SOPHIA

Sustainable Off-grid solutions for Pharmacies and Hospitals In Africa

NEEDS ASSESSMENT IN MEDICAL CARE CENTRES IN AFRICA

DELIVERABLE D1.1

VERSION 1.0

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SOPHIA CONSORTIUM

NO.	BENEFICIARY	ADDRESS	MAIN CONTACT
1.		**HOCHSCHULE KARLSRUHE (HKA)** Moltkestr. 30, DE-76133 Karlsruhe, Germany	**Coordinator:** Prof. Dr.-Ing. habil. Michael Kauffeld michael.kauffeld@h-ka.de
2.		**OST - OSTSCHWEIZER FACHHOCHSCHULE (SPF-OST)** Oberseestrasse 10, CH-8640 Rapperswil, Switzerland	Dr. Mihaela Dudita mihaela.dudita@ost.ch
3.		**MAKERERE UNIVERSITY (MAK)** Main Campus, PO Box 7072, 256 Kampala, Uganda	Prof. Dr. Nicholas Kiggundu kiggundu@caes.mak.ac.ug
4.		**FONDATION 2IE ASSOCIATION (2IE)** Rue de la Science, PO Box 01BP594, 01 Ouagadougou, Burkina Faso	Dr.-Ing. habil. Kokouvi Edem N'Tsoukpoe edem.ntsoukpoe@2ie-edu.org
5.		**STEINBEIS INNOVATION GGMBH (SEZ)** Steinhäuserstr. 12, DE-76135 Karlsruhe, Germany	Dr. Anthony Salingre anthony.salingre@steinbeis-europa.de
6.		**MINISTERE DE LA SANTE PUBLIQUE (MPHC)** Boulevard Rudolph Manga Bell Yaounde, Cameroon	Ms. Jeanne Aurélie Abomo Ayinda aureliejeannea@yahoo.fr
7.		**INSTITUT INTERNATIONAL DU FROID (IIR)** Boulevard Malesherbes 177, FR-75017 Paris, France	Ms. Ina Colombo i.colombo@iifiir.org
8.		**OPERIEREN IN AFRIKA EV (OiA)** Wirthstrasse 11, DE-79110 Freiburg, Germany	Prof. Bernhard Rumstadt b.rumstadt@gmail.com
9.		**EVERFLO(PTY)LTD (EVERFLO)** 10 Mclaren Way Racing Park, 7441 Milnerton, South Africa	Mr. Evert Potgieter evert@everflo.co.za
10.		**KOVCO PTY LTD (KOVCO)** Century City, PO Box 134, 7446 Century City, South Africa	Mr. Brendan Prestage bprestage@kovco.co.za
11.		**MARTIN SYSTEMS GMBH (MS)** Address: Friedrichstrasse 95, DE-10117 Berlin, Germany	Dr.-Ing. Jose Ordonez jose-ordonez@martin-systems.com
12.		**SIMPLY SOLAR SCHEFFLER TECHNOLOGIES AND CONSULTING (SISO)** Graf von Werdenbergstrasse 6, DE-89344 Aislingen, Germany	Ms. Heike Hoedt h.hoedt@simply-solar.de
13.		**RAACH SOLAR GMBH (RS)** Stellwinkel 1, DE-88451 Dettlingen an der Iller, Germany	Mr. Jürgen Raach juergen.raach@raachsolar.com

DOCUMENT INFORMATION

RESPONSIBLE PARTNER	MAKERERE UNIVERSITY (MAK)
AUTHOR (S)	Nicholas Kiggundu (MAK), Denis Muhangi (MAK), Sarah Bimbona (MAK)
REVIEW	Oliver Schmid (HKA), Mihaela Dudita (SPF-OST), Irene Robles Garcia (SEZ), Heike Hoedt (Simply Solar)
APPROVAL	Michael Kauffeld (HKA)
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ABBREVIATIONS

FCFA	**F**ranc de la **C**oopération **F**inancière en **A**frique Centrale

EXECUTIVE SUMMARY

SophiA project aims to provide sustainable off-grid energy supplies and clean drinking water for rural and remote health facilities in Africa, thereby accelerating the sustainable development, growth and economic transformation, and ensuring improved access to energy and health services for all. SophiA will develop and locally manufacture innovative, modular, flexible, affordable and efficient solar containers to provide the local population in four rural health centres located in four different climatic regions where help is most needed, offering sustainable solutions adapted to the African context and then transferable to the whole of Sub-Saharan Africa. Led by Hochschule Karlsruhe (HKA), the SophiA consortium consists of 13 project partners from three European (France, Germany and Switzerland) and four African countries (France, Germany, Switzerland, Burkina Faso, Cameroon, Uganda and South Africa).

This deliverable summarizes the information collected across over 19 sites in the four countries Burkina Faso, Cameroon, Malawi and Uganda, providing an overview of the needs and requirements of rural hospital sites, which could benefit from the technologies developed in the SophiA project.

This report was made in the frame of Work Package 1, led by Makerere University and describes the needs assessments of the selected hospital sites. The deliverable first introduces WP1, in the frame of which this needs assessment was made, and how this work contributes to the rest of the project's activities. Then, the methodology is presented and the questionnaire elaborated by the project partners to collect the required information from the potential hospital sites is described. After this, the responses collected from the hospital sites are summarized in an anonymized format. The selected hospitals are also presented.

1. INTRODUCTION

SophiA project will enable beneficiary hospitals and health center in **Africa to access carbon-neutral energy** for **cooling of medicine and for heating purpose,** and provide clean, **virus free drinking water**, as well as demineralised water for steam production and for different medical applications. A broad implementation of SophiA systems, hybrid, modular, plug-in energy systems, will bring **environmental, economic, social and** especially **health benefits,** enhancing the quality of life in a sustainably way. SophiA systems will be demonstrated at four health facilities in different geographical regions in Burkina Faso, Cameroon, Malawi and Uganda where aid is most needed, by providing sustainable solutions appropriate to the African context. For small rural health stations, SophiA will provide a separate energy autarkic solution called PVMedPort. This can be used to power (or provide additional power), or for outreach programs (awareness campaigns, health and education programs, vaccination campaigns). Moreover, it can be implemented as a completely equipped energetically self-sufficient station (e.g. a dispensary or a pharmacy). The multinational, multidisciplinary SophiA team comprises all capabilities to develop this innovative combination of a modular and flexible structure, which will be easy to integrate without needing to re-design the existing infrastructures at the health center.

SophiA will develop and locally manufacture **innovative, modular, flexible, affordable and efficient solar powered**:

i. cooling of medicines and food at +5°C;
ii. low temperature storage of blood plasma at -30°C;
iii. ultra-low temperature storage of sensitive medication (e. g. some Covid-19 or Ebola vaccines) at -70°C ;
iv. safe, clean, cooled drinking water and demineralised water for steam production and for different medical purposes;
v. hot water and steam production for hospital thermal requirements and sterilization;
vi. cooling of surgical or intensive care units;
vii. emergency electricity supply for surgical and intensive care units.

2. WP1: OVERALL OBJECTIVES

The main objective of WP1 “Boundary conditions of the SophiA systems” is to assess the needs of health stations in Burkina Faso, Cameroon, Malawi and Uganda and identify the most significant and suitable health station where SophiA systems can be tested and demonstrated. Locations from different climatic regions were chosen considering the potential impact of SophiA technologies, replicability potential, costs, accessibility and safety. The tasks to which this deliverable refers to are shown in Table 1. Moreover, WP1 includes also the analysis of other available information (e.g. solar radiation) and the design requirements for the containers and the working conditions under which they must perform.

Table 1: WP 1 Tasks covered by Deliverable D1.1.

Title	Main Objectives	Partners involved	Duration
1.1. Perform needs assessments for hospitals/medical stations from Burkina Faso, Cameroon, Malawi and Uganda	At least 10 health stations will be contacted directly and/or via health authorities and/or associated partners. The selection criteria will be established by the SophiA consortium, together with the Associated partners. The needs and all relevant data will be gathered using a questionnaire.	MAK, HKA, SPF-OST, 2iE, MPHC, IIR, OiA, SISO	M1 – M9
1.2 Analyze data from hospitals/medical stations	It is of high importance that the needs identified in Task 1.1 will be matched with what SophiA solutions can offer. One of the main beliefs of the SophiA consortium is sustainable engineering and the development of solutions that are tailored to the needs. The data from Task 1.1 will be processed and analysed using dedicated software. As one demonstration location is already fixed (via the SophiA partner OiA in Burkina Faso), three more locations will be selected after the data analysis.	MAK, HKA, SPF-OST, 2iE, MPHC, IIR, OiA, EVERFLO, SISO	M2 – M9

The approach used for the needs assessment of potential hospital sites is described in this report, and the data analyzed from the hospitals is presented. The four hospitals selected for demonstrating the SophiA technologies are presented as well.

2.1 Dependencies of other WPs upon WP1

WP1 has a significant importance for the entire SophiA project due to the information flow and dependencies arising from this WP to the other technical and transversal tasks (Figure 1). One of the most important output of this WP1 is the selection of the three demonstration sites in Cameroon, Malawi and Uganda. These sites will be the focus of the demonstration of SophiA technologies, but also have a particular importance for the training and capacity building activities, events and show-case workshops throughout the full project.

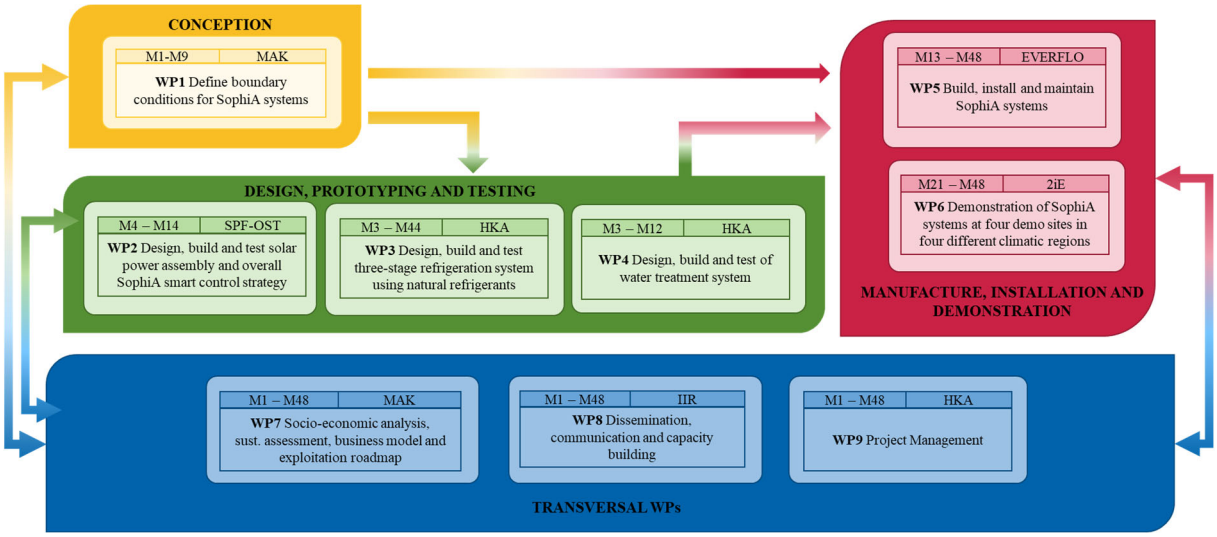

Figure 1: SophiA project PERT Chart.

3. NEEDS ASSESSMENT

3.1 Approach used

Several approaches were used to fulfil the WP1 objectives. As a first step, stakeholders and relevant local leaders, ministry representatives and public healthcare officials were invited to local "kick-off" meetings or workshops where SophiA project was presented. On the other hand, internal meetings were held within consortium to prepare the questionnaire, which was used to collect the relevant information from potential hospitals.

Each of these activities is presented below with more detail, while Section 3.2 provides an in-depth description of the Questionnaire and of the results obtained.

3.1.1 Introduction of SophiA to local leaders and public authorities

Due to the nature of governance in the four countries, it was important to introduce the SophiA project to the local leaders in each country. This was done by making visits to different offices and having meetings with the relevant leaders and Ministries. This process was also important in order to get the approval of potential hospital sites to collaborate with the project as a demonstration site, since many of the hospitals are part of the public healthcare system. The Health Ministries and local authorities were informed about the aims of SophiA project and what the demonstration of SophiA technologies would involve. For facilitating the selecting of the three demo sites in Cameroon, Malawi and Uganda, the health authorities provided a preliminary list of hospitals that could potentially be involved as a demo site in the project.

A selection of the key meetings and initiatives in the demo countries are described below. SophiA partner MAK (Makerere University) was mainly involved for organizing the meetings in Uganda and Malawi, and SophiA partner MPHC (Ministry of Public Health Cameroon) for Cameroon.

- Kick-off meeting at Makerere University in Uganda, involving local stakeholders: it was held on 8th December 2021 and was hosted by Prof. Nawangwe, Vice Chancellor of Makerere University. The meeting was attended by: Director General Health Services, Ministry of Health; The Commissioner Renewable Energy, Ministry of Energy and Mineral Development; The Executive Secretary, Uganda National Council for Science and Technology; members of Makerere University Management and Academic Staff; Mr. Oliver Schmid (HKA, project coordinator); Dr. Bonet Kamwana of Lilongwe University of Agriculture and Natural Resources; and members of the Media from the major Media Houses in Uganda. The SophiA project was well received at Makerere University and all stakeholders pledged their support.
- Meeting with relevant officials of Dr. Sedogo Hospital Léo in Burkina Faso: this is the first demo site at OiA (Operieren in Afrika). OiA is managing the hospital and it is part of SophiA consortium.
- Meetings with officials and representatives of SophiA partner MPHC (Ministry of Public Health in Cameroon) with local hospital sites.
- Meetings between MAK and officials of the Ministry of Health and Population in Malawi.

3.1.2 Data collection for needs assessment from four countries

Data collection from the four countries was preceded by the formulation of the questionnaire (see Section 3.2 for more details). The process of selecting the questions was of highly importance and SophiA partners from the different technical specialties participated. The process involved several meetings and drafts of the questionnaire. It was important that partners agree on the questions. In collaboration with local contacts from the demo site countries, the 19 hospitals were identified for data collection (Figure 2).

An evaluation matrix was developed to choose the three most suitable hospitals. An important aspect was that the hospitals included into the selection process have challenges with cold storage of medicine, blood samples and vaccines. In addition, the hospitals should have a lack of clean water (cold and hot) supply. Moreover, it was assessed if the hospital could use the PVmedPort for outreach programs (awareness campaigns, health and education programs, vaccination campaigns) or implement it as a completely equipped energetically self-sufficient station (e.g. a dispensary or a pharmacy). It was also considered beneficial if the hospital had the ability to expand its medical services with the help of SophiA systems. Last, but not least, it was important that the hospital had space to safely accommodate the SophiA containers and the PVmedPort.

Table 2: Hospitals visited in the four countries selected.

No.	Country	Hospitals Visited
1	Burkina Faso	Dr. Sedogo Hospital Léo

No.	Country	Hospitals Visited
2	Cameroon	1. Bangang 2. Bonaberi 3. Bonamoussadi 4. Douala 5. Edea 6. Efok 7. Soa 8. St. Jean de Malte 9. Otélé
3	Malawi	1. Nkhamenya Community Hospital, 2. Santhe Health Center, 3. Kabudula Community Hospital, 4. Mitundu Community Hospital, 5. Mua Mission Hospital
4	Uganda	• Kakumiro Health Centre IV [1)], • Bbaale Health Centre IV, • Nakasongola Health Centre IV • Buvuma Health Centre IV

[1)] Health Centre IV means mini hospital serving a county or a parliamentary constituency.

As shown above, 19 hospitals were visited by consortium partners and information from them collected and analysed before the final demo sites were selected.

3.2 Questionnaire

All partners from SophiA consortium were involved in the development of the questionnaire, which included specific questions created by SophiA technical partners. These questions were important for the development of SophiA systems, as the capacity and configuration of the entire SophiA system depend on these answers. Several internal meetings were held within the consortium to prepare the final version of the questionnaire.

The first draft of the questionnaire was sent to the vice president of SophiA partner "Operieren in Afrika e.V." to check whether answers could be given by a person with a medical background. Meanwhile, local partners reached out to the Governments from Uganda, Cameroon and Malawi to get the approval of the project. The Government has supported the project and provided a list of potential hospital sites. The questionnaire was send out to these hospitals.

The questionnaire is divided into the following sections:

1. General information about the hospital
2. Staff information
3. Annual patient loads
4. Services provided by the hospital
5. Electrical power supply
6. Cooling requirement
7. Thermal energy consumption
8. Water
9. Additional information and observation checklist

Since the remote hospitals usually do not have in-house technicians, the questionnaire was completed by doctors or nurses. Dr. Christoph Müller from SophiA partner Simply Solar travelled to Dr. Sedogo Hospital in Burkina Faso, and analysed the conditions on site.

In the end, the data collected was analysed and SophiA hospitals were selected in consultation with consortium partners and local leaders. In the next section, the questionnaire and answers received from all hospitals are presented.

3.2.1 General information

The general information was needed to identify the hospital or health centre. Moreover, it was also asked whether it is possible to deliver large containers to the hospital in question (relating to road accessibility, access to installation space, etc.). Also, the catchment population was needed to know if there is any potential that more people can be treated in the hospital once SophiA containers are installed. Based on the GPS data, the location could be visualised using the aerial photo from an open-maps provider. The available space was often an exclusion criterion for the choice of hospital, even if all other answers were in favour of this facility.

Table 3: Section 1 of the questionnaire.

	Question/Item	Response	Comments
101	Country		
102	Name of hospital / health facility		
103	Level of hospital / health facility	1. Hospital 2. Health Centre IV 3. Health Centre III	*This classification is for Uganda. Please adapt to your country situation*
104	Ownership	1. Government 2. Private-not-for-profit 3. Private	
105	District/State/Region of location		
106	GPS coordinates of the location		
107	Nearest city / big town		
108	Distance from nearest city / big town (in km)		
109	Is the hospital accessible by truck with a large shipping container?	1. Yes 2. Yes, with difficulty 3. No	
110	Size of catchment population		
111	Name of Contact Person at the hospital/health facility:	Tel.	Email:

	Question/Item	Response	Comments
112	Name and positions of persons responding to this questionnaire	Name 1. 2.	Position 1. 2.

The facilities provided by the governments can be categorized as health care center III and IV or hospitals. The differences between the different health care centres are related to the services they provide and the size of their catchment. A health centre I and II has the catchment area of a parish and provides basic treatment such as outpatient care, antenatal care, immunization and outreach services. Health centre III also provides inpatient care in a sub-county. Health care centres level IV and hospitals carry out complex surgeries, which is why they need to have blood transfusion stored at their facilities. Their catchment is from a whole district or even a county. In the interest of the SophiA consortium are Health Care Centers IV and hospitals. Depending on the population size of the county, the number of people vary between the health centres and hospitals.

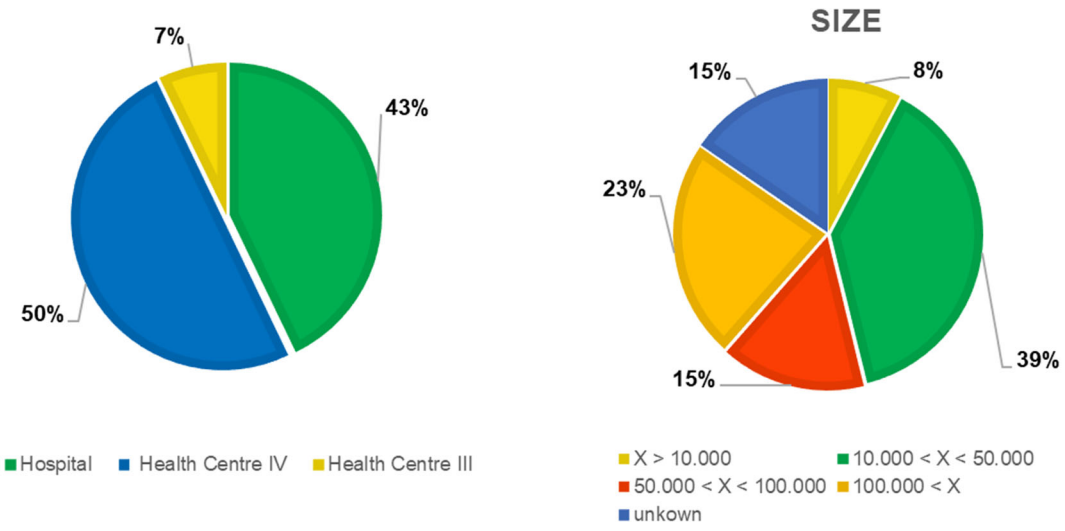

Figure 2: Types of medical care centers which answered the questionnaire (left) and the population included in their catchment area (right).

3.2.2 Staff information

The staffing of each hospital mainly dependents on the size of the facility. Of particular interest are hospitals with their own doctor, pharmacist and technicians. The qualification of these person groups would facilitate training on the proper use of the technologies and the maintenance.

Table 4: Section 2 of the questionnaire.

	Category of staff	Number currently employed	Comments
201	Number of doctors		
202	Number of midwives / nurses		
203	Number of laboratory staff		
204	Pharmacists		
205	Other medical personnel		
206	Number of administrative staff		
207	Number of support staff		
208	Number of technicians e.g. electrician, plumber, etc.		

3.2.3 Annual patient loads

To verify that the SophiA containers can adequately supply the hospital with cooling, water and thermal energy, the number of patients is of great significance. Splitting the table into female and male patients ensures that the hospital has a fair share of both genders. However, it should be considered that the number of female patients could be attributed to childbirth and its preparation. Patient numbers were also asked per month to determine if there is a seasonal dependency, such as Malaria season.

Table 5: Section 3 of the questionnaire.

Month	Female	Male	Total patients
Jan			
Feb			
Mar			
…			

Nearly half of the hospitals answered this question. They treat between 100 and 500 patients per month, three hospitals are treating around 1500 patients, two hospitals around 2500 and one has more than 5000 patients per month. However, the data should be interpreted with caution. Smaller hospitals may not have the capacity to record the number and gender of patients. In addition, the government provided also some hospitals which are not suitable for SophiA project since they are located in rather dense areas. No seasonal dependence of patient load was observed. One hospital has a spike in September, which could be an

indication of an infective disease. Unfortunately, no explanation was provided in the questionnaire.

3.2.4 Services provided by the hospital

Even though the level of the facility is already an indication of the size and the services it provides, this section is intended for a closer evaluation of the equipment onsite.

Table 6: Section 4 of the questionnaire.

	Question	Responses	Options
401	List all the services provided by the hospital		1. Outpatient 2. Eye care 3. Dental services 4. Family Planning 5. Antenatal 6. Maternity 7. Immunization / vaccinations 8. Surgeries 9. Blood transfusions 10. Laboratory services 11. Other
402	Does the hospital / health facility admit patients?		1. Yes 2. No
403	How many beds are available?		
404	How many days a week is the hospital / health facility open?		
405	Is there an operating theatre?		1. Yes 2. No
406	What kind of surgeries do you conduct?		1. Minor surgery (sticking, circumcision, etc 2. Major surgeries (internal, caesarean, amputations, etc.) 3. Specialize surgery

Depending on the operations performed by the hospital or health centre, the required storage capacity and temperature levels of medications and equipment change. Due to the possibilities of the refrigerated container, special attention was paid to hospitals offering blood transfusions and vaccination campaigns. This gives a direct benefit of the -30°C room and the -70°C freezer boxes. All of the potential sites answered they are open 7 days a week. Only one of the sites did not have an operation theatre. The level of surgery indicated if there is potential for an expansion of their services and how complicated it would be to implement the containers into the procedure of the hospitals structures.

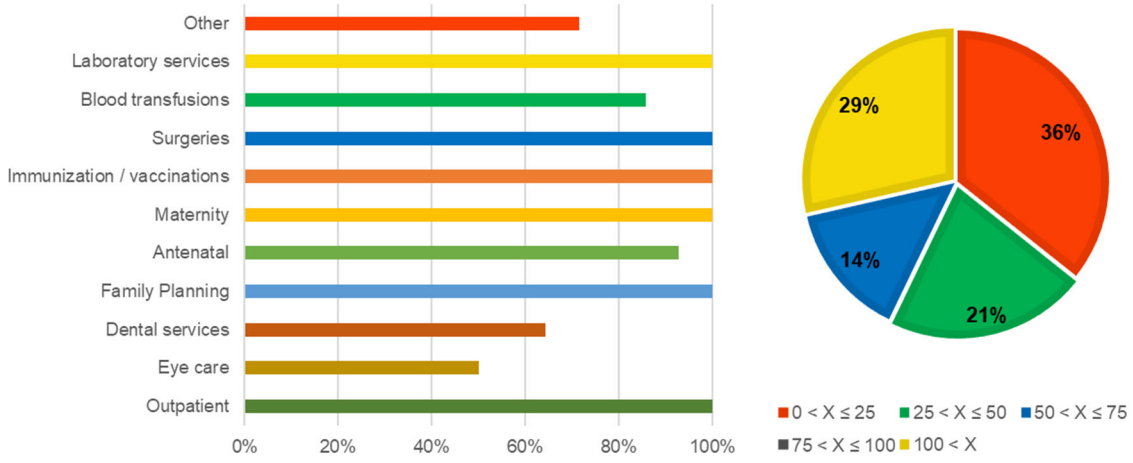

Figure 3 Share of the medical sevices provided by the different hospitals (left) and number of beds inside their facilities (right)

3.2.5 Electric power supply

The questions in section 5 about the existing electric power supply was necessary to identify the electrical conditions in advance and thus be able to plan the connection between the hospital and containers. It is not possible to record all individual circumstances of the electrical infrastructure in the questionnaire. In Cameroon there was a health centre which is connected to a water power plant.

Table 7: Section 5 of the questionnaire.

	Question	Responses	Options
501	What is the hospital / health facility's main source of power?		1. Central grid electricity 2. Localized electricity supply 3. Solar power (PV) 4. Engine-generator 5. Other (specify): _____
502	What is the annual energy consumption of the hospital? Specify (e.g. kWh electricity, kg gas, kg wood, etc)		
503	What are the costs of 1 kWh? What are the costs of 1 kg gas? What are the costs of 1 kg wood? Etc.		
504	If the hospital / health facility connected to the electricity grid, what is the capacity?		1. Single phase 2. Three phase 3. Other (specify): _____

	Question	Responses	Options
505	If the hospital / health facility connected to the electricity grid, what the used voltage / frequency?		1. 230 V 2. 400 V 3. 50 Hz 4. 60 Hz
506	If no, what is the distance to the nearest grid line?		Km
507	(If hospital is not connected to grid power) Are you aware of any plans by government / utility agency to extend grid power to this area?		1. Yes 2. No
508	Are there already PV systems installed?		1. Yes 2. No
509	If yes, what was the year of installation?		
510	Is the solar PV system functional?		1. Yes 2. Partly functional 3. No
511	If the solar PV system is nonfunctional or partial functional, please give more details?		
512	What is the total area of PV Panel (m^2)?		1. 15 m^2 2. 25 m^2 3. More:_____

All hospital answered they are connected to the central grid. However, due to occasional power short cuts, 9 out of 10 hospitals are also equipped with an engine-generator. According to the answers, the price for one kWh electricity depends on the consumption and on the region of the hospital. They range from 60 FCFA (**F**ranc de la **C**oopération **F**inancière en **A**frique Centrale) to 99 FCFA, which corresponds to approximately 0.09 € and 0.15 € per kWh electricity, respectively.

3.2.6 Cooling

The cooling section was made to screen the existing situation of the refrigeration capacity in selected hospitals. The goal was to keep the questions as simple as possible without detailed technical questions and still get the most important details out of the answers. Therefore, all questions can be answered with yes or no. It was also important to find out if the hospital operators already have ideas about how they would like to use the different temperature levels by indicating that they are in need of the certain temperature level.

Table 8: Section 6 of the questionnaire.

	Question	Responses	Options
601	Are there already refrigeration devices available (if yes, specify with amounts)?		
602	Does the hospital need additional cooling?		1. No 2. __ small refrigerator box(es) 3. __ refrigerator (s) 4. __ freezer(s) 5. __ cold storage room(s) 6. __ deep freezer storage room(s)
603	Does the hospital need additional cooling at +5°C?		1. Yes 2. No
604	Does the hospital need additional cooling at -30°C?		1. Yes 2. No
605	Does the hospital need additional cooling at -70°C?		1. Yes 2. No
606	Does the hospital have the potential to expand their medical treatments and operations, so that they can use and have the need of additional cooling spaces (like blood for additional surgeries etc.)?		1. Yes 2. No
607	Does the hospital have the possibility to organize or purchase the required medical devices in order to expand the medical treatments / surgeries?		1. Yes 2. No
608	Does the hospital have the possibility to receive medicine / vaccines / blood plasma that has to be cooled (in relation to the infrastructure)?		1. Yes 2. No
609	Does the hospital have excess medical equipment they cannot use due to a lack of cooling devices?		1. Yes 2. No
610	Did the hospital have to dispose of sensitive medicine due to insufficient or interrupted cooling?		1. Yes 2. No

Most of the hospitals answered they are in need of all three temperature levels. Currently, they are equipped with just one refrigerator and only one hospital seems to be equipped sufficiently enough. Additionally, it was important for the SophiA project that the hospitals have the

capability to expand their medical treatment and that they can carry out vaccination and blood donation campaigns. The need for additional cooling could also be detected if the hospital had to dispose equipment or medicine due to insufficient cooling. The cooling container is expected to replace the existing refrigeration devices, thus decreasing the power demand and ensuring a consistent and reliable cooling of the sensitive goods.

3.2.7 Thermal energy consumption

The questions about the thermal energy consumption are similar to the cooling section. The SophiA concept allows hospitals to replace their fossil fuel equipment with a sustainable option. Therefore, it was important to ask about the thermal infrastructure on site and expansion plans. The thermal energy systems are developed in close contact with the hospital operators so that the new technologies can be easily implemented.

Table 9: Section 7 of the questionnaire.

	Question	Response	Options
701	Is there already a thermal energy supply in the hospital?		1. Yes 2. No
702	Does the hospital need additional thermal energy? (for example for: laundry, water for washing dishes, warm water for washing patients, autoclaves, sterilizers, energy for cooking, room heating, etc.)?		1. Yes 2. No
703	Does the hospital have the potential to expand their medical treatments, so that they can use and have the need of additional thermal energy?		1. Yes 2. No
704	Does the hospital have the possibility to organize or purchase the required medical devices in order to expand the medical treatments?		1. Yes 2. No
705	Did the hospital have issues to provide reliable medical treatment due to insufficient sterilization?		1. Yes 2. No
706	Does the hospital have excess medical equipment they cannot use due to a lack of sterilization / thermal energy supply?		1. Yes 2. No

Around 60% of the hospitals have a thermal energy supply at their facilities. Another 20% claimed they are in need of additional thermal energy. Surprisingly, up to 60% of the potential partner hospitals have issues with a reliable thermal energy supply and lack of sterilization.

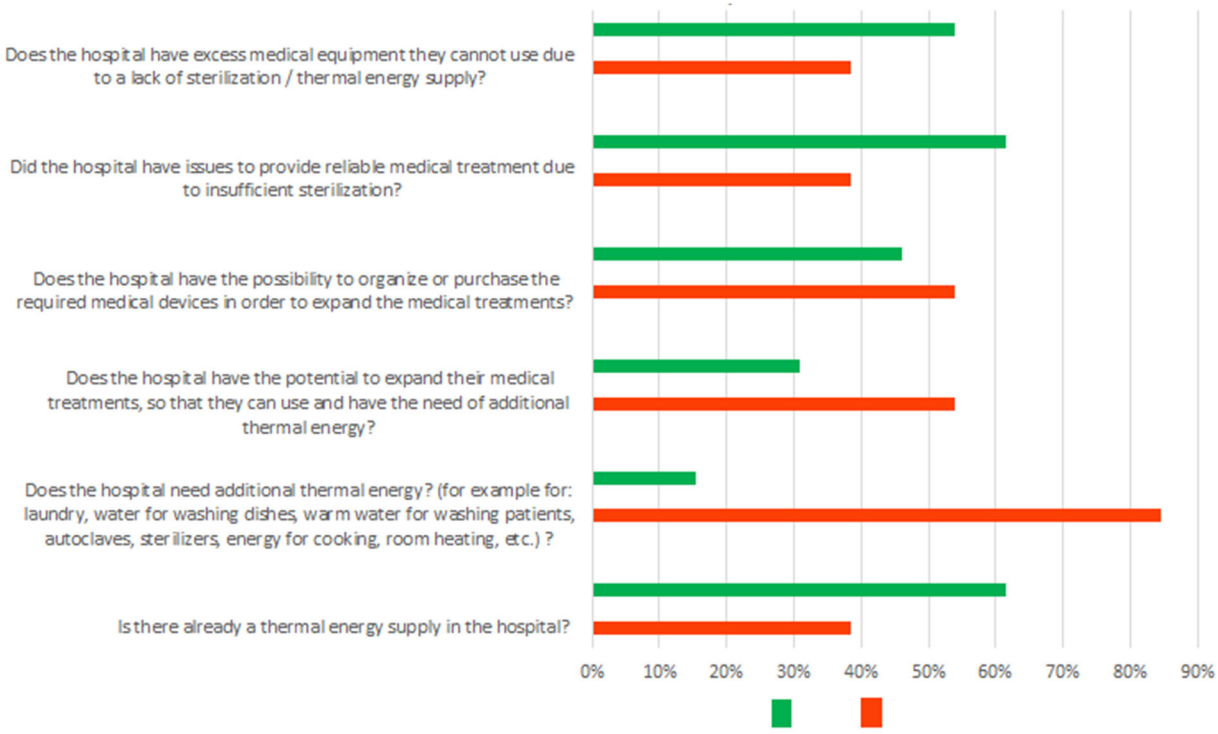

Figure 4 Evaluation of the answers from section 7 regarding thermal energy supply

3.2.8 Water

The water container will produce steam for the disinfection of the medical equipment as well as drinking water. The technologies installed depend on the quality of the water source. Hence, it was important to find out the potential water sources. The water treatment plant has the greatest impact on a hospital that has a contaminated or polluted water source. Many of the hospitals surveyed have a sufficient water quality. Nevertheless, patients or their relatives have to buy water from the supermarket because there is not enough drinking water available. The current water consumption is indicating the capacity of the water treatment plant. Since a drinking water quality is offered it can be assumed that the consumption for the water will increase considerably. For the ultrafiltration system, it is important to know the pressure in the feed. If the pressure is too low, the pressure drop over the filtration would result in a low fresh water production and a pump needs to be foreseen.

Table 10: Section 8 of the questionnaire.

	Question	Response	Options
801	What is the main source of water for the hospital / health facility for drinking water?		1. Piped water from utility company 2. Own piped scheme 3. Own borehole 4. Rainwater harvesting 5. Mobile water tanker 6. Other (specify):_____
802	What is the annual water consumption of drinking water?		
803	What are the annual costs of drinking water?		

	Question	Response	Options
804	What is the main source of water for the hospital / health facility for de-ionized water for hospital equipments (sterilizers, autoclave, etc)?		1. Piped water from utility company 2. Own piped scheme 3. Own borehole 4. Rainwater 5. Mobile water tanker 6. Other (specify)
805	What is the annual deionized water consumption?		_____
806	What is the annual costs of deionized water?		_____
807	What is the main source of water for the hospital / health facility for regular use (laundry, toilet flushing, cleaning, etc.)?		1. Piped water from utility company 2. Own piped scheme 3. Own borehole 4. Rainwater 5. Mobile water tanker 6. Other (specify)
808	How much is the water polluted?		1. No pollution (according to local specifications) 2. Slightly polluted 3. Polluted 1. 4. Strongly polluted
809	What is the pressure of water in the pipes?		_____ (units) ____
810	What is the annual total water consumption?		_____ (m^3)
811	What other alternative sources of water are available to the hospital?		1. Piped water from utility company 2. Own piped scheme 3. Own borehole 4. Rainwater 5. Mobile water tanker 6. Other (specify) 7. Dug well None
812	How regularly is this alternative source of water available?		1. Everyday 2. Most days 3. Once in a while
813	What are the accepted standards (parameter regulations) for treated water depending on usage: (Please check the acceptable standards with specific government regulatory body responsible for standard check of treated water)		
	- Steam		

	Question	Response	Options
814	- Drinking		
815	Does the hospital have a water reservoir?		1. Yes 2. No
816	If yes, how big is the water reservoir?		
817	Does the hospital need additional drinking water supply?		1. Yes 2. No
818	Does the hospital need additional deionized water supply?		1. Yes 2. No
819	Does the hospital need additional water supply?		1. Yes 2. No
820	Did the hospital have patients who could not recover due to a lack of clean drinking water?		1. Yes 2. No
821	Did the hospital have patients who got sick during the medical treatment due to polluted drinking water?		1. Yes 2. No

It was asked if there are different sources for the various uses of the water such as drinking water, deionized water and regular used water. All of them have more than one water source. Most of them obtain water from a utility company and have their own borehole as a backup. The de-ionized water is either bought from companies and stored in canisters onsite or produced by ion exchangers inside the facilities, for which the cartridges must be replaced regularly and they are costly. Almost 3 out of 4 hospitals have an existing water reservoir. The hospitals in Uganda have a higher storage capacity in their water reservoirs. Additionally, 70% of the hospitals in Uganda using water from rain harvesting. According to the weather data, the mean annual precipitation in Uganda with 1282.30 mm is lower than in Cameroon with 1627.26 mm. However, rainfall in Uganda is more consistent throughout the year, making rainwater harvesting a viable alternative.

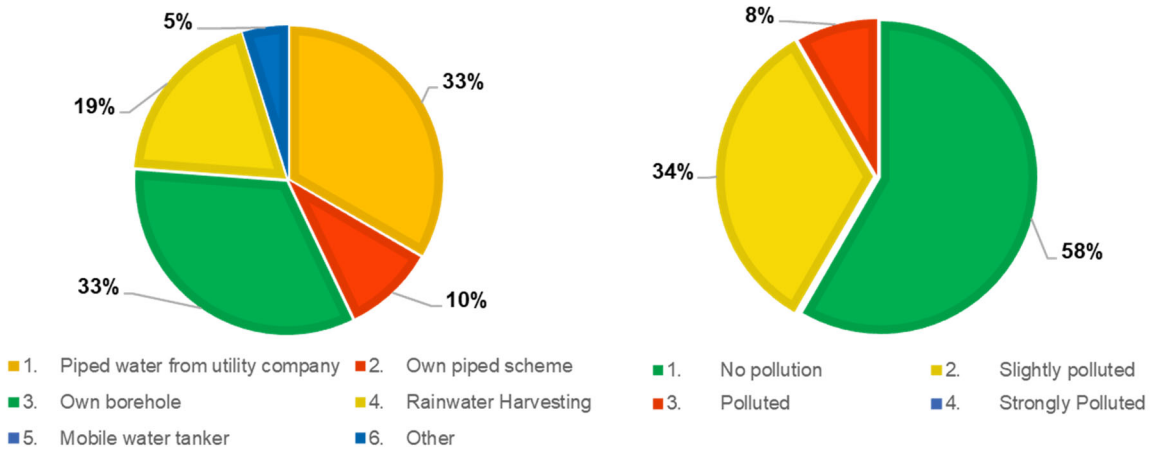

Figure 5 Evaluation of the water sources (left) and the level of pollution of the water supplies (right)

3.2.9 Additional information and observation checklist

Through the additional information and the onsite observations section, an impression of the local situation of the facility can be gained. Often, hospitals were excellently suited for cooperation in terms of their needs and equipment. However, through the GPS data and the pictures, it became apparent that the hospital lacked space for the installation. During the discussions, one hospital even offered to provide the small parking lot, which would leave only a small driveway for the ambulance. In addition, the government established contact with hospitals in larger cities. Besides the lack of a place to install the containers at a facility located in a bigger city the intended goal of the SophiA project is to equip a remote facility providing the chance to extend their medical treatment.

Table 11: Section 9 and 10 of the questionnaire.

	Question	Response
901	What is the annual budget for the hospital/health facility?	
902	Area of land owned /available to the hospital / health facility	
903	Ask for a copy of the hospital strategic plan and organogram	
904	Ask for the hospital masterplan/layout	
905	Is the hospital interested in participating in the SophiA Project?	
	Observations/photos	
1001	Hospital location - show where the containers could be placed / Selection of the exact placement of the containers - take GPS location data	

	Question	Response
1002	Hospital buildings - distance from the containers to possible connection inside the hospital / health facility - how many different hospital buildings are there? - how many staff houses are there?	
1003	Roofs of hospital buildings - show where additional solar panels could be placed - send layout of buildings and plot - what are the permissible additional roof loads for solar installations?	
1004	Refrigeration equipment	
1005	Solar PV and thermal panels	
1006	Engine -generators	
1007	Inside the Laboratory	
1008	Inside the operating theater	

3.3 Partner hospital selection process

The responses were categorized into four sections: cooling, thermal, water and location. Each hospital was ranked from zero to two In addition, information was obtained on transportation from the port to the possible demo site. Attention was paid to the length of the route and road quality. The information collected were visually presented to the SophiA consortium. In case of Cameroon, the three most promising hospitals operators were invited to an online meeting. The meeting served to present the SophiA project and what would be expected from the hospital in the case of a cooperation. Furthermore, the intention was to find out how the hospital will use the containers and if they have already thought about a location to install the containers The answers from the interview were presented to the consortium and finally a hospital was selected that satisfied all expectations and requirements.

3.4 Water quality assessment

Drinking water samples from selected hospitals - Dr. Sedogo hospital in Léo and Health Care Center in Buvuma Islands were sent to HKA and SPF-OST for analyses. The analyses carried out were to measure the mineral content and heavy metals traces in the water samples. The water sample from Dr. Sedogo hospital in Léo contained minerals below the minimum contamination level (MCL) except for fluoride, which was above the MCL of 1.5 mg/L (see deliverable D4.1 for details). The water sample from Health Care Center in Buvuma Islands showed traces of zinc above the MCL of 5 mg/L (reported in details in Deliverable D4.2). The biological contamination report from the hospital Ad Lucem Otélé in Cameroon stated unsatisfactory hygienic standard (see Deliverable D4.2). These results show the need of UF treatment followed by UV treatment to eliminate any biological contamination. The concentration of critical minerals like fluoride and heavy metals traces like zinc can be reduced

below MCL by the MCDI technology. Analyses of source water and treated water samples for biological, minerals and heavy metals contamination will also be carried out on-site after installation of the container.

4. SELECTED HOSPITALS

In each of the four countries, a hospital partner was found for demonstrating the SophiA technologies. The four hospitals selected are presented below:

- Dr. Sedogo Hospital Léo, Burkina Faso;
- Ad Lucem Hospital, Otélé, Cameroon;
- Mua Mission Hospital, Malawi;
- Buvuma Health Centre IV Hospital, Uganda.

4.1 Dr. Sedogo Hospital Léo, Burkina Faso

The hospital was built under the direction of the SophiA partner “Operieren in Afrika e.V.”. The association has been organizing surgical campaigns of specialized medical doctors, such as urologists and plastic surgeons, since 2000. After 13 years of using the medical facilities in the city of Léo, it was agreed to build its own hospital. The architect Diébédo Francis Kéré, who was born in Burkina Faso, was recruited as architect and he has received several prices for his work. The hospital has been in operation since 2014. It is equipped with two operation theaters, a maternity and has around 20 beds. Five guest houses can accommodate up to 10 specialists during surgical campaigns. Surgery specialists from Europe are hosted during winter to perform sophisticated operations and to familiarize and train local personnel.

Location

The hospital is located near the city Léo, in Burkina Faso.

Figure 6: Overview of Dr. Sedogo Hospital in Léo, Burkina Faso.

Catchment

The catchment area of the hospital is about 60,000 inhabitants from Léo. However, the hospital is also known beyond the region, which is why many patients travel a long way to be treated there. The hospital can provide assistance especially for pregnant women. The mortality rate of newborns has decreased considerably and it is now comparable with the European level.

Number of doctors and teams

Around 20 permanent employees work at Dr. Sedogo Hospital. They include three midwives, two nurses, a surgeon, an anesthetist, a radiologist, a technician and a pharmacist. During the surgical campaigns, up to 10 additional doctors and nurses are accommodated.

Power supply and consumption

Power blackouts often occur in the regions outside the major city of Léo. Therefore, during the construction of the hospital, a PV system was installed to cover 90% of the electricity. Furthermore, a battery storage is available. When the power supply is interrupted, a diesel generator can be used for a short time. However, due to the further expansion of the hospital, the current power supply is not sufficient. SophiA technologies will complement the current power supply and ensure the future development of the hospital.

The thermal energy such as cooking and steam production is exclusively provided with the use of fossil energy. Two refrigerators and one freezer ensure the cooling of the drugs and medicine.

Water supply and consumption

Water supply is already provided in a sustainable manner. During the rainy season, water is collected in an underground rainwater retention basin. About one third of the dry season can be bridged when the reservoir is full. The rest of the time, water is pumped via a well. A 1000 litre elevated water tank provides the water pressure in the building. Three autoclaves sterilize used surgical instruments. Currently, the deionized water required for this purpose is purchased from a local store.

Figure 7: Dr. Sedogo Hospital in Léo, Burkina Faso.

4.2 Ad Lucem Hospital, Otélé, Cameroon

In Cameroon, the hospital in Otélé has been chosen as a partner, Figure 8. The Benedictines settled in the village in 1936 and created an infirmary, which was managed by the Catholic sisters for many years. When the nuns left in 2008, the Saint Martin Foundation and the Ad Lucem Medical Foundation agreed on a partnership for the construction of a modern hospital named “Hôpital Ad Lucem Hikoa-Maen: Père Urs Memorial Clinic” which was inaugurated and put into service in January 2016.

Location

Otélé Hospital is situated in Otélé village, which is situated about fifty kilometres southwest of Yaoundé, the political capital of Cameroon.

Figure 8: Ad Lucem Hospital in Otélé, Cameroon during the onsite visit by MPHC.

Catchment

The hospital receives over 100 patients per month and its main aim is to provide quality health care to the rural and poor population in the region, which is about 10'000 inhabitants.

Number of doctors and teams

The team includes one doctor, five nurses, one laboratory technician, four administrative staff, two nursing assistants and three support staff. There are emergency services, surgery, paediatrics, radiology, hospitalisation, medical analysis, as well as a maternity ward and a pharmacy.

Power supply

The electrical power is provided by the grid but power outages occur on a daily basis. They are neither equipped with solar thermal nor PV panels. The hospital has two refrigerators, one for food and one for medicine and drugs. This hospital has the potential to increase their medical treatment once the SophiA technologies are installed.

The hospital is connected to the national electricity grid, but due to frequent load shedding periods, it regularly uses a generator.

Water supply

The hospital benefits from a water supply through the water tower of the Saint Martin Fondation, supplied by the borehole. Additional water sources such as rain water harvesting and ground water will be processed in the water treatment system.

Figure 9: Ad Lucem Hospital in Otélé, Cameroon.

4.3 Mua Mission Hospital, Malawi

Location

Mua Mission Hospital is situated on the Lake Shore of Lake Malawi in the area of Traditional Authority Kachindamoto, the Eastern side of Dedza District, which is in the Central Region of Malawi. It boarders Salima District Health Office (DHO) and Dedza District Health Office (DHO) which are at a distance of approximately 60 km and 65 km respectively.

Figure 10 Mua Mission Hospital in Malawi during the onsite visit by MAK.

Catchment

Mua Mission Hospital is the principal referral hospital within a poor and remote rural area. The hospital has a capacity of 140 beds and has a catchment of about 30'000 people. It receives about 170 cases daily. The number of patients increases beyond the 170 cases during the months of Dec-April due to the high incidences of Malaria cases.

Number of doctors and teams

Around 25 permanent employees work at Mua Mission Hospital. They include 6 doctors, 10 nurses, 2 preventive health, 4 health technical support (e.g. technician, pharmacist). Moreover, almost 30 midwives are also working for the hospital. The hospital has 140 beds, two theatres, a pharmacy and a well-equipped laboratory that also does Covid-19 testing. It has outreach activities which will benefit from the SophiA technology PVMedPort.

Power supply and consumption

The hospital is connected to the national electricity grid. However, the supply of electricity in Malawi is unreliable. Often there are power cuts, sometimes taking even more than two days at a time. Since October 2020, a photovoltaic system was installed with support from Dutch and Spanish organizations (about 30'000 Euro). However, the installed PV system is not sufficient enough to provide reliable electricity to the big facility. The facility is equipped with five refrigerators for medicine and two for cooling down food.

Water supply and consumption

Since 2019, water is supplied from a borehole, via an electric water pump. The main source of water at the hospital is piped water from a utility company.

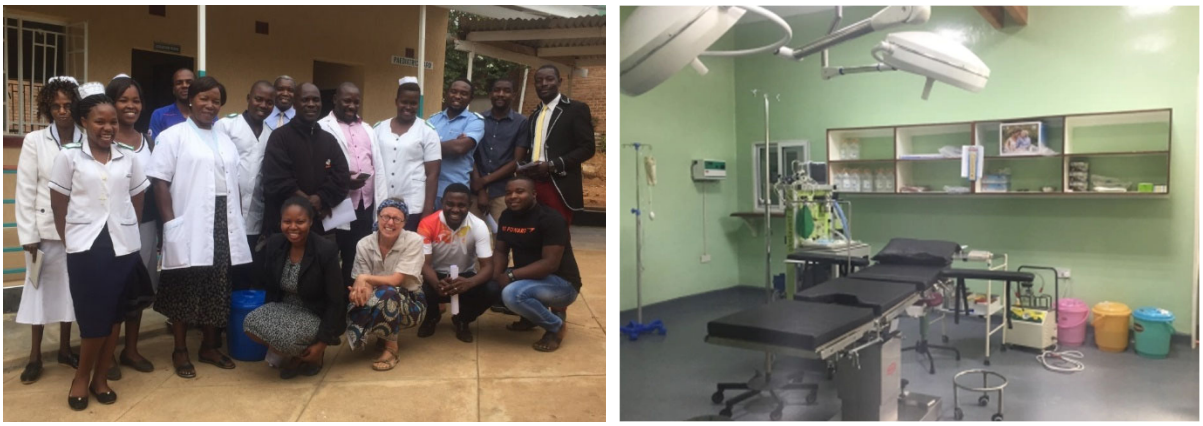

Figure 11 Mua Mission Hospital in Malawi.

4.4 Buvuma Hospital, Lake Victoria, Uganda

Location

Buvuma Hospital is located on the Main Island of Buvuma Island, which consists of 52 Islands and is located a few kilometres off the northern shores of Lake Victoria, Uganda in the

Napoleon Gulf. Buvuma is approximately 25 km (16 mi), by water, south of the major city of Jinja, and around 90 km (56 mi) southeast of the national capital city of Kampala. As the ferry to Buvuma Island has a fixed schedule, it takes about 6 hours from Kampala to reach the hospital.

Figure 12 Image of the hospital in Uganda with the water tanks during the onsite visit

Catchment

The hospital receives just over 100 patients per month and its main aim is to provide quality health care to the rural and poor population in the region (which is about 50,000 inhabitants).

Medical team

The Hospital has 2 doctors, 15 nurses, 4 laboratory technicians, 1 pharmacist (dispenser), 7 other medical personnel, and 2 support staff.

Power supply

The hospital in Uganda is located on the Buvuma island, see Figure 12. The island has no power supply from the mainland and no power plant of its own, which makes it the ideal site for SophiA technologies. Buvuma Hospital is the only public Health Facility without a power grid. The hospital is equipped with 2 kW PV system, which is not sufficient for all the hospital's equipment. Some equipment (2 large refrigerators of about 200 L each) are unusable due to the low output of the PV panels. There is one PV system for the laboratory, another for the maternity ward, another unit for the OPD building. The operating theatre is equipped with a PV system and there is also a diesel generator. The PV systems have capacities in the range of 0.5 – 2.0 kW. Since the Hospital lacks an electrician, it was not possible to estimate the actual needs.

The hospital is equipped with two large refrigerators. Due to the lack of sufficient electricity the hospital is not able to reliably maintain the cold chain.

Water supply

The hospital obtains its water supply from a utility company at a subsidised price (half the price). The water is pumped from an aquifer and treated before it is distributed. The water consumption is about 90 cubic metres/month. Onsight, there is also a rainwater harvesting system. The water is stored in a 5000 l elevated buffer tank. Solar thermal systems provide hot water for the heat applications. De-ionized water is provided by the Government's National Medical Stores.

Figure 13 Buvuma Hospital, Lake Victoria, Uganda

5. DEVIATIONS FROM THE WORKPLAN

There have been challenges that have affected the smooth flow of the project activities in Malawi. The challenges have been addressed as indicated in Table 7.

No.	Challenge	Proposed solution
1	Identification of the hospitals in Malawi was delayed due to the procedural requirements in Malawi.	Nicholas Kiggundu, from Makerere University travelled to Malawi and 5 hospitals were visited
2	The initial arrangement of finalizing a MOU between Ministry of Health and Population, Malawi and Makerere University couldn't be carried out, due to the procedural requirements in Malawi.	Mua Mission Hospital was identified and a MOU is being made with the Uganda's Solicitor General with the assistance of the Directorate of Legal Affairs, Makerere University.

6. CONCLUSIONS

The needs assessment covered 19 hospitals in Africa from which 4 hospitals were selected to serve as SophiA pilot sites. These are Dr. Sedogo Hospital Léo in Burkina Faso, Otélé in Cameroon, Mua Mission Hospital in Malawi, and Buvuma Health Centre IV in Uganda. The selection was based on a wide range of criteria including the high patient load for each of the selected hospital, the need for the SophiA systems (technology), and the willingness of the hospital administration to participate in the project and provide hospital data to the research team.

Data showed that all the 4 hospitals are receiving patients from distant places and these hospitals served as a referral for many smaller health centres and clinics in the 4 countries. The 4 hospitals have well equipped operating theatres, and offer a wide range of services namely: Outpatient, Eye care, Dental services, Family Planning, Antenatal, Maternity, Immunization/vaccinations, Surgeries, Blood transfusions, and Laboratory services. These hospitals receive support from the governments in form of medicines, vaccines, deionized water, and salaries for the case of Mua Mission Hospital in Malawi. Apart from Dr. Sedogo Hospital, the other 3 hospitals experienced energy insufficiency either to run all the equipment in the hospital or to light the hospital during the night. The proposed PV Med port for the outreach programmes was a well-received idea in all hospitals due to the associated benefit of additional energy supply. In all hospitals, technical support for fixing electrical appliances, plumbing, or trouble shooting ICT gadgets was outsourced from the neighbouring big towns/cities.

In all the hospitals visited, there was a general feeling that SophiA was a well thought-out project that will enhance the quality of life in the pilot hospitals, thus, subsequently triggering early adoption of the SophiA systems in other hospitals.

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