a week from 8.00am to 5.00pm from Monday to Friday and up to 2.00pm on Saturdays. The opening hours are however dependent on the availability of staff quarters at the HC premises. For HCs without staff quarters, the HC is typically open from 9.00am, as staffs have to commute from far off locations each day. Some HCs however are open for longer hours than the official time (beyond 6pm).

Owing to the lack of trained health workers in the public health sector, HC IIs typically do not have doctors. The standard number of health staff at the HCs II (recruited by the District Health Office with the same procedure for all HCs whether electrified or not) is four; comprising of an In-charge (usually a Midwife), 1 Enrolled Nurse and 2 Nursing Assistants. In addition to the medical staff, each HC II typically has 1 security guard and 1 porter who are recruited and remunerated by the HC II. The latter 2 employees are not on the district payroll, but are paid out of funds availed to the HC by the district office.

The minimum health care package (services available) at HCs II include outpatient services (basic medical care); emergency deliveries (for mothers who unable to reach HCs III in time); maternal and child health services; and immunization of children under 5. Typically HCs II do not have laboratories and are therefore only supposed to treat minor illnesses and make referrals to HCs III for cases that they are unable to treat successfully. Ideally, a HC II should not handle deliveries as they are unable to test mothers for HIV and therefore take the necessary precautions to prevent mother to child transmission of HIV/AIDS. To this end, HC IIs are currently supposed to handle deliveries for only those expectant mothers who are unable to travel to HCs III and IV due to the long distance or those who deliver children at night. Typically, there is no charge for health services at public health units, however some HCs II supplement their income by charging a fee of UGX 300 per injection so as to meet additional HC costs.

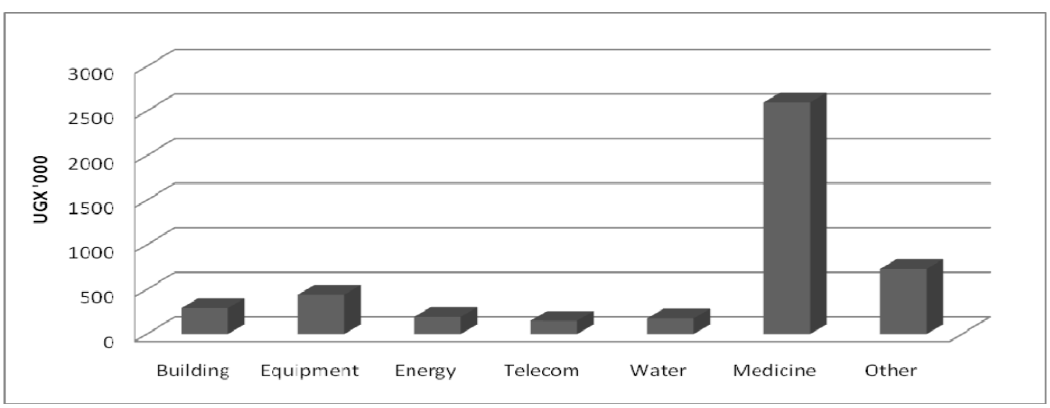
The target population that HCs II are expected to cover is 5,000 people. HCs II in Jinja and Kayunga on average serve 500 patients per month which means that around 10% of the target population regularly visits HCs II. The most treated illnesses at the

HCs II (in order of rank) are: malaria, acute respiratory tract infection and diarrhoea. Out of the HCs II visited, 63% mentioned always having enough medicines to treat the main illnesses while 37% experience occasional stock outs of medicines in cases of high demand or towards the end of the month and have to write prescriptions for their patients to purchase the drugs from private pharmacies.

Out of the sampled HCs II, 85% expressed having vaccines available at the HCs and are able to carry out vaccination at any time, while 15% either do not have functional fridges or have no fridges at all and have to keep the vaccines at a nearby HC. This proportion of HCs conducts vaccinations only on specific days of the week after collecting the vaccines from other health units with a functioning fridge.

The typical budget of a HC is determined at Health Sub District and District levels respectively. The largest proportion of the annual HC II budget is spent on the procurement of medicines (about UGX 2.5 million), health equipment (UGX 400,000) and other items such as porters' and security guard's wages and staff allowances for meetings and training, all of which accounting for UGX 750,000 (see graphic). Most of the items utilized at the HCs are supplied directly by the District Health Office (DHO). The DHO is also responsible for remunerating the staff, hence the salaries of HC staff are not part of the budgets generated at the HC II level. Typically the HC II medical staff earn a salary of UGX 250,000 (USD 120) a month.

Figure 1: Mean monthly expenditure of HCs II



The general difficulties that HCs II have to cope with include the following:

- Stock outs of essential medicines and health supplies due to high demand relative to the supplies received from the DHO;

- Lack of accommodation for health workers at the Health Centres which affects the timeliness and regularity of delivery of services and notably deliveries during nighttime. Among the HCs with staff quarters, the rooms are also inadequate to house immediate family members;

- Shortage of critical staff at the HCs compromising the delivery of quality health services. This is partly attributed to inadequate recruitment, retention and motivation strategies for health workers due to limited funding;

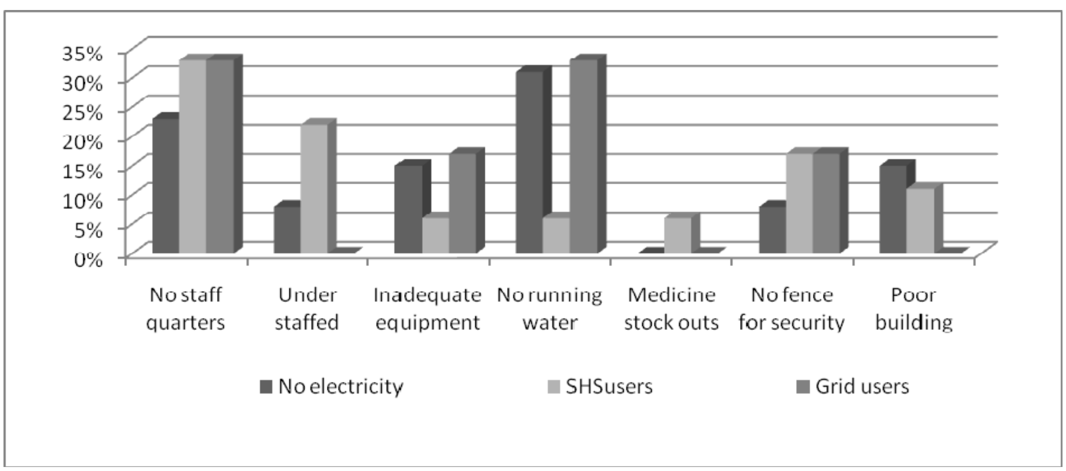
- Low motivation of health staff due to low payment characterized by high rates of absenteeism which puts a strain on the available staff that are unable to cope with the numbers of patients.

III. ASSESSMENT FINDINGS

3.0 Main Difficulties of Health Centres II

In general, HCs face similar challenges irrespective of whether electricity is used or not. The main difficulties that HCs II cope with, according to HC In-charges interviewed, are the lack of accommodation for health staff at the HC premises and the lack of safe water for use during the delivery of medical services. Comparing the HCs with electricity (solar or grid) to those without electricity, in addition to the lack of staff quarters, the challenge of insecurity due to the absence of a perimeter fence around the HC is more distinct among the HCs with electricity than those without electricity. It is reported that the security lights attract people from the surrounding village who trespass on the HC property, at times vandalizing HC property. The danger is even greater for HCs with solar electricity that risk the loss of the solar panels through theft. Other challenges include inadequate medical supplies such as gloves and injections; few staff in relation to the number of patients – possibly due to low payment as it will be discussed further; and the poor state of the HC buildings in relation to size and quality of structure (see chart).

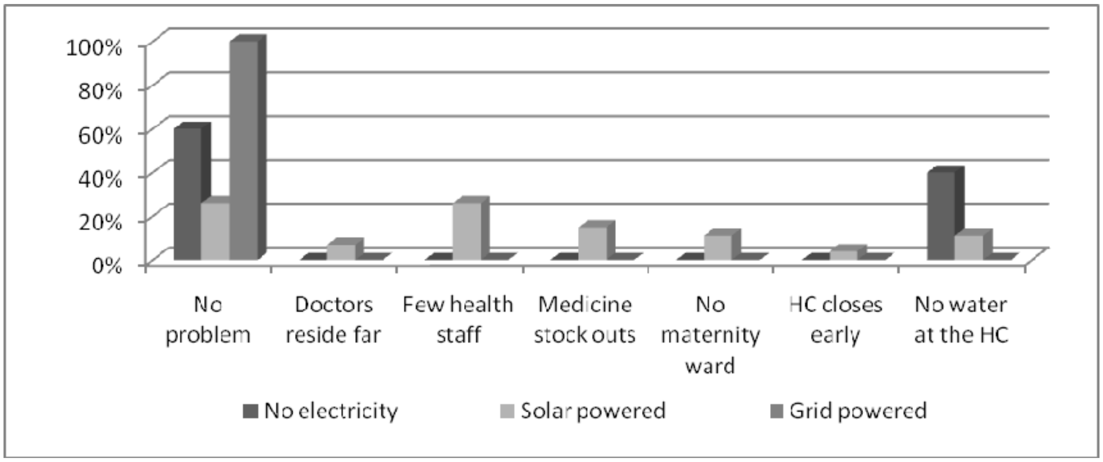
Figure 2: Main difficulties faced by HCs II



The findings from interviews with patients who receive services from the HCs II also confirm the inadequacies in staffing which causes patients to spend long hours at the

HCs before they are attended to. Other challenges mentioned include the lack of water at the HCs and the occasional medicine stock outs that make medication expensive for especially the poor (see chart).

Figure 3: Main critics of HCs II by patients

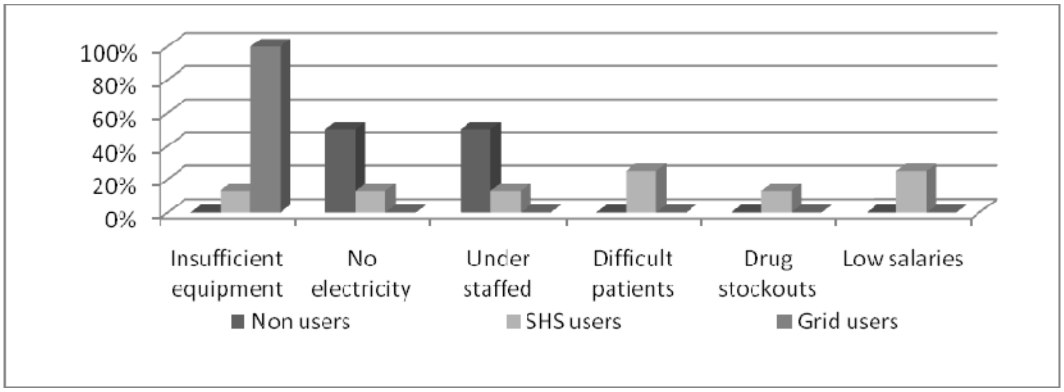


Interestingly the lack of energy and lighting was neither quoted by the In-charges nor by patients of HCs without electricity. Although astonishing at the first glance, it becomes clear that lighting is not seen as a major problem for HCs II as the main service is to treat outpatients during the day, for which no artificial light is necessary. Further, concerning the second main service of immunization, even HCs II that do not have any electricity source are to a great extent equipped with gas fridges so that vaccines are most of the time available.

3.1 Main Difficulties faced by Staff residing in HC II Staff Quarters

According to HC II staff, the main challenges with the working conditions - irrespective of the availability of electricity – is inadequate pay which results in low motivation, and absenteeism of health staff at the Health Centres. The available staff is therefore strained in having to attend to several patients, which compromises their quality of service delivery. Similarly in non electrified HCs II, the main challenge is the lack of staff - possibly due to low payment - which affects the workload and quality of medical care. But in contrast to HCs which have a solar system, the non electrified HC staff mentioned the lack of electricity as their second most important problem. The lack of light was especially said to be a major problem by HCs that provide emergency services when examining and treating emergency cases in the evenings (see chart).

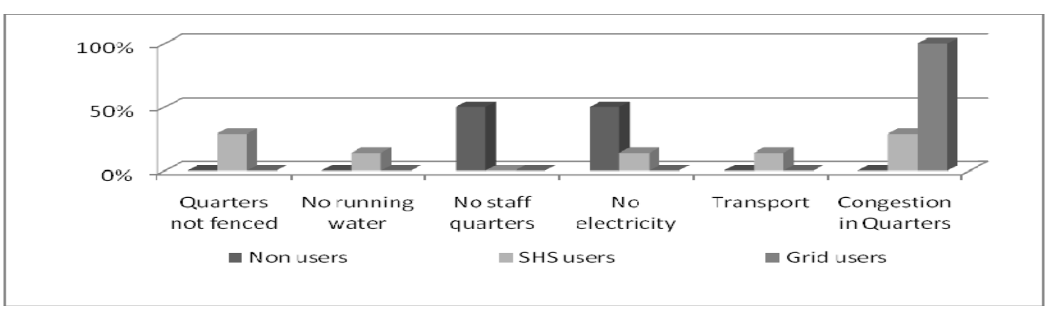
Figure 4: Main difficulties of working conditions for HC II staff



With regard to the living conditions at the HC II staff quarters, the main challenges faced by solar system equipped quarters include insecurity due to the absence of perimeter fencing around the HC premises and congestion in the staff quarters. Typically, the staff quarters at health centres are made up of 4 rooms which all health staff have to share with some of their family members.

Most HCs without electricity do not have staff quarters, and health staff that have to attend to emergency deliveries at night have to spend the night at the HC. Other difficulties mentioned include high transport costs to nearby towns and the lack of safe water for use at the staff quarters (see graphic).

Figure 5: Main difficulties of living conditions at HCs II staff quarters

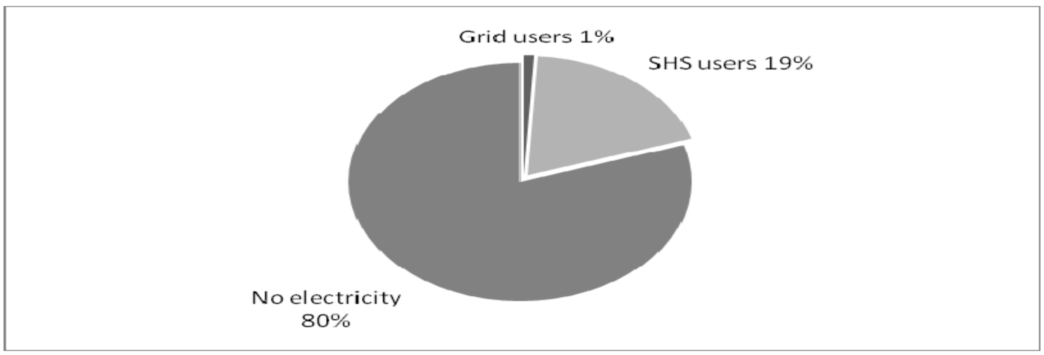


4.0 ENERGY

4.1 Electricity Sources

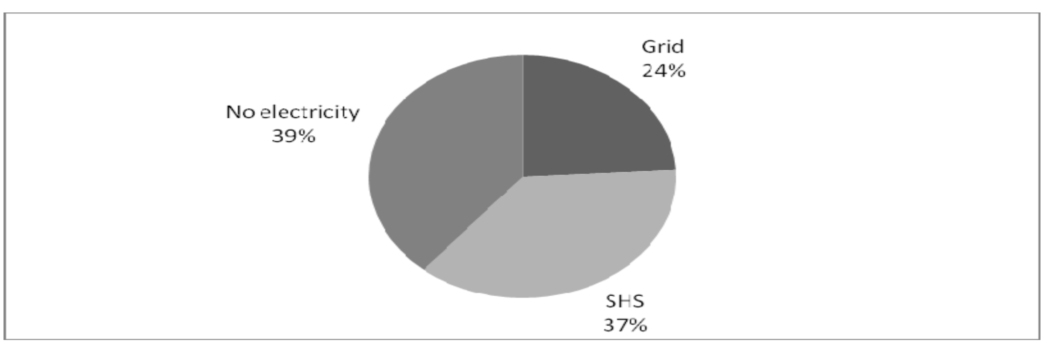
According to the ERT Health baseline report- 2004, 80% of all the HCs II in Uganda do not use any form of electricity owing to their location in remote rural areas. Out of all the HCs II, 19% use solar electricity, while only 1% are connected to grid electricity (see chart).

Figure 6: Electricity sources used by HCs II in Uganda[3]



In contrast, according to the findings in the study region (Kayunga and Jinja, 2009) a bigger proportion (60%) of the HCs II are electrified with grid or solar, with the majority of these (37%) having solar electricity as a result of donor and government support. The 24% of HCs II with grid power are mainly located near major towns or along highways, while the remaining 40% of the HCs II do not have access to electricity (see chart).

Figure 7: Electricity sources of HCs II in Jinja and Kayunga



[3] Source: ERT Health report- Baseline

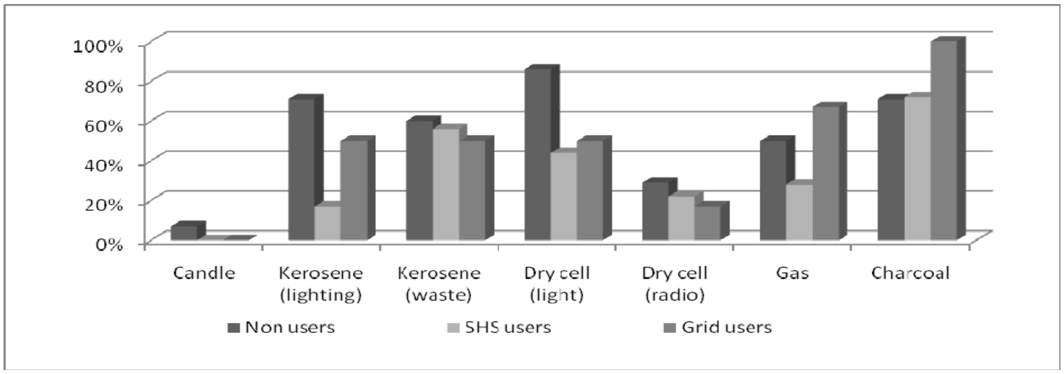
4.2 Other Energy Sources

Usage of traditional energy sources

Irrespective of whether HCs are electrified or not, HCs II use alternative sources of energy including gas, kerosene, charcoal and dry cell batteries. Kerosene is mainly used for waste burning by all the HCs and for lighting by the HCs without electricity. Further, kerosene is used as backup lighting for grid electrified HCs during periods of power outages at night, which in some areas last up to one week and might occur several times a month. Gas on the other hand is used for running the cold chain for vaccines; while charcoal is used for sterilization of medical equipment used by the HCs. In addition, HCs II use dry cell batteries to light torches used by security guards at night, and in some cases to power radios used at the HCs.

With regard to usage of the traditional sources of energy, there is minimal difference between the electrified and non electrified HCs II. Both use charcoal and kerosene for waste burning. There is however reduced usage of kerosene for lighting and gas for the cold chain among solar users compared to grid users and non electrified HCs. As a result of the relatively stable and reliable electricity provided by the solar system, HCs II with solar PV systems rarely use kerosene lanterns for emergency work at night. The use of gas for the cold chain among some solar users has also been replaced with the use of solar fridges with only 17% continuing to use gas fridges in addition to the solar fridges. The continued use of gas fridges was explained by the solar fridges not having the required temperature for vaccine storage with some being either too cold or not cold enough, while others were non functional at all. The usage of dry cell batteries for lighting is also less among the electrified HCs (roughly 50%) and is lesser among the solar users, again due to the stability of electricity supply especially for security at night. Candles are rarely used and were only reported among 7% of the non electrified HCs (see chart).

Figure 8: Usage of traditional sources of energy by HCs II



In terms of quantities utilized, kerosene is the most used energy source by both electrified and non electrified HCs II mainly for waste burning with an average of 6.3 liters per utilized month. In contrast, the usage of kerosene for lighting is highest among the non electrified HCs II (on average 9.7 liters per month) followed by grid users who use kerosene during periods of load shedding (on average 3.5 liters per month). Due to the reliability of solar electricity, however, HCs with a solar system nearly completely replaced kerosene light with electric light and use the least amount of kerosene for lighting (on average 2.3 liters) to conduct nighttime emergencies on the days when the system is not working.

All the HCs II use charcoal for sterilization of medical equipment. The quantity utilized is one sack per month irrespective of whether an electricity source is available. The quantity of gas utilized is also similar among the users in electrified and non electrified HCs with - on average - one cylinder being utilized in three months. HCs with grid electricity mainly utilize the gas during power outages, while HCs that were equipped with a solar fridge that is well functioning discontinued the use of gas (see table).

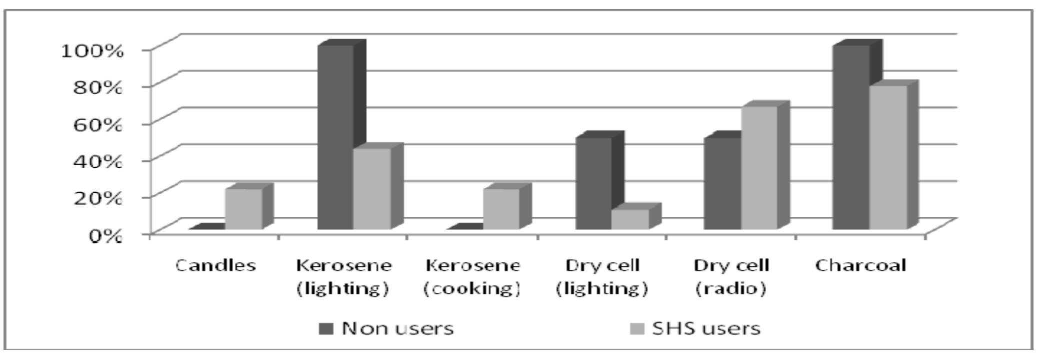
Table 3: Average monthly quantities of energy sources used by HCs II

USE	Kerosene-lighting *(liters)*	Kerosene-waste *(liters)*	Dry cell - lighting *(pairs)*	Dry cells-radio *(pairs)*	Gas *(cylinder)*	Charcoal *(sack)*
Non users	9.7	5.2	4.3	3.8	.4	1.1
SHS users	2.3	7.1	5.2	4.0	.4	1.0
Grid users	3.5	8.3	2.3	.0	.3	0.9
Total	6.9	6.3	4.4	3.9	.4	1.0

Usage of traditional energy sources- HC II staff in quarters

The findings also show reduced use of kerosene for lighting among HC II staff residing in staff quarters equipped with solar PV systems in comparison to the non electrified staff quarters (represented by 40% and 100% respectively). There is also reduced use of dry cell batteries for lighting among the solar users. In contrast however, there is no significant difference in the use of charcoal for cooking and dry cell batteries for radio between the solar users and non users represented by an average of 70% and 50% respectively (see chart). As will be discussed further however, the quantities utilized of dry cell batteries used for radio differ between the users and non users of solar PV systems. Candles, although rarely used, supplement the PV light on the days when the system does not light due to bad weather or technical faults. Unlike the non electrified quarters, more solar PV users use kerosene for cooking- possibly as a result of their preference to cook from indoors due to the availability of electric light.

Figure 9: Usage of traditional energy sources by staff residing in HC II staff quarters



Generally, on a monthly basis, the staff residing in quarters with solar PV systems use smaller quantities of traditional energy sources compared to their counterparts residing in quarters with no electricity source (see table 4). With the exception of kerosene for cooking (6 liters per month by some solar PV users); all other traditional sources of energy (kerosene for lighting, charcoal dry cell batteries for lighting and for radio) are used in larger quantities among the non PV users than the users.

Table 4: Mean monthly quantities of energy sources used by HC staff residing in quarters

USE	Kerosene-lighting *(liters)*	Kerosene-cooking *(liters)*	Dry cell -lighting *(pairs)*	Dry cells-radio *(pairs)*	Charcoal *(sack)*
Non users	11.0	0	4.0	8.0	1.5
PV users	1.4	6.0	2.0	5.6	.8
Total	4.6	6.0	3.0	5.9	0.9

The use of kerosene for cooking among solar users can be attributed to the preference to cook from indoors as a result of the electric light provided by solar, while the reduction in quantities of dry cell batteries for radio used can be partly explained by the availability of solar electricity to power radios. These findings point to the conclusion that the availability of solar power in staff quarters reduces the use of traditional sources of energy notably for lighting, but has little effect on the usage of energy sources for cooking.

4.3 Expenditure on Energy

4.3.1 Expenditure on energy by HCs II

A comparison of the total monthly expenditure on the various energy sources reveals the highest cost to be incurred by HCs II that use grid electricity (on average UGX 40,000 per month) compared to solar users of AC systems that typically spend UGX 2,000 per month (replacement costs of AC bulbs; battery replacement costs not included[4]). In Kayunga, where some DC systems were installed the replacement cost for one bulb might represent as much as UGX 20,000. The electricity source notwithstanding, all HCs II spend on kerosene for waste burning (some HCs were not able to quantify the amount) and charcoal for sterilization. The average monthly expenditure represents UGX 12,000 for kerosene and UGX 16,500 for charcoal (see table). The other major expenditure is on kerosene for lighting - particularly for non electrified HCs and as backup for the grid-connected HCs II at UGX 12,000 per month. Considering that grid electricity is unreliable, requiring grid electrified HCs II

[4] Battery replacement is a major re-investment which is expected to be necessary after 4-5 years. According to the MoU between GTZ and the DHO, the DHO is responsible for battery replacement.

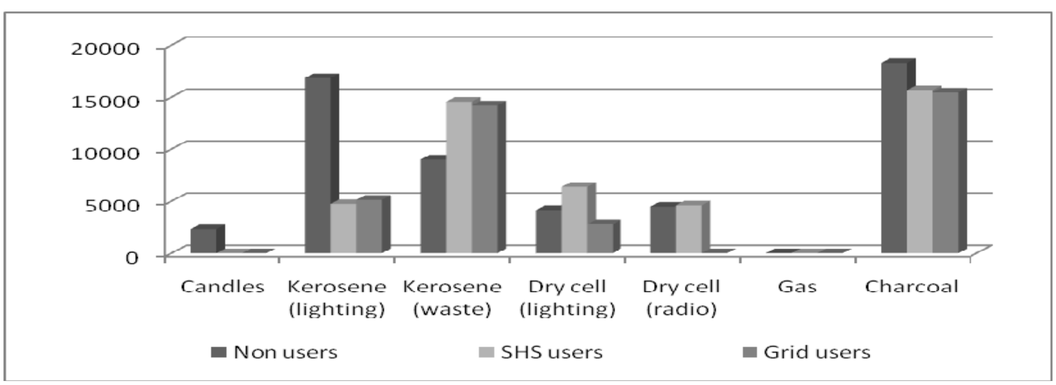
to spend on kerosene for lighting alongside the payment of the electricity bills, the use of solar electricity by HCs II becomes a cheaper option in the long term.

Table 5: Average total monthly expenditure on energy sources by HCs

Energy source	Mean (UGX)
SHS	2,000
Grid electricity	40,000
Dry cells for lighting	4,871
Dry cells for radio	4,538
Kerosene for lighting	11,947
Kerosene for waste burning	11,738
Charcoal	16,575

In line with the usage of the various energy sources, further analysis of the total monthly expenditure on energy by electrified and non electrified HCs II reveals minimal difference between the expenditure on charcoal and kerosene for waste burning. In contrast, solar PV users spend the least on kerosene for lighting per month (on average UGX 4,700) compared to non electrified HCs and grid users at UGX 16,000 and UGX 5,100 respectively. The use of dry cell batteries for lighting is slightly higher among the solar PV users than the non electrified and grid users, possibly as a result of increased use of torches by security guards at night to prevent the theft of the solar panels (in areas not lit by the solar system). The use of candles and dry cell batteries for radio is rare - on average 11 candles a month and 4 pairs of dry cell batteries- whereas the gas for refrigeration- on average 1 cylinder in 3 months - is supplied to the HCs by UNEPI (Ugandan National Program on Immunization) at no direct cost to the HC (the government bears the cost). (see chart).

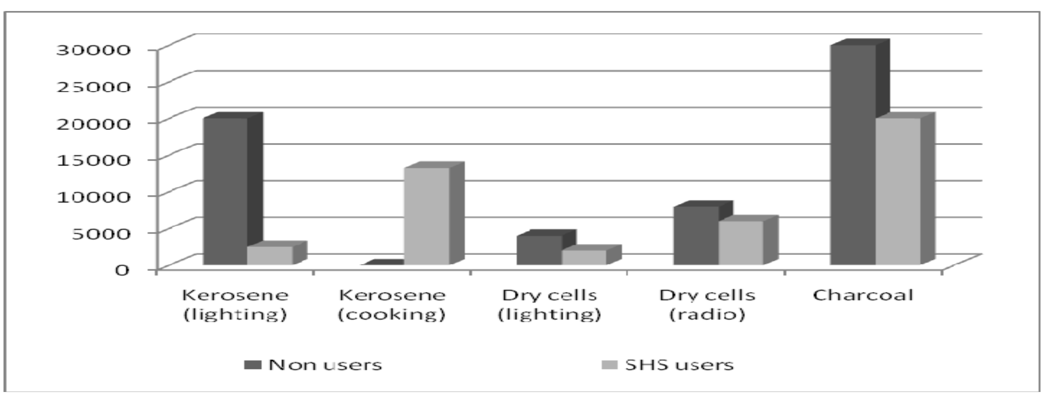
Figure 10: Expenditure on traditional sources of energy by HCs II



4.3.2 Expenditure on energy- HC staff residing in staff quarters

The HC II staff residing in quarters equipped with solar systems do not incur any monthly cost to use the electricity. The main energy expenditures for these staff are on charcoal for cooking (an average of UGX 30,000 per month for the non users and UGX 16,000 for the solar PV users) and on kerosene for lighting by staff residing in non electrified quarters (UGX 20,000) and kerosene for cooking among solar users (UGX 13,300). In line with the quantities of dry cell batteries used by solar users and non users, it was also found that the staff residing in quarters with solar systems on average spend less on dry cell batteries for lighting and for radio at UGX 2,000 and UGX 6,000 respectively compared to the staff in non electrified quarters represented by UGX 4,000 and UGX 8,000 respectively (see chart). This could be attributed to the availability of solar as a substitute for batteries for powering radios and providing electric light. Hence solar PV has a likely positive impact of reducing health staff expenditure on traditional sources of energy, notably on kerosene for lighting and dry cell batteries. In addition, as will be discussed further, most staff possess cell phones of which those that work in non-electrified HCs charge for around UGX 300 to UGX 500 in nearby trading centers. Monthly expenditures can range from UGX 2000 - UGX 3000, an expenditure which is not incurred by the staff working in solar equipped HCs and staff quarters. It is becomes more common to also use cell phones to listen to radio, in which case the cost could rise to UGX 5,000per month.

Figure 11: Mean monthly expenditure on energy by HC II staff residing in staff quarters



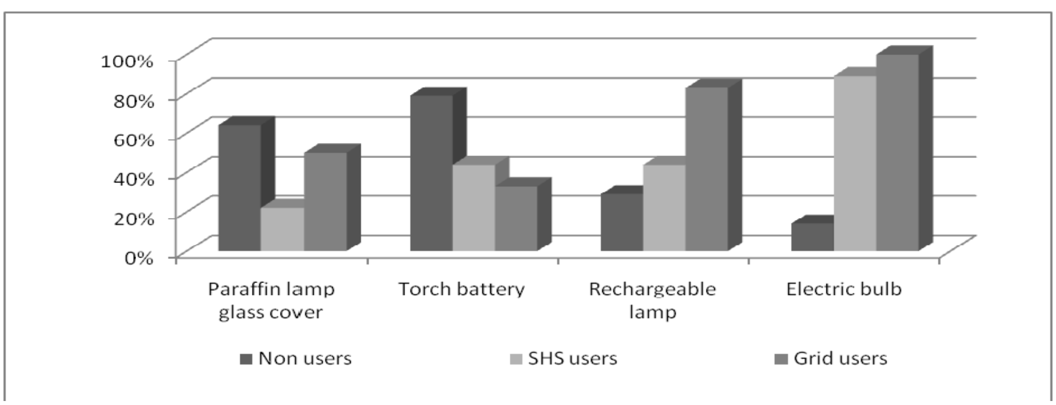
5.0 MEDICAL CARE

5.1 Use of lighting devices for medical care

Typically HCs II open from 8.00am and close at 5.00pm, except for some HCs II with staff quarters or an emergency nurse sleeping over at the health centre that may open to attend to emergency cases during nighttime. Irrespective of the use of solar PV or grid, about 65% of HCs II with solar systems and 50% of the grid connected centers attend to emergency cases during nighttime and carry out emergency deliveries. In consequence, around 35% of HCs II- irrespective of whether they are equipped with solar systems or not- do not work beyond 5.00pm and typically do not use any lighting devices for medical services.

For the HCs II that do open at nighttime, the lighting devices that are used include electric bulbs (including mobile spotlights which were distributed to HCs in Jinja), rechargeable lanterns (for HCs II with grid or solar power) and paraffin glass cover lanterns (for both non electrified and electrified HCs). About 50% of the non electrified HCs II and the grid users use paraffin glass cover lamps while this is the case for less than 20% of the centers equipped with solar systems. Accordingly, the finding that the use of solar reduces the use of kerosene for lighting can be reaffirmed. The findings also show more use of rechargeable lamps among grid users than solar PV users as a result of the frequent power outages due to load shedding or delayed payment of electricity bills (see chart).

Figure 12: Lighting devices used by electrified and non electrified HCs II



On average, irrespective of the use of electricity, HCs II own 1 paraffin glass cover lamp and 1 dry cell battery torch. In addition, HCs II with electricity use an average of 10 electric bulbs of 7 to 11 watts and 1 rechargeable lamp. Typically, 2 out of the 10 electric bulbs are located outside the Health Centre to serve as security lights, which are typically lit for 10 hours every night. The remaining 8 bulbs are rarely used and are notably for emergencies and deliveries and in only those HCs II that occasionally open in the night. Rechargeable lamps are used as back up by grid and solar PV users on nights when there is no electric light and are lit for a maximum of 3 hours in one night. The torches on the other hand are used by security guards at night to patrol the unlit areas around all HCs.

The paraffin glass cover lamps are used mainly by non electrified HCs II that open for emergency deliveries in the night and are then lit for an average of 7 hours in one night. Nevertheless, paraffin lamps are also used by grid users and solar users as backup and are lit for an average of 4.5 hours by grid users and for 0.5 hours by solar users on days of technical faults with the PV systems or bad weather.

5.2 Impact of the lighting source on medical care

All HC staff of the grid connected HCs II rate the light quality at the health centres as sufficient or very good, whereas this is the case for only 7% of the non electrified HCs. Over 80% of the staff in HCs II with solar electricity rate the light quality as either very good or sufficient, while the remaining 20% had faults with their systems which were currently not fully functional. In contrast 90% of the staff in non electrified HCs II rate the light quality as not sufficient or very bad as the light output of a kerosene lantern are 5-10 times lower than of energy savers of 11 watt (see chart). Considering that HCs II are not typically open each night (on average 6 to 7 emergency night deliveries and 10 to 13 other emergencies such as accidents per month), this finding does not specifically affect the routine provision of medical care but rather the lighting for emergencies and security at the HC.

Accordingly, irrespective of whether HCs II have an electricity source or not, only 65% open for emergencies, while the remaining 35% - mainly those without staff quarters - are never open at night but use the light for security purposes only. Considering that not many emergency services are offered on a monthly basis and that the light at night is mainly used for security, it can be concluded that the quality and provision of light of the PV systems at HCs II is generally sufficient and that HCs are “over equipped” (some of the 8 bulbs located in back corridors, store rooms and other non-utilized rooms are not used at all and in some cases not even during nighttime emergencies).

The major problem which the current lack of lighting causes in the non-electrified HCs II is the complexity in conducting emergency deliveries. Some of the problems that have arisen due to inadequate lighting (expressed by 91% of the non electrified HCs) include accidents such as the midwives pricking themselves in the process of stitching the mother, and the inability of health staff to critically observe anomalies with the baby during delivery as well as ensure mother and child safety during delivery. Other challenges which the inadequate lighting causes include the difficulty to prepare the delivery room and to locate medical equipment at night during an emergency. Besides the absence of quality light at night, non electrified HCs II using kerosene lanterns also face the risk of accidents from the lighting device itself such as burns. Whereas none of the In-charges in electrified HCs II reported having had a staff member encounter an accident as a result of using kerosene lanterns, this was the case for 30% of the HCs without electricity.

It can be concluded that the quality of examinations and deliveries is enhanced by the availability of electric light, hence making solar energy better than kerosene light and even more reliable than grid electricity due to its irregularity.

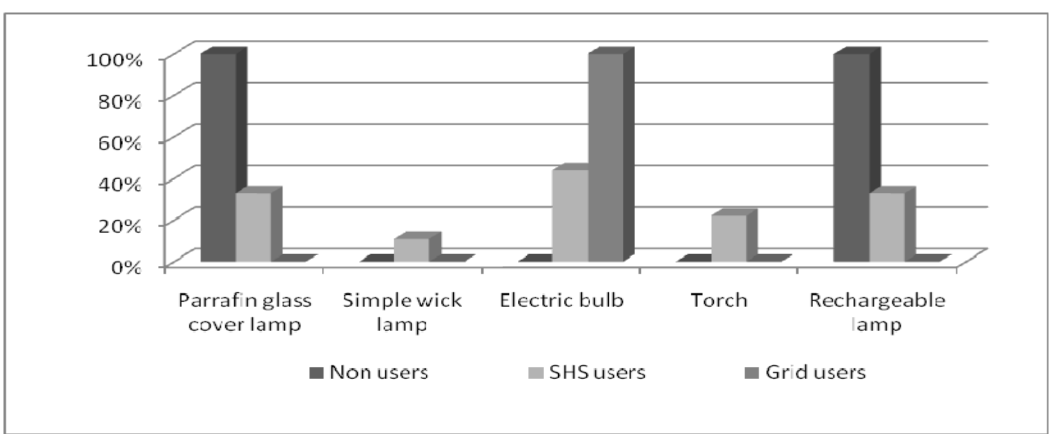
Overall, there is no difference in the number of emergency cases attended to between the electrified and non electrified HCs II which operate at night. In case of emergency, people do not choose the HC to go to but rather go to the HC that is closest irrespective of whether it is equipped with a solar system, grid or has no electricity.

Interviews with patients that visit the respective HCs II revealed that whereas 100% of the patients feel more comfortable and secure being treated in a HC with electric light, 92% do not choose to visit a HC because it has electric light. For the patients, it is more relevant if the centre has health workers to attend to them, offers good services and is near their place of residence. Out of the patients that were indifferent about the availability of solar electricity at the HCs, over 70% were more concerned about their ability to be attended to and obtain medication. 10% had never witnessed the PV system being used at the HC since the HCs were not open at night. In contrast, the 8% patients that visit the HCs because they are equipped with solar systems expressed that they were able to have instant immunization for their children and that the emergency services were better at nighttime due to the better quality of light. To this end, the installation of a solar system at a HC does not necessarily attract new patients to the HC, but enhances the confidence in the quality of service delivery and the timeliness of services offered.

5.2.1 Use of lighting in staff quarters

The main lighting devices used by HC II staff residing at staff quarters include paraffin glass cover lamps and rechargeable lamps for the non electrified staff quarters and electric bulbs for grid and solar PV users. The solar PV users mainly use electric bulbs for lighting (represented by 44% of the respondents- 5 out of the 9 PV systems at the staff quarters were not working at the time of interview) and paraffin glass cover lamps and rechargeable lamps to supplement the system during periods of bad weather or technical faults with the system. The latter two devices are also used to aid mobility to unlit areas. Other lighting devices include torches and simple wick lamps to light outside kitchens and other places not lit by the solar system.

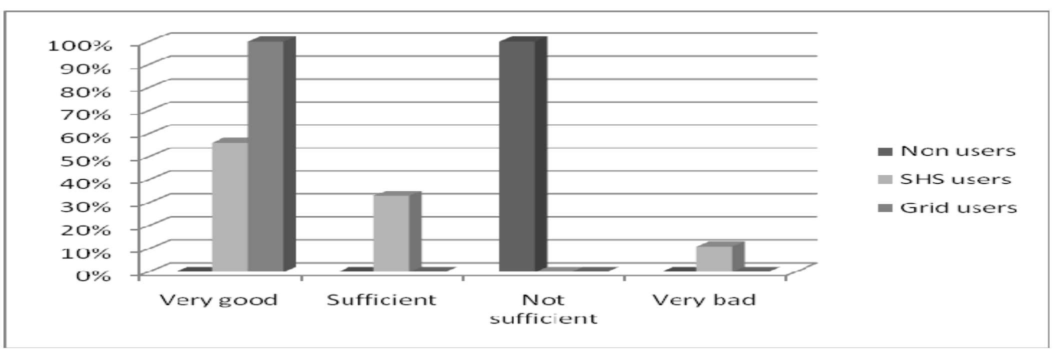
Figure 13: Lighting devices used by HC II staff residing in staff quarters



On average 2 rechargeable lamps are used in staff quarters without electricity and are used for 2 hours per night, while 1 rechargeable lamp is used in staff quarters with solar systems to supplement the electricity supply and is lit for 1 hour per night on average. The main lighting devices used in staff quarters with electricity are electric bulbs of 7 - 11 watts by all the grid users and 44% of the solar PV users whose systems are fully functional. On average, 4 electric bulbs are used and are typically lit for 3 hours each night. In addition, solar PV users occasionally use candles to supplement the system during power outages. The light is reportedly used to complete HC records work and other domestic chores of HC staff in the evenings.

The health staff residing in quarters with electricity generally rate their light quality as very good and sufficient as represented by 90% of the solar PV users and 100% of the grid users respectively. The non electrified HC staff quarters and 10% of the SHS users (with non functional solar systems) on the other hand rate the light quality as not sufficient and very bad (see chart). This finding justifies the usage of kerosene for lighting and rechargeable lamps among some of the solar users.

Figure 14: Rating of light quality in HC II staff quarters



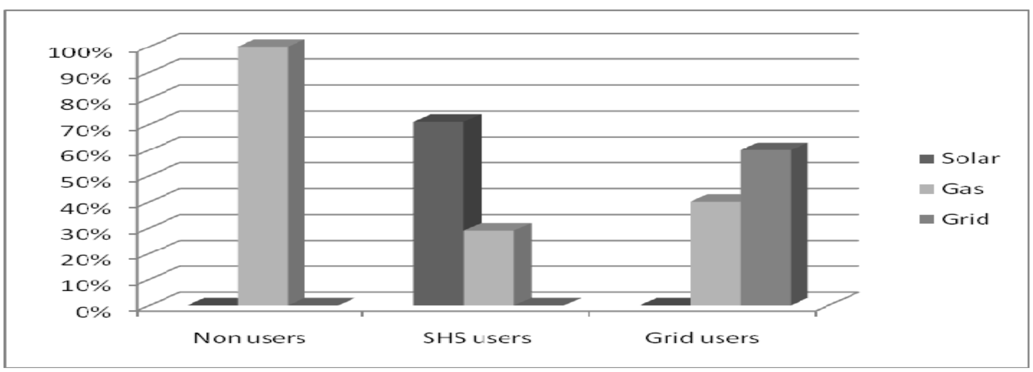
5.3 Use of technical appliances for medical care

In accordance with the minimum health care package for health units, HCs II do not own any electric technical equipment since out patient, immunization and emergency deliveries are the only services offered. The kind of appliances found at the HCs included a weighing scale, radios powered by dry cell batteries and/or electricity and private cell phones which are also used for work (as mentioned in the lighting section

HCs in Jinja were equipped with additional mobile medical spotlights; other centers received rechargeable lanterns; the exact number could not be established as some spotlights and rechargeable lanterns seemed to be stolen). Although not provided by the Ministry of Health, the In-charges expressed the need to use electric sterilizers and microscopes to enhance their service delivery.

Considering that immunization is one of the key services of HCs II, refrigeration becomes central for vaccine storage. Whereas all HCs II are supposed to have fridges, this was the case for only 85% of the HCs visited. Typically, all HCs II without an electricity source use gas fridges whose effectiveness is hampered by the intermittent supply of gas and the fact that there are no warnings when the gas runs out.[5] The HCs II with grid electricity on the other hand use fridges that operate on electricity and gas and therefore switch to gas only during periods of power outages. Out of the HCs II with fridges, 35% have solar fridges which were supplied with the support of PREEEP. Only the HCs II in Jinja (70%) were equipped with solar fridges while the remaining 30% of the solar equipped centers in Kayunga were not provided with solar fridges and continue to use gas (see chart).

Figure 15: Energy sources for fridges used at HCs II

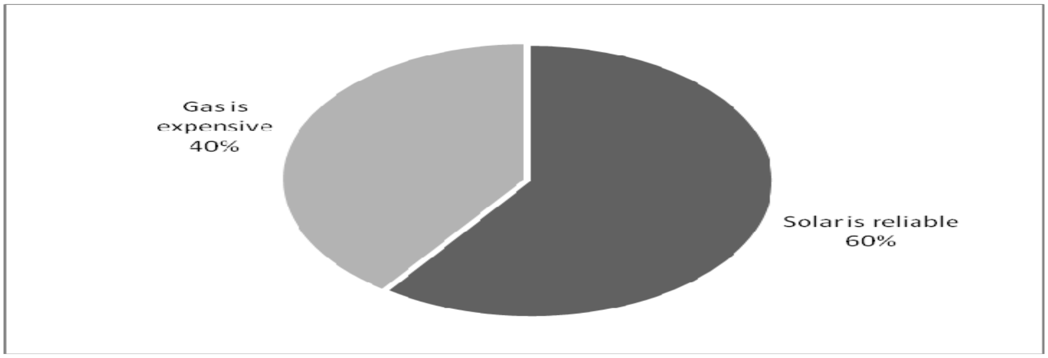


Comparing the use of solar fridges to gas fridges, 95% of the HC II In-charges preferred solar fridges to gas fridges for the main reasons that solar fridges- if technically functional- are more reliable than gas. They are also cheaper to operate as they do not involve running costs that are common to gas fridges. Such costs include transport to transfer vaccines to the nearest health unit when the gas runs out and to

[5] The reliability of gas supply through MoH varies from district to district.

collect replenishments of gas cylinders from the District Health Office which is far off from most HCs, as well as the risk of gas scarcity (see chart).[6]

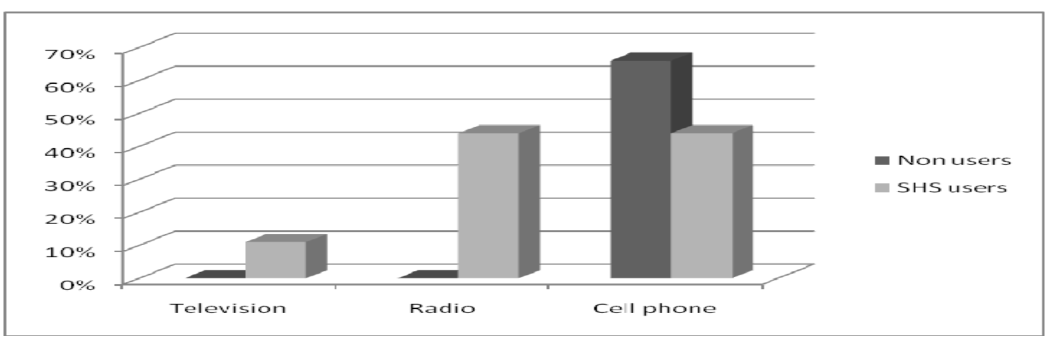
Figure 16: Reasons for preference of solar fridges to gas fridges by HCs II



5.3.1 Use of electric appliances in staff quarters

The kind of electric appliances used at HC II staff quarters include televisions, radios and cellular phones- among the solar and grid users- and mainly cell phones among the non users. Whereas the staffs in staff quarters equipped with solar systems charge their phones from within the HC premises (in the staff quarters and at the HC), the staffs residing in the quarters without electricity on the other hand mainly charge their cell phones from nearby trading centres and at the HC (for staffs who have electricity at the HC but not within their quarters) (see chart). The appliances are used for an average of 3 hours for the television and 6 hours for the radio. The findings show that the availability of solar power promotes the use of electric appliances that might enhance knowledge through media information.

Figure 17: Electric appliances used by Health Staff residing in staff quarters



[6] In addition, MoH has to purchase the gas and transport it to the DHO.

5.4 Use of cellular phones for medical service

In all the HCs II visited, the In-charges own personal cellular phones which they also use to facilitate their medical work through communication with the DHO and other colleagues in the medical profession. However, the availability of the cellular phones of In-charges without electricity is not always guaranteed due to lack of an immediate phone charging facility. As such, the availability of solar systems at previously non electrified HCs II facilitates more reliable communication.

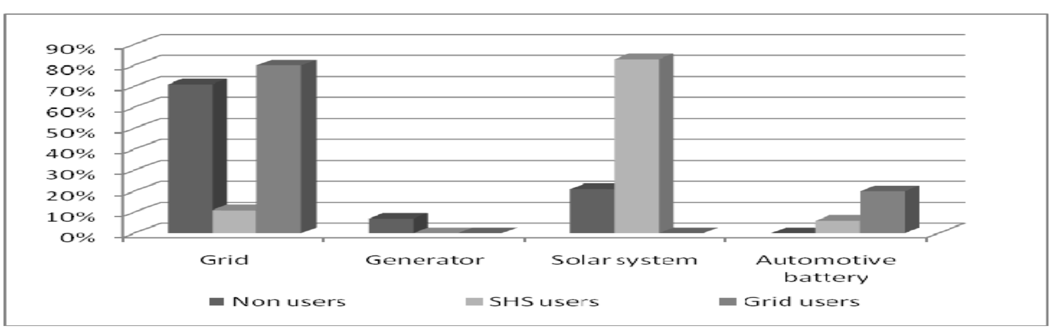
On average, the health staff at the HCs II have 4 cellular phones, however the number of phones among staff is higher in HCs with grid and solar electricity than among the staff in non electrified HCs (see table). The availability of an electricity source to facilitate phone charging can be taken to influence the ownership and use of cellular phones.

Table 6: Mean number of cellular phones at HCs II

USE	Mean	Frequency
Non users	3.2	14
SHS users	4.4	18
Grid users	5.2	5
Total	4.1	37

It was found that the majority (80%) of staff from HCs with grid and solar electricity charge their phones at their workplaces or at staff quarters, while staff from non electrified HCs mainly charge their phones using grid electricity at their residences (outside HC premises) or at nearby trading centres.

Figure 18: Electricity sources for charging phones at HCs II

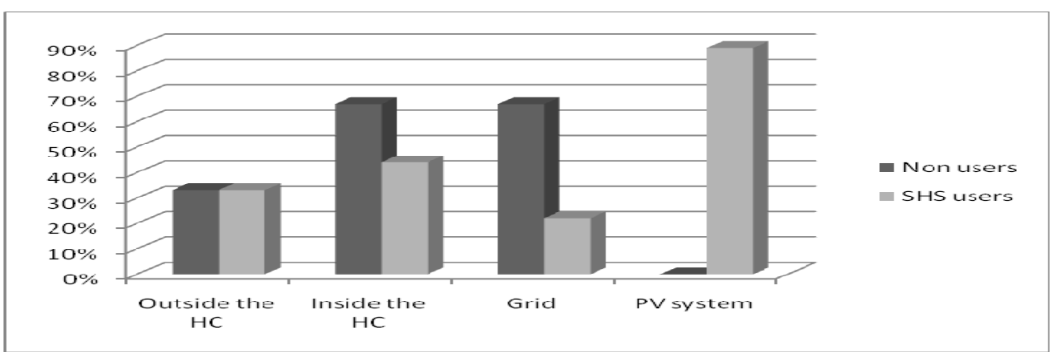


5.4.1 Use of cell phones in staff quarters

Nearly all the staff residing in HC II staff quarters own cellular phones. The findings however reveal that on average, the staff in quarters with solar systems have more cell phones than the staff residing in quarters without electricity (represented by 4 phones and 1 phone respectively). The availability of solar power at the staff quarters facilitates uninterrupted communication for the staff, who are able to charge their phones using the PV system.

The findings show that 90% of the solar PV users charge their phones using the system while the remaining 10% charge their phones using grid power outside the HC owing to technical faults of the installed systems. The majority of staff in HC that do not have solar systems on the other hand charge their phones using grid power at the HCs (if available), while others charge their phones from nearby trading centres or their private residences outside the HC premises (see chart). In addition to the cell phones owned by the staff, an average of 4 other phones not belonging to HC staff are regularly charged using the PV systems in staff quarters at no charge, hence enabling other people and notably family members of the staff to benefit from (cheaper) communication as well. Although beneficial for staff family members, the charging of too many phones reduce the available power for necessary lighting in the HCs and staff quarters.

Figure 19: Sources for charging phones owned by HC II staff residing in staff quarters



5.5 Gender impacts of solar PV electrification of health centres

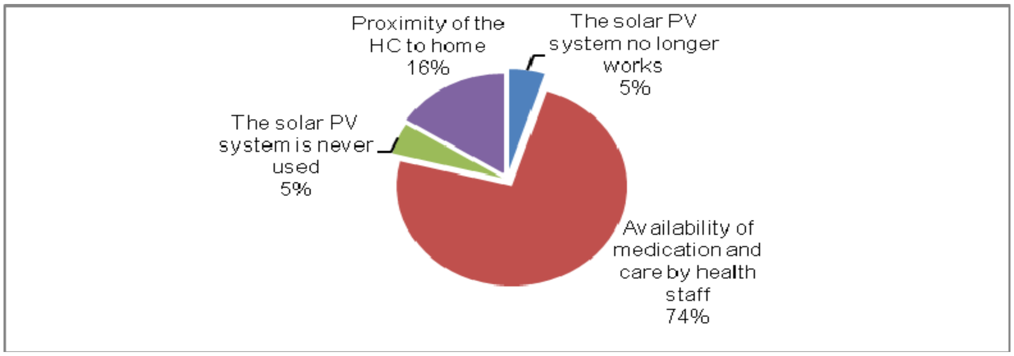
As indicated in section 5 above, the electrification of rural health centres with solar PV has the benefits of providing lighting for extended period and/ or emergency night health services, clean light for safe child delivery, external lighting for enhanced security and the local storage of vaccines in solar powered refrigerators.

5.5.1 Gender impact of solar PV electrification of health centres on patients

The majority (82%) of patients and/or patient attendants that were found and interviewed at the health centres during the study were female, while only 18% were male. The high presence of women at the health centres was explained by the fact that women- being the main caretakers of children in the household- make frequent visits to the health centres seeking treatment for their children. Other services mainly sought by women at the health centres include child immunization and antenatal services respectively. It was also reported by the women respondents that the availability of vaccines at the health centres kept in refrigerators powered by solar PV eased the burden of having to walk long distances for immunization services.

The findings however revealed that 100% of the men and 90% of the women respectively reported not to have chosen to visit the solar PV powered health centre because it had electric light, while 10% of the women reported that they had chosen the health centre because of the presence of solar PV. Further, 50% of the men and 80% of the women respectively expressed indifference about the availability of solar PV at the health centre. The majority of respondents attributed importance to the care and medication provided by the health staff (74%), the proximity of the health centre to their residence (16%), whereas 10% expressed that they had never seen the solar PV being used, as it was either never used or was not working entirely (see figure below).

Figure 20: “Do you visit the solar powered HC II because it has electric light?”

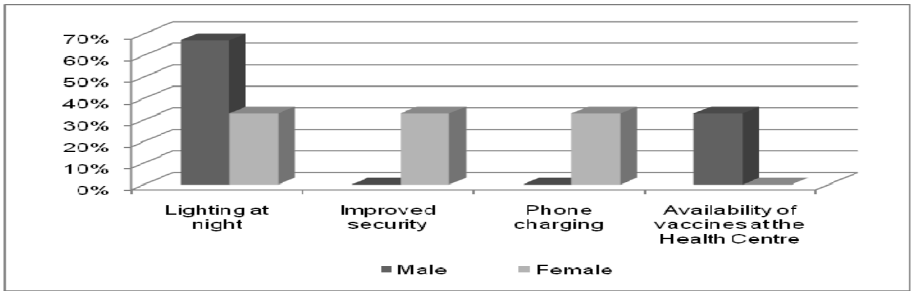


On the other hand, 50% of the men and 20% of the women interviewed expressed that they preferred to visit the health centre because it had solar PV. The reasons given for this were that the solar PV availed immunization services expressed by 50%, while the other 50% expressed that the presence of good light at the health centres ensured the proper diagnosis of illnesses through clearer observation of symptoms, hence better treatment.

From the findings above, it can be concluded that the electrification of rural health centres to a large extent benefits women more than the men as they are able to access emergency services for night deliveries (using clean and safe light) as well as addressing child emergencies.

5.5.2 Gender impacts of solar PV electrification of health centres on medical staff

The main benefit mentioned by health centre staff resulting from the installation of solar PV at the health centres as well as at their staff quarters was lighting that facilitated the completion of domestic chores and reading at night, expressed by 66% of the male staff and 33% of the female staff respectively. The female staff in addition mentioned the benefits of charging mobile phones to facilitate communication (33%) and improved security at the health centres and staff quarters facilitated by the security lights throughout the night represented by 33% (see figure below).



Following the experience of working in a health centre powered by solar PV, 60% of the female staff and 75% of the male staff respectively expressed that given the prerogative; they would opt to work in a health centre with electric light, while 40% and 25% of the female and male staff respectively expressed indifference to the availability of light at the health centre and staff quarters. These findings indicate that the electrification of rural health centres and staff quarters eases the work of the medical staff as well as the living conditions and is likely to contribute towards attracting and possibly retaining medical staff in rural health centres.

6.0 TECHNICAL FINDINGS OF PV SYSTEMS INSTALLED AT HCs II

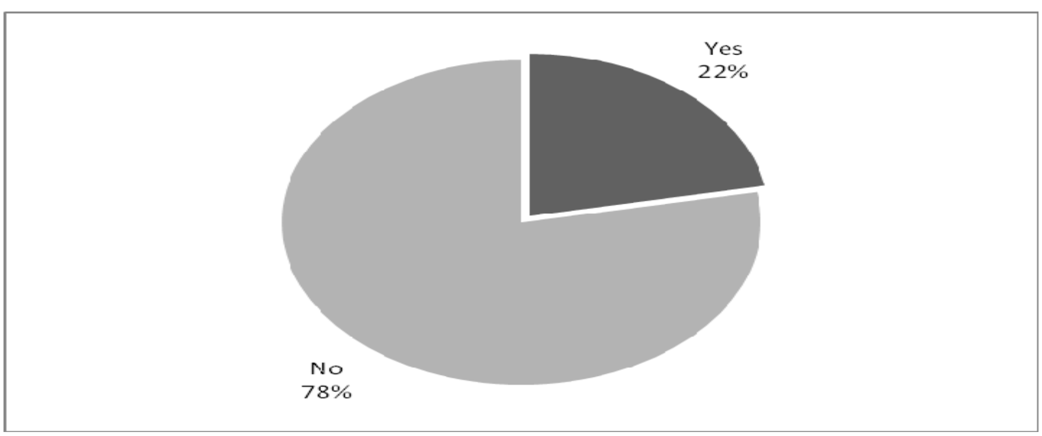
6.1 Technical performance of solar systems

The PV systems that are installed at the HCs II comprise of PV panels, batteries, a charge controller and bulbs for the DC Systems (Jinja) and with an additional inverter for the AC systems (rest). The PV panels and battery sizes vary between the different HCs depending on - beside other factors like size of building - the inclusion of a solar fridge alongside the PV lighting. Whereas the MoU with the Jinja DHO included the installation of solar fridges alongside the lighting system (of on average of 10 bulbs with sockets for cell phone charging and radio), the MoU with Kayunga DHO comprised of the installation of only lighting systems (also about 10 bulbs with sockets for cell phone charging and radio). As a result the PV panel sizes installed range from 450 to 650 watt peaks, with batteries of 1,000 to 1,400 ampere hours (for the systems with solar fridges) and 160 to 140 watt peaks with batteries of 200 to 800 ampere hours (for lighting only).

6.1.1 PV lighting systems

Out of the HCs II with PV lighting systems, 22% expressed having ever encountered problems with the systems whereas 78% had never experienced any problem with their system (see chart).

Figure 21: HCs II that encountered technical faults with the PV lighting systems

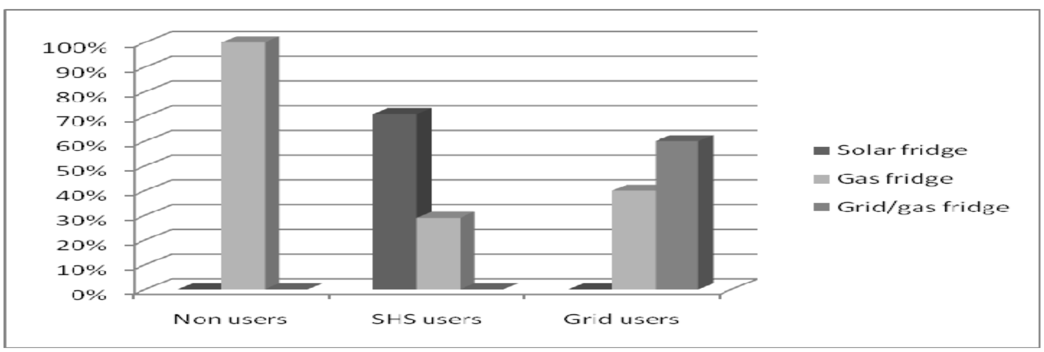


The main problems encountered were blown out bulbs, mentioned by 75%, while 25% mentioned that some switches and sockets[7] were not working. On average, it costs between UGX 10,000 to UGX 15,000 to replace a DC bulb whose average lifetime should be 2 years. Frequent blow outs of bulbs therefore make PV systems costly to run for the HCs II. Bulbs for AC systems are standard ones with a price of around UGX 2000. In contrast however, a paraffin glass cover lamp costs UGX 10,000 with an average lifetime of 3 years - and UGX 4,000 for a torch whose average lifetime is 1.5 years.

6.1.2 Solar fridges

Out of the 20 HCs II supplied with PV systems supported by GTZ PREEEP, 14 use solar fridges, while the remaining 6 use gas fridges. All non electrified HCs II on the other hand use gas fridges while 60% of the grid-connected health centres have fridges that are powered by either gas or grid electricity and the remaining 40% use gas fridges (see chart).

Figure 22: Types of fridges used by HCs II

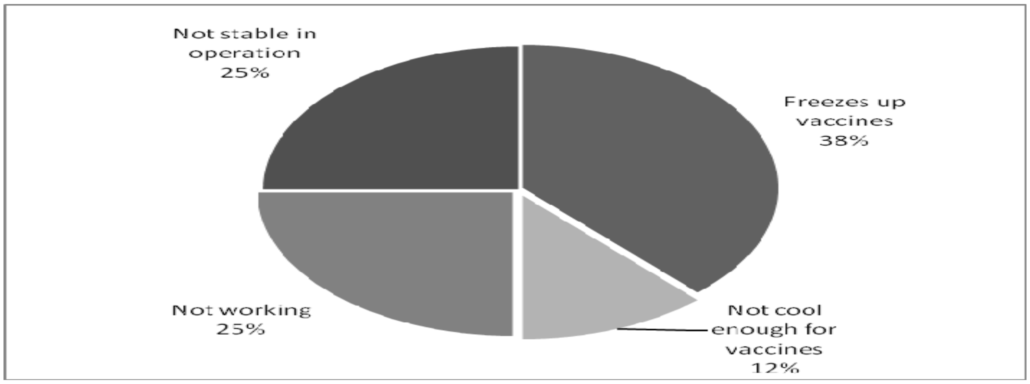


Half (50%) of the HCs II with solar fridges mentioned having encountered technical faults with the solar fridges while the other half had their fridges functioning well. The major faults of the fridges are believed to be linked to irregularities in the solar fridge compressor control unit (expressed by 50% of HCs with fridge faults). Whereas vaccines require storage conditions of a temperature ranging from -2 to +8 degrees to remain effective, 38% of the fridges with faults were too cold and would at times

[7] Users sometimes don't understand that some of the systems are DC systems with DC sockets. When plugging in AC appliances users believe the socket is not working. Therefore, GTZ included DC phone chargers and DC-AC converters for radios in more recent tenders and are also planning to equip the DC systems in Kayunga with these appliances ex post.

freeze the vaccines, while 12% of the faulty solar fridges were not cool enough. The other half of the faulty fridges (50%) were either not working consistently or not working at all (see chart).

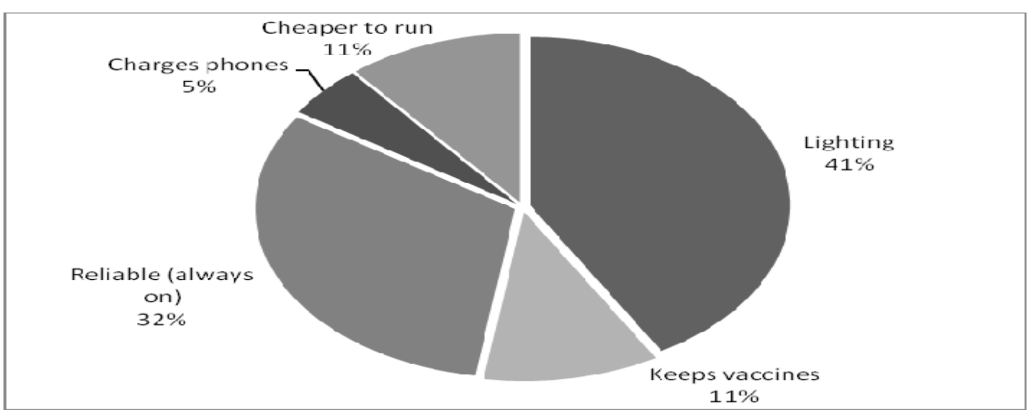
Figure 23: Technical faults encountered with solar fridges



6.2 Strengths of the PV systems

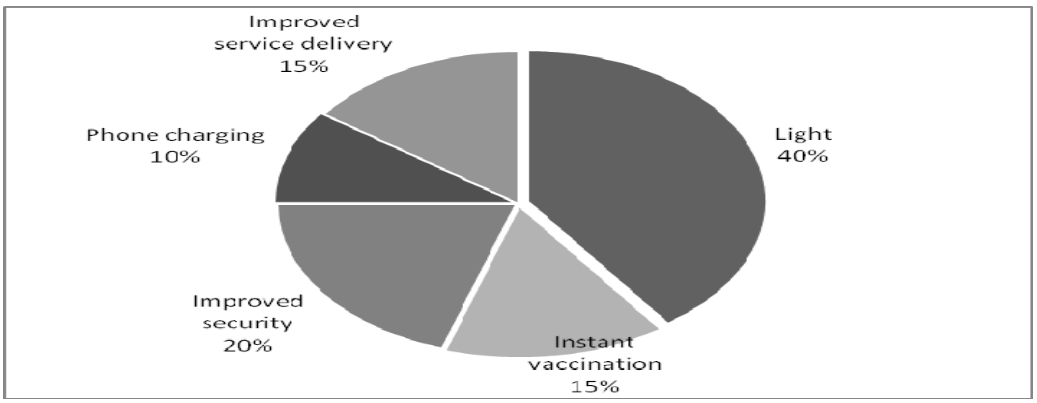
The main strengths of the PV systems- according to HC II staff- are the provision of light and the reliability of the system as an electricity source compared to grid power expressed by 73% respectively. Other strong points about the system, if functioning well, include its ability to power fridges for vaccines thereby facilitating instant immunization and the fact that it does not require monthly running costs. It also facilitates communication by providing free access to phone charging facilities in non electrified locations (see chart).

Figure 24: Strengths of the PV systems



The PV systems at HCs II – according to the In-charges - mostly benefit the staff (60%) followed by the patients (40%). The main benefits of the system include the availability of light for use when attending to emergency cases at night; light to facilitate completion of HC paper work by health staff after sunset, and improved security of the HC II premises throughout the night. On the other hand it was also quoted that the security light attracts theft and vandalism at night. Other benefits include the reduced costs of travel to obtain vaccines from nearby health units resulting from the use of solar fridges- for HCs that previously had no fridges, improved delivery of services (examination and treatment at night) due to better light and the access to a phone charging facility (see chart).

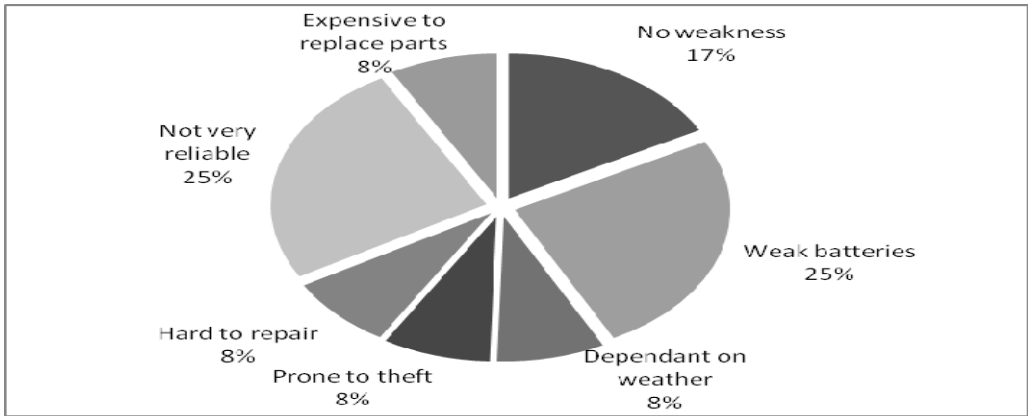
Figure 25: Major gains of PV systems



6.3 Weaknesses of the PV system

The weaknesses of the PV systems on the other hand include the weak capacities of some systems- particularly in HC staff quarters- which are unable to light for the designated hours (expressed by 25%). The weaknesses of systems at staff quarters could partly be explained by misuse by staff (too many phones charged) by way of overload, or by other technical faults. Severe weaknesses are faults which are related to the technical unreliability of some systems especially with regard to the 50% of the solar fridges not properly functioning hence are unable to store vaccines (expressed by HCs with faulty solar fridges). Other weaknesses of the installed systems - as mentioned by the HC staff - include the PV system's dependence on the weather for efficient functionality, its proneness to theft notably of panels, the complexities of the system for local technicians to repair and the expenses on replacement of parts and notably blown out bulbs for faulty systems (see chart).

Figure 26: Weaknesses of the PV systems



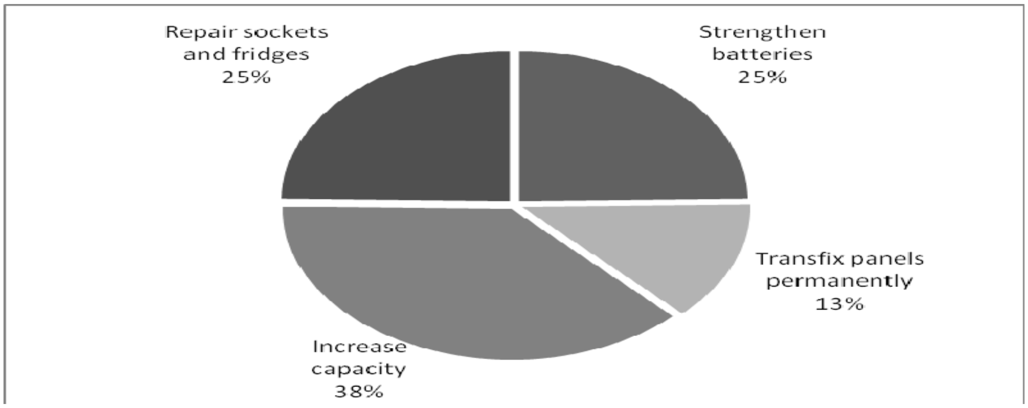
6.4 Improvements to the System

In line with the weaknesses mentioned about the solar systems, recommended solutions should focus on improving the technical reliability of the systems. The systems installed should also be of a kind that can be easily repaired by local technicians in case they were to develop faults.

In addition to the technical reliability, as illustrated in the chart below, HC II staffs recommend that in order to enhance the systems, stronger batteries (that can store energy for longer hours) should be provided; repairs made to the non functional systems and transfixion of solar panels made on the HC rooftops during installation to protect them from possible theft[8].

[8] As the roof panel fixations were not physically inspected it is impossible to conclude whether the panels are protected from theft as outlined by the solar companies. Whether the systems are weaker than technical data pretend cannot be proved neither as the information collected here relies on respondents´ subjective answers. It can only be assumed that while systems were installed by professionals that the weaknesses are due to too many cell phones charged by the staff.

Figure 27: Proposed improvements to the PV systems



Irrespective of the above mentioned perceived weaknesses, all the HC II In-charges recommend for PV systems to be installed at other HCs because solar light for emergencies during nighttime and refrigeration facilitates the delivery of improved medical services. Overall, 85% of the HC II staff are satisfied with the system, while only 15% - whose systems are currently not functioning well - are not very satisfied (see table). Similarly, all the non electrified HCs II (100%) and 70% of the HCs II with grid electricity would prefer to use PV systems as back up due to the unreliability of grid electricity.

Table 7: Satisfaction rating of PV systems by HC staff residing in staff quarters

		Frequency	Valid Percent
	Very satisfied	10	50.0
	Satisfied	7	35.0
	Not very satisfied	3	15.0
Total		20	100

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

From the assessment, the following conclusions are drawn:

- **Solar as pre or final electrification:** Solar electricity, although viewed as a viable option for pre-electrification of HCs II that are currently not covered by the national grid, seems to be a better and cheaper final electrification option considering the current problems associated with the intermittent supply of grid electricity at HCs. Solar electricity is a sufficient electricity source for HCs II which enables the uninterrupted delivery of the three main health services that are provided by HCs II namely treatment of outpatients, vaccination and emergency deliveries during nighttime. Nevertheless investment in inverters and batteries as back up for grid electricity would have a similar effect but is more costly in the long run.

- **Use of traditional sources of energy:** The use of solar electricity reduces the expenditure on traditional sources of energy notably for lighting and gas (in cases where solar fridges are provided) but has no impact on energy expenditure on fuel for waste burning and sterilization, which constitute the highest shares in the HC's total energy expenditure.

- **Use of lighting in HC:** Given the nature of services that HCs II are supposed to offer in accordance with the UNMHCP, the use of lighting is mostly for security purposes and at most two other rooms in the HC to attend to emergency cases and notably emergency deliveries.[9]

- **Use of lighting in staff quarters**: Although staff recruitment is strictly done at district level and is completely independent of the availability of solar electricity, staff quarters that are equipped with solar are likely to increase the motivation and morale of the staff who are able to complete paper work and

[9] However, it should be noted that the policy of the MoH is changing. According to an official from MoH it is planned to include deliveries in the range of services to be offered by HC II.

other domestic chores in the evenings after work, and whose living standards are also increased by quality light and a facility to charge their cell phones.

- **Use of technical appliances:** Considering that HCs II are not supposed to offer laboratory services, solar electricity becomes useful in powering solar fridges and sockets to charge cellular phones.

  Use of solar fridges: Solar fridges, if well functional, are better and cheaper than grid powered and gas fridges as they are more reliable and eliminate the associated costs for electricity bills or gas; transportation of vaccines in cases where the gas has run out and the risks of loss of vaccines due to gas scarcity.

- **Technical performance of PV systems:** The functioning of the PV systems and notably the solar fridges is hampered by the complexity of the systems which cannot easily be repaired by the districts' cold chain engineers.

- **Use of cellular phones:** The use of solar eases communication between HC II staff and their counterparts at the District Health Office and at other Health Centres as a result of providing a phone charging facility to ensure full availability.

7.2 Recommendations

The following recommendations could enhance program results:

- The installation of solar systems at HCs II should prioritize the HCs with staff quarters, as these are more likely to be open for emergency cases at night. HCs without emergency services at night that strictly open from 8am to 5pm should not be prioritized.

- Solar lighting systems should not be oversized as typical opening hours of HC II are from 8am to 5pm with around 10 emergencies during nighttime per month. As not all rooms are used for emergency services at night electric light is not required in all rooms.

- All HCs II should be equipped with solar fridges as, apart from emergency deliveries, immunization is a key service that is required by HC II. Gas fridges are unreliable due to occasional gas shortages.

- Care should be taken to install solar fridges which can be easily repaired by the districts' cold chain engineers (hence there is the need of simple and locally available solar fridges), and whose spare parts are readily available to ensure efficient functionality. Additional sound training and capacity building of the local cold chain engineers on how to repair the already installed systems is also key to enhance effectiveness.

- Coordinate with the Ministry of Health to prioritize the installation of PV systems at HCs III and IV which open 24 hours and where there is more use for electricity in accordance with the services offered under the Minimum Health Care Package.

APPENDIX I: HEALTH CENTRES II VISITED

	Health Centre	Electricity source
Jinja District		
1	Bubugo HC II	Solar
2	Bunawona HC II	None
3	Busegula HC II	Solar
4	Buwolero HC II	None
5	Bwase HC II	Grid
6	Ivunamba HC II	None
7	Iwololo HC II	None
8	Kabaganda HC II	Solar
9	Kabembe HC II	Grid
10	Kamiigo HC II	Solar
11	Kitanaba HC II	Solar
12	Kyomya HC II	Solar
13	Lumuli HC II	None
14	Lwanda HC II	Grid
15	Mafubira HC II	Grid
16	Masese Danida HC II	None
17	Masese Port HC II	None
18	Mawoito HC II	Solar
19	Mpungwe HC II	Solar
20	Muguluka HC II	None
21	Musima HC II	Solar
22	Mutai HC II	None
23	Nabitambala HC II	None
24	Nalinaibi HC II	Solar
25	Namwendwa HC II	Grid
26	Nawampanda HC II	None
27	Nawangoma HC II	Solar
28	Nsozibirri HC II	Solar
29	Wansimba HC II	Solar
Kayunga District		
30	Bukamba HC II	Solar
31	Bulawula HC II	None
32	Busaale HC II	Solar
33	Kakiika HC II	Solar
34	Kasokwe HC II	Solar
35	Nakatovu HC II	Solar
36	Nakyesa HC II	Solar
37	Namagabi Mission HC II	Grid
38	Namusaala HC II	None