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Original Research

Proposal for the Sustainable Electrification of a Primary Healthcare Centre (PHC) Facility in Nigeria

Vincent Anayochukwu Ani *

Energy Commission of Nigeria, Plot 701C, Central Business District, P. M. B. 358, Garki, Abuja. Nigeria; E-Mail: anayochukwu.vincent@gmail.com

* **Correspondence:** Vincent Anayochukwu Ani; E-Mail: anayochukwu.vincent@gmail.com

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Abstract

Energy is a prerequisite to running health facilities and is, therefore, key to the success of the service. Karshi primary healthcare centre (PHC) facility is confronted with an unreliable power supply that leads to a high cost of generating power from diesel to operate its equipment. This facility needs a sustainable and reliable electricity supply and therefore a change in their energy system to enable it improve its quality of healthcare delivery services. A solar energy-based electricity generation system that would make the PHC to become resilient and contribute to climate mitigation was selected. A step by step on the design of solar powered system for the health facility was demonstrated, and therefore a grant to develop, install and train health workers on how to use the solar powered system effectively is needed. This program will measure the increased availability of energy, and there is a need for a follow-up program to measure the improvement in healthcare delivery. It was suggested that a data logging system and energy metering equipment should be installed to monitor the function and performance of the solar photovoltaic (PV) system. Monitoring and evaluation is specifically for project installation and management, and recommend that monitoring and evaluation team be set up by the Ministry of Health to collect data that will be used to measure these improvements. This project is aimed at providing 24 hours green and reliable electricity supply to the facility, and reduce CO_2 emissions compared to diesel generator. The project will cost 27,169.00 euros, and the organization of this paper follows EREF grant proposal guidelines.

Keywords
Primary healthcare centre; alternative energy; solar-photovoltaic system; health services

1. Introduction

Electricity is essential for access to health services, and the lack of access to energy in healthcare facilities contributes to the immense healthcare challenge faced by developing countries. The connection between energy and health is solid and critical for the effective delivery of quality healthcare. Medical devices, diagnostic equipment, and other general needs, including lights, fans, computers, mobile charging stations, water pumping, heating, and purification systems, all need energy to run. As the World Health Organization mentioned, a healthcare center requires 24-hour emergency services, inpatient services, laboratory services, and diagnostic services [1]. Therefore, Universal Health Coverage cannot be achieved without energy access in healthcare facilities.

Nigeria is one of the countries with the largest population without access to modern energy. It is located in West Africa on the Gulf of Guinea between Benin and Cameroon, bordered to the north by Niger, to the east by Chad and Cameroon, to the south by the Gulf of Guinea of the Atlantic Ocean, and to the west by Benin. It lies within latitudes 4 1' and 13 9' North and longitudes 2 2' and 14 30' East. Nigeria is a democratic Federal Republic of 36 States and the Federal Capital Territory (FCT). FCT of Abuja covers a land area of 8,000 square kilometers and is in the middle of the country. Abuja falls within latitude 7°25' N and 9°20° North of the equator and longitude 5°45' and 7°39' east of Greenwich [2]. Electricity supply in Nigeria is a leading barrier to improved healthcare performance. In Nigeria, there are 30,098 Primary Healthcare Centre (PHC) facilities across the 36 States plus the FCT Abuja [3]. The ability of these facilities to provide certain services to meet the health needs of the people is undermined by poor energy access. Many PHCs, particularly those in rural areas, lack reliable, affordable electricity supplies for powering essential services such as lighting, communications, refrigeration, diagnostics, and the medical devices required for health services. Out of the over 30,098 PHCs in Nigeria only 6,000 is functional. Over 80% of poorly functioning PHCs are located in densely populated communities in the peri-urban, and far remote villages suffer from unreliable energy networks, impeding health service provision. Over 43% of PHCs are not connected to grid electricity supply. 57% of the PHCs connected to the national electricity grid have less than 5 hours of grid electricity supply daily [4]. Currently, PHCs in the country have an average power supply of 6-10 hours from any combination of sources. Most PHCs across Nigeria are forced to shut down before nightfall, as they lack illumination to operate nightshifts; otherwise, they rely on torchlight or kerosene lanterns for critical night-time emergencies [4]. Stable access to electricity supports core facility operations, resulting in various benefits to patients and communities. Sustainable and reliable electricity is central to ensuring that PHCs function optimally. Still, the current national electricity grid and fossil generators cannot guarantee sustainable and reliable electricity supply to PHCs in Nigeria. A common recourse for PHC operators has been to employ renewable energy solutions to combat this prevalent issue.

1.1 Case Study of Karshi-Abuja

PHC in the Karshi community is located in Abuja Municipal Area Council (AMAC), one of 6 area councils in the FCT. The Karshi Community in AMAC of FCT is among the many communities affected by the country's energy crisis. Karshi Healthcare Center has been experiencing worsening power outages in the past several years, lasting from several hours to several days. Many of the functions in this healthcare facility depend on a reliable electricity supply for critical care situations, and the loss of power can easily contribute to loss of life [5]. They have no illumination at night, making night work an arduous task and night emergencies impossible. Due to the unreliable power supply, the facility now relies on a diesel-powered solution. The power situation is so unreliable that the generator runs in the morning and afternoon, consumes a lot of diesel, and negatively impacts patients and the environment. Medical workers are exposed to adverse work temperatures from the worsening heat caused by global warming to the noise and poisonous carbon monoxide from fossil generators, which harm users' health. Using generators to cope with the irregular power supply is a burden on the operational budgets of the health facility as it spends between N30,000.00 and N39,000.00 monthly to fuel fossil generators (this excludes maintenance and repairs). These costs are borne mainly by the medical workers in the health facility, as the budgetary allocation from the FCT and Area Council to power the generator and cover the grid electricity bill are either too marginal (at an average of N25,000 to N37,000 a month) or unavailable. When diesel prices go up, the budget doesn't increase, and existing or planned public health programs must be reduced or delayed because less money is available from the budget [6]. Better energy generation and management is one of the keys to improving public health, and one of the ways to control increasing costs in this public health setting is to reduce the energy cost by moving to a different energy system, in this case, renewable energy. The renewable energy situation assessed through field surveys and experiments by [7] and [5] confirmed that solar energy is available in abundant quantity, particularly since geographic and political boundaries do not limit it; it is more or less equally distributed over the country throughout the year. As research has proved and as we see today, this energy from the sun is an efficient means of an alternative energy supply.

1.2 Solar Energy

Solar energy is produced directly using the radiant energy emitted from the Sun to the Earth. PV technology can transform the energy associated with solar radiation into electrical energy. Solar energy is converted to electricity via the PV effect in electricity generation. The PV effect is a physical phenomenon in which a voltage or electric current is produced between two electrodes attached to a system when light is shined upon it [8]. This effect allows electricity to be made directly from sunlight. PV panels can be connected in series or parallel to obtain the desired voltages and currents (for cells connected in series, the voltages are additive; cells connected in parallel to the currents are additive). In particular, an off-grid PV system must be integrated with an energy storage system to compensate for the differences between the availability of solar power and the power required by the load during the intervals of insufficient generation. Solar energy has strong potential as a fuel-free renewable source of energy, which can contribute to the deployment of offshore health facilities' power needs. The free, theoretically inexhaustible supply of energy holds great appeal, particularly since geographic and political boundaries do not limit it: no one owns the sun, and every place receives it to a greater or lesser extent.

To demonstrate that solar is entirely reliable for power generation, the Lagos State Government, through the Lagos State Electricity Board (LSEB), joined forces with the United Kingdom Department for International Development (UK-DFID) in 2014 to bring forth an ambitious project “Lagos Solar” to power PHCs located within the rural areas using solar PV systems [3]. The LSEB has tested and proven that the failures were due to poor design, installation, improper use due to the lack of user awareness and training, lack of maintenance, and no follow-up other than the solar technology itself. Field experience has also shown that most of Nigeria's solar-powered health facility projects are not working as expected due to poor design and poorly managed systems.

The problem of poor design is incorrect sizing (dimensioning, selection, and matching of stand-alone photovoltaic system components) of components that make up a complete working solar energy generation, storage, and supply system. If the system is poorly sized or designed, its operation would be interrupted, thus reducing its overall reliability as a power supply entity [9]. A single mistake or error in the component sizing can bring the whole system down. Therefore, the load of the PHC facility and the components must be correctly sized to deliver the needed power when required. Hybrid Optimization Model for Electric Renewables (HOMER), a sizing software, will be used to determine the optimal model of each system component, such as number of PV modules, batteries, charge controllers, and tilt angle so that the total system cost is minimized.

1.3 Solar Powering PHCs in Nigeria

The use of solar PV technology provides a plethora of exciting opportunities to be used in rural PHCs. A look into this technology, which has been utilized in PHCs to tackle the constant issue of electricity unreliability in rural PHCs, and compelling evidence from the four separate case studies carried out in Nigeria show that clean, sustainable energy alternatives can help significantly improve healthcare services.

Implementing solar power solutions for almost a dozen PHCs throughout rural Lagos by the Lagos State Government tagged “Lagos Solar Power Project” are expected to benefit 4.7 million clinic patients [3]. These numbers represent the remarkable impact solar will bring to the future of Nigeria. Since the completion of this project, immediate changes have already been witnessed:

- Care is accessible 24 hours a day.
- An estimated 4.7 million patients will receive better healthcare.
- The regular power source will catalyze overall improvements in health services.
- Millions of Naira will be saved annually on the PHCs fossil fuel bills.

In Edo State, the state government has set up an intervention program known as the Edo Healthcare Improvement Program (EDO-HIP), which aimed at increasing access to efficient, effective, and sustainable quality healthcare services with the central focus of the provision of 24hrs power supply to the PHCs in Edo State. Under the EDO-HIP, the state government has delivered solar-powered energy solutions to 20 PHCs. The initiative saw the transition to clean, reliable energy in the state.

In Kaduna State, the government has delivered clean and reliable energy solutions (solar systems) to 34 PHCs. These PHCs serving over 180,000 patients annually were supplied all the power they needed to provide quality healthcare round the clock in an environmentally friendly manner. Almost 6,000 babies are delivered yearly across 34 PHCs [10]. Moreover, solar systems have eliminated the need for noisy generators, reducing carbon emissions and creating a more serene environment for patients. These projects each boast a healthcare center that has electricity 24 hours a day [11]. Through PV technology, healthcare centers that previously had little or no access to electricity supply from the national grid now have clean and sustainable power solutions.

In Oyo state, Power Africa awarded Havenhill Synergy a grant to electrify 21 rural healthcare facilities using an energy-as-a-service business model. The facilities are primarily within peri-urban communities with limited reliable electricity access. Havenhill Synergy installed off-grid solar energy in these healthcare facilities successfully and envisages providing long-term operation and maintenance of the solar energy systems.

Given the background above and the lack of access to power in Nigeria, it is pertinent to say that increased energy access for health facilities serving poor communities in off-grid areas not connected or poorly served by the grid will improve health care service delivery as well as reduce the cost of running generators and carbon emissions associated with diesel generators.

1.4 Novelty of the Study

The novelty of the study is that it has not been done before in Karshi-Abuja, and it is similar enough to be able to take the success from these four states (Lagos, Edo, Kaduna, and Oyo) and replicate it in Karshi-Abuja. This project would benefit both the PHC and the environment, offset utility costs, and allow for further investment in the PHC.

2. Study Objectives

The overall objective is to develop a proposal for the sustainable electrification of PHC that will improve the quality of healthcare delivery services while mitigating greenhouse gasses.

Specific objectives: to reduce the healthcare facility's energy costs by 61.3% and CO_2 emissions by 100% in Karshi-Abuja in two years and train medical staff on the current energy management plan, as shown in Table 1 below.

Table 1 Logical Framework Matrix.

	Intervention logic	Objectively verifiable indicators of achievement	Sources and means of verification	Assumptions
Overall objective	Improve the quality of healthcare delivery services.	Operational hours increased from 6.30 pm to 10.00 pm. Level of use of diagnostic and emergency health services increased by 50% by the end of the project compared to the baseline year.	End-user survey	
Specific objectives	Provision of reliable energy system to reduce the operational costs of the health facilities' energy supply and energy-related CO_2 emissions through substituting diesel-powered with solar-powered system.	By the end of the project, • Operational costs for the health facilities' energy supply reduced (2,107.00€ compared to the baseline of 8,779.00€) by 61.3%. Recouped in 2.5 years. • Energy-related CO_2 emissions were reduced by 100% (0.000 t/yr. compared to the baseline of 9.371 t/yr.).	Project file (Data in Table 4)	
	Train medical staff on the current energy management plan.	The proportion of trained health workers who were satisfied with the training and have gained skills and knowledge of energy management practice guidelines.	Sample of the beginning and end of the training using questionnaire.	
Expected results	Increased quality of healthcare as the health centre will be able to make use of the full range of diagnostic and emergency health services available in order to provide consistent services.	The proportion of all healthcare staff at the health facility who were satisfied with the energy services and considered that these services contribute positively to providing high-quality care.	Six to twelve months after implementation of project, using questionnaire.	
	Increased number of patients that can be attended to per day as	The proportion of women and their families who attended the health facility who were satisfied with the	Six to twelve months after implementation of	

	improved lighting allows the health centre to stay open longer.	power and lighting source and would recommend the facility to friends and family.	project, using questionnaire.	
	Increased reliability as energy management plan is maintained by appropriate trained staff.	Consistent supply of electricity in all clinical areas, including labour room, childbirth and newborn rooms.	Six to twelve months after implementation of project, using questionnaire.	
	Activity	**Means**	**Cost (€)**	**Assumption**
Activities	1. Install solar energy equipment 1.1. Solar equipment as per specification manufactured. 1.2. Solar equipment transported to the site and installed.	Installation of equipment	**20,539.00** **3,330.00**	
	2. Establish solar energy management team 2.1. Establish a solar energy management team to enable them take ownership of the project developed.	Seminars on the value and benefits of the facility's energy system.	**300.00**	
	2.2. Train the established team on the skills and knowledge necessary to carry out energy-related assignments in their facility.	Conference room, Audio & visual apparatus.	**2,100.00**	

3. Description of the Stages of the Program

The program was divided into 4 stages as shown in the Figure 1 below.

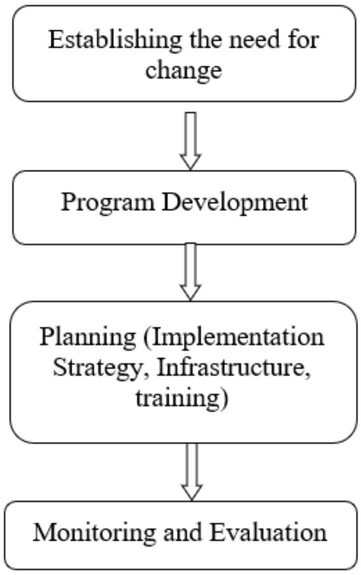

Figure 1 Stages of the Program - Adapted from Cresswell, Bates and Sheikh (2013) [12].

3.1 Methodology of the Different Stages

3.1.1 Stage 1: Needs Assessment

PHC energy assessments for solar system design consider the existing loads and their utilization at the health facility. This can lead to optimal solar system technical designs and optimal solar for health program designs. Therefore, the energy needs assessment was carried out in Karshi PHC to assess the electrification status of the health facility and its state of energy access through a series of key informant interviews at the PHC using a structured questionnaire (see Appendix). This system approach ensured that the solar for health program is technology-enabled and not technology-led. Table 2 below shows the load profile for the rural health facility, while the Table 3 was provided for a clear understanding of the load profile.

Table 2 Load Profile for the rural Health Facility to be powered by the solar system.

S/no	Power Consumption	Qty	Power (Watts)	Total (Watts)	Daytime hours (07:00-17:59)	Evening hours (18:00-21:59)	Night hours (22:00-06:59)	Total Hours/day	Total Energy (kWh/day)
Clinical Medical Devices									
1	Refrigerator-Vaccine	1	60	60	5	3	2	10	0.60
2	Centrifuge	2	242	484	4			4	1.94
3	Microscope	2	20	40	6			6	0.24
4	Blood Chemical Analyzer	1	88	88	4			4	0.35
5	Hematology Analyzer	1	230	230	4			4	0.92
6	CD4 Machine	1	200	200	4			4	0.80
Lighting									
7	Interior Lighting (a)	2	12	24	11	4	9	24	0.58
8	Interior Lighting (b)	3	12	36	1	4		5	0.18
9	Security/Pathway Lighting	5	18	90		4	9	13	1.17
Clinical Appliances									
10	General Purpose Refrigerator	1	150	150	2	2	1	5	0.75
Infrastructure									
11	Radio	1	15	15	2			2	0.03
12	Phone charge	2	7.5	15	2			2	0.03
13	Notebook Computer	1	30	30	4			4	0.12
14	Fan	5	25	125	8	5		13	0.38
15	Miscellaneous equipment	1	100	100	7			7	0.70

Source: Data from the nurse, key informant interview.

Table 3 The electrical load (Daily load demands) data for the healthcare facility in Table 2.

Time	**DAILY LOAD DEMANDS**													**Total Energy (Wh/d)**
	RV	GPR	Centrifuge	Microscope	BCA	HA	CD4 Machine	Radio & Phone	Notebook Computer	Fan	ME	Interior Lighting	Security & Pathway Lighting	
0.00-0.59												24	90	**114**
1.00-1.59												24	90	**114**
2.00-2.59	60											24	90	**174**
3.00-3.59	60											24	90	**174**
4.00-4.59												24	90	**114**
5.00-5.59												24	90	**114**
6.00-6.59		150										24	90	**264**
7.00-7.59	60											24		**84**
8.00-8.59	60							30	30			24		**144**
9.00-9.59	60			40	88				30	125	100	24		**467**
10.00-10.59	60	150		40	88		200			125	100	24		**787**
11.00-11.59	60	150	484	40			200			125	100	24		**1183**
12.00-12.59			484	40	88	230	200			125	100	24		**1291**
13.00-13.59			484	40	88	230	200			125	100	24		**1291**
14.00-14.59			484	40		230				125	100	24		**1003**
15.00-15.59						230			30	125	100	24		**509**
16.00-16.59									30	125		24		**179**
17.00-17.59								30		125		60		**215**
18.00-18.59	60									125		60	90	**335**
19.00-19.59	60									125		60	90	**335**
20.00-20.59	60	150								125		60	90	**485**
21.00-21.59		150								125		60	90	**425**
22.00-22.59												24	90	**114**

23.00-23.59												24	90	**114**
Total	**600**	**750**	**1936**	**240**	**352**	**920**	**800**	**60**	**120**	**1625**	**700**	**756**	**1170**	**10029**

Abbreviations: RV (Refrigerator-Vaccine); GPR (General Purpose Refrigerator); BCA (Blood Chemical Analyzer); HA (Hematology Analyzer); ME (Miscellaneous Equipment).

3.1.2 Stage 2: Program Development

This stage will design the solar-powered system to improve health service delivery in the Karshi community. The optimal sizing of a stand-alone PV energy system for power generation is a highly complex task requiring interdisciplinary knowledge and suitable computation and simulation tools. The solar resources of the location were identified using a geographic information system (GIS) mapping as shown in Figure 2, then the PV energy system sizing and the costs and emissions of stand-alone power supply options (generator versus solar system) using HOMER Software. The simulation results are shown below (Table 4).

Figure 2 GIS mapping showing the location of Karshi PHC.

Table 4 Comparative costs and emissions of stand-alone power supply options (generator versus solar system).

Configuration	PV Capacity (kW)	Generator Capacity (kW)	Number of Batteries (6 V/225 Ah)	Converter Capacity (kW)	Initial Capital (€)	Annual Generator Usage (Hours)	Annual Quantity of Diesel (L)	Total Net Present Cost (€) for 25 Years	Cost of Energy (€/kWh)	Renewable Fraction	CO_2 Emission (t/yr.)
Generator only	0	2.5	0	0	2,100	8,760	3,558	85,528	2.31	0.00	9.371
PV+Battery	10	0	10	2	19,379	0	0	21,478	0.58	1.00	0.000

Simulation Results and Discussions. The simulations provide information concerning each system's economic costs and environmental pollution, such as CO_2 emissions.

From the economic analysis, the diesel power generating system has the least initial capital cost of €2,100 but, in the end, has the highest total net present cost of €85,528. In contrast, the solar PV-powered system with battery has the highest initial capital cost of €19,379, but in the end, it has a lower total net present cost of €21,478, as shown in Table 4. From the simulation results, it has been demonstrated that the use of a solar PV-powered system with a battery could achieve significantly lower net present cost (NPC) and cost of energy (COE) than a stand-alone diesel system.

From the environmental analysis of pollutant emission, the diesel-only system operates for 8,760 h/annum with a fuel consumption of 3,558 L/annum. This system emits 9.371 tonnes of CO_2 annually into the atmosphere of the location under consideration as a result of burning a lot of fossil fuel, whereas in the solar PV-powered system, there is no fuel consumption, which means no emission of CO_2 from the energy system. Electricity from solar PV-powered systems is environmentally friendly, silent, and does not require fuel or diesel.

These comparisons (cost and emission) show that solar PV-powered system is the optimal energy system for PHCs in Nigeria. It has been determined that using a solar PV-powered system to power health service facilities is far better than the diesel-only power generation system, especially in areas without utility power.

3.1.3 Stage 3: Implementation and Training

If successful, this project will form a replicable model that can be used in PHCs throughout FCT. This endeavor may be the first phase of Abuja's PHC solar electrification program. The second goal, described in the project plan, is the establishment of energy management team and training them on the facility energy management practice guidelines. Surveying has shown that when implementing solar-powered projects, it is crucial to have the operators properly trained on how the solar PV technology are used and to verify that they can use them.

Training of the management team will be obtained in two ways. During the installation, health workers from Karshi Healthcare Center will be tutored by an expert on installing and maintaining the system. The other aspects of renewable energy, such as skills and knowledge of energy management practice guidelines, will be taught during a conference at the Ministry of Health, conference Hall, Abuja.

3.1.4 Stage 4: Monitoring and Evaluation of Solar Energy System Program

Monitoring and Evaluation will improve the quality of healthcare delivery services by measuring the effect and impact of solar-powered systems on health service indicators, such as providing faster childbirth emergency response, prolonging night-time service provision, and total hours of service provision per day. These indicators will be used to evaluate the solar-powered system's impact on health outcomes. From the outcomes in the logical framework matrix of Table 1, solar energy system design, in this manner, becomes a catalyst for strengthening health systems.

4. Resources Needed, Including Personnel and Equipment

4.1 Project Costs

The project costs are divided into 6 categories: personnel costs, travel and subsistence, equipment and supplies, services, workshops and training, and other costs. The project initiator will arrive in Abuja a week before installing the solar system to check if all is ready. An energy management team will comprise six health workers from Karshi PHC and be trained on how to use the equipment more responsibly and better. The solar system is manufactured in Nigeria, so shipping costs are excluded. The detailed project budget breakdown is shown in Table 5 below.

Table 5 Budget Sheets according to Result Areas and Activities of the Logical Framework Matrix of Table 1.

Total Eligible Direct Costs of Activity						Indicative Budget Schedule	
Budget items	Unit	Unit Rate in EUR	No. of Units	Total Costs (€)	% of Total Costs	Year 1	Year 2
Result 1: Increased quality of healthcare delivery services.							
Activity 1.1: Solar equipment as per manufacturer specifications.							
A. Personnel Costs							
International Expert							
Local Expert							
B. Travel and Subsistence							
Per diems for missions/travel							
Flight tickets							
C. Equipment and Supplies				20,379.00	99.2%	20,379.00	
PV equipment	Per item	19,379.00	1.00	19,379.00		19,379.00	
Laptop and Software's (HOMER)	Per item	1,000.00	1.00	1,000.00		1,000.00	
D. Services				60.00	0.3%	60.00	
Consultancy							
Studies	Per item	30.00	2.00	60.00		60.00	
E. Workshops and Training							
Workshop Costs							
F. Other Costs				100.00	0.5%	100.00	
Running Costs - transport	Per item	100.00	1.00	100.00		100.00	
Sub Total 1.1				20,539.00	100%	20,539.00	
Total Eligible Direct Costs of Activity						Indicative Budget Schedule	
Budget items	Unit	Unit Rate in EUR	No. of Units	Total Costs (€)	% of Total Costs	Year 1	Year 2
Result 1: Increased quality of healthcare delivery services.							

Activity 1.2: Solar equipment transported to the site and installed.							
A. Personnel Costs				200.00	6%	200.00	
International Expert							
Local Expert	Per day	200.00	1.00	200.00		200.00	
B. Travel and Subsistence							
Per diems for missions/travel							
Flight tickets							
C. Equipment and Supplies							
PV equipment							
Laptop and Software's (HOMER)							
D. Services				2,030.00	61%	2,030.00	
Consultancy	Per item	30.00	1.00	30.00		30.00	
Installation	Per item	2,000.00	1.00	2,000.00			
E. Workshops and Training				1,000.00	30%	1,000.00	
Workshop Costs	Per item	1,000.00	1.00	1,000.00		1,000.00	
F. Other Costs				100.00	3%	100.00	
Running Costs - transport	Per item	100.00	1.00	100.00		100.00	
Sub Total 1.2				3,330.00	100%	1,330.00	
Total Eligible Direct Costs of Activity						Indicative Budget Schedule	
Budget items	Unit	Unit Rate in EUR	No. of Units	Total Costs (€)	% of Total Costs	Year 1	Year 2
Result 2: Increased reliability of power supply							
Activity 2.1: Establish an energy management team to take over the ownership of the project developed.							
A. Personnel Costs							
International Expert							
Local Expert							
B. Travel and Subsistence				300.00	100%	300.00	
Per diems for missions/travel	Per day	300.00	1.00	300.00		300.00	

Flight tickets							
C. Equipment and Supplies							
PV equipment							
Laptops and Software's (HOMER)							
D. Services							
Consultancy							
Studies							
E. Workshops and Training							
Workshop Costs							
F. Other Costs							
Running Costs - transport							
Sub Total 2.1				300.00	100%	300.00	
Total Eligible Direct Costs of Activity						Indicative Budget Schedule	
Budget items	Unit	Unit Rate in EUR	No. of Units	Total Costs (€)	% of Total Costs	Year 1	Year 2
Result 2: Increased reliability of power supply							
Activity 2.2: Train the established team on the management of the energy system							
A. Personnel Costs				600.00	28.6%	600.00	
International Expert	Per day	400.00	1.00	400.00		400.00	
Local Expert	Per day	200.00	1.00	200.00		200.00	
B. Travel and Subsistence				400.00	19%	400.00	
Per diems for missions/travel							
Flight tickets	Per ticket	400.00	1.00	400.00		400.00	
C. Equipment and Supplies							
PV equipment							
Laptop and Software's (HOMER)							

D. Services						
Consultancy						
Studies						
E. Workshops and Training				1,000.00	47.6%	1,000.00
Workshop Costs	Per item	1,000.00	1.00	1,000.00		1,000.00
F. Other Costs				100.00	4.8%	100.00
Running Costs - transport	Per item	100.00	1.00	100.00		100.00
Sub Total 2.2				2,100.00	100%	2,100.00

In total, this leads to a project cost of about 27,169.00 euros, as shown in Table 6.

Table 6 Compiled Budget Sheet of Result Areas and Activities.

Total Eligible Direct Costs (all activities)			**Indicative Budget Schedule (€)**	
Budget items	**Costs (€)**	**% of total costs**	**Year 1**	**Year 2**
A. Personnel costs	800.00	2.9	800.00	
B. Travel and Subsistence	700.00	2.6	700.00	
C. Equipment and Supplies	20,379.00	75.0	20,379.00	
D. Services	2090.00	7.7	2090.00	
E. Workshops and Training	2,000.00	7.4	2,000.00	
F. Other costs	300.00	1.1	300.00	
G. Monitoring & Evaluation	900.00	3.3	300.00	600.00
Total Costs	**27,169.00**	**100**	**26,569.00**	**600.00**

5. Time Schedule and Work Plan

For the realization of the project, there are 4 stages left, which will be performed in the upcoming months. The following 4 stages are represented below and shown in Table 7 (the timeline).

Table 7 Time Line.

Activities	**2023**						**2024**											
	07	**08**	**09**	**10**	**11**	**12**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**
Contacting the EREF for sponsoring the project																		
Manufacturing of solar equipment as per specification																		
Transportation of solar equipment to the site																		
Installation of solar equipment																		
Establishment of solar energy management team																		
Training of the established team																		
Conference																		
Monitoring and Evaluation																		

5.1 Stage 1: Acquire the Needed Funding

When: July/August 2023.

In this stage, the project Manager will contact the ECOWAS Renewable Energy Facility (EREF) to sponsor the project. If this is not sufficient, more sponsors need to be found.

5.2 Stage 2: Preparation of Solar System Instalment and Conference

When: September/October/November 2023.

The National Agency for Science and Engineering Infrastructure (NASENI) will be contacted when the budget is sufficient to perform the project. They will be in charge of manufacturing the solar equipment, which will be conducted according to the necessities of the PHC. Only the PV products from NASENI will be considered to facilitate easy replacement in the case of a component failure. The Karshi PHC, Abuja, will also be contacted to plan the conference and residence of the Project Manager and the speakers.

5.3 Stage 3: Instalment of the Solar System and Conference

When: November/December 2023.

The installment can be started when all things have been arranged for the solar system, the conference, and the traveling and residence for the project Manager and the conference speakers. During the installation, health workers of the Karshi PHC will be trained in installing and maintaining solar systems. When the solar system is installed, it will be officially commissioned, after which the conference will occur the next day.

5.4 Stage 4: Monitoring and Evaluation (Report and Follow-Up)

December, 2023 to December, 2024.

This work plan allows monitoring of the project's progress so that the milestones in the work plan are verifiable. So once the system is installed, it will be monitored, and the experiences will be written down in a report.

6. Expected Results

The project will result in multiple benefits for the primary healthcare center by achieving our objective. These will include:

- electricity-driven equipment for medical and diagnostic services and appropriate medical technologies available will be functional as the health center will now boast a steady supply of electricity;
- increased access to health services as the health center can provide consistent services;
- improved quality of healthcare delivery services as the healthcare center will be able to make use of the full range of diagnostic and emergency health services available;
- increased number of patients that can be attended to per day as improved lighting allows the health center to stay open longer;
- reduced operational costs for health facilities' energy supply and
- reducing environmental impacts through solar-powered system rather than fossil fuels.

Conclusively, this project will be key to improving health service availability, including improving maternal health, reducing child mortality, and disease prevention in this community.

7. Conclusion

The major reason for the deficiency of quality healthcare services in this PHC facility is the lack of a reliable supply of electricity needed to utilize healthcare equipment, and the assumption is that with a more reliable, secure, and cost-effective energy source, the health workers will be able to do their work better. Solar PV systems with battery storage are viable options for providing this energy access. The need assessment and program development have been done. Therefore, I am approaching the funder because I want to ask the funder to fund the implementation, monitoring, and evaluation. On the training of the energy management team, their training is not to measure the improvement, but their training is to use the equipment (solar energy) well. Therefore, the monitoring and evaluation are specifically for project installation and management. More data is needed to assess the function and performance of solar PV systems properly. A data logging system and energy metering equipment are required in order to monitor the power production from the solar PV arrays and the charging and discharge of the battery banks to feed the loads. With this information, it will be possible to understand better whether the system sufficiently meets the needs of the PHC or if it is oversized or undersized. More information will need to be gathered over time, like watching the number of patients the PHC can serve to determine if there is any correlation between the installation of the new system, the increased energy access, and the amount of service that can be provided. Data will need to be taken over the year to be compared with that collected in the past. Therefore, it was recommended that the Ministry of Health set up a monitoring and evaluation team to collect data on how many people are coming to the clinic, how many people are being diagnosed, what are the changes over time in the use of electrical medical devices.

Author Contributions

The author did all the research work of this study.

Competing Interests

The author has declared that no competing interests exist.

Additional Materials

The following additional materials are uploaded at the page of this paper.

1. Appendix: Questionnaire on Service Availability Assessment for Energy Module in Health Facility.

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