Highlights of Sustainability

ISSN 2696-628X, A Peer-Reviewed Open Access Journal by Highlights of Science
https://www.hos.pub/ho/sustainability

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This article is part of the Special Issue
Energy Efficiency and Renewable Energy

Cite this Article

ACS Style

Njoh, A.J.; Ngyah-Etchutambe, I.B.; Soh-Agwetang, F.C.; Tah, P.T.; Tarke, M.O.; Asah, F.J. Implications of Non-technical Factors for Off-grid Electrification Initiatives in Cameroon: A Review of the Esaghem Village Solar PV Project. ***Highlights Sustain.*** **2022**, *1*, 159–170. https://doi.org/10.54175/hsustain1030012

APA Style

Njoh, A. J., Ngyah-Etchutambe, I. B., Soh-Agwetang, F. C., Tah, P. T., Tarke, M. O., & Asah, F. J. (2022). Implications of Non-technical Factors for Off-grid Electrification Initiatives in Cameroon: A Review of the Esaghem Village Solar PV Project. ***Highlights of Sustainability***, *1*(3), 159–170. https://doi.org/10.54175/hsustain1030012

Highlights of Science

Publisher of Peer-Reviewed Open Access Journals
https://www.hos.pub
Barcelona, Spain

Review

Implications of Non-technical Factors for Off-grid Electrification Initiatives in Cameroon: A Review of the Esaghem Village Solar PV Project

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Abstract Ensuring access to clean energy for all—Sustainable Development Goal (SDG) #7—remains one of the most elusive SDGs in developing countries. This study reviews efforts to meet this goal in a developing community, namely Esaghem Village, Manyu Division in Cameroon. The efforts involved the use of a micro-off-grid solar PV system. The study employed primary data collected in-situ and from the project documents, and secondary data from electronic as well as conventional sources. The review is intended to highlight the impact of political, economic, social, technological, ecological, cultural and historical (PESTECH) factors on renewable energy (RE) initiatives in a developing country. These are important but oft-ignored historio-cultural factors in the energy domain. The review reveals how one feature of indigenous African tradition, namely the self-help ethos can be harnessed to improve clean energy access in a developing country. It also showed how factors commonly associated with developing countries such as war, administrative centralization, bureaucratic corruption and ineptitude as well as poverty, thwart RE initiatives. The review underscores the importance of non-technical dimensions of RE projects and holds many lessons for the development, management and sustainability of such projects in developing countries writ large.

Keywords Cameroon; clean energy; off-grid electrification; sustainable renewable energy; self-help energy supply projects; solar PV

Open Access

Received: 4 May 2022
Accepted: 2 August 2022
Published: 8 August 2022

Academic Editor
Hegazy Rezk, Prince Sattam bin Abdulaziz University, Saudi Arabia

1. Introduction

Sustainable Development Goal (SDG) #7, which calls for ensuring access to energy for all by 2030 ranks among the most elusive SDGs [1]. This assertion is confirmed by the World Health Organization's observation that some three billion persons, mainly in developing countries, remain without access to electricity [1,2]. The problem of limited access to energy, particularly clean energy [3] for cooking and other domestic uses is most acute in the rural areas of these countries [4].

Rural areas are often not connected to national electricity grids especially because of the urban-biased proclivities of the state in developing countries. Yet, it is impossible to overstate the importance of access to clean energy in these areas. A cost-effective and potentially sustainable alternative means of ensuring this access is through micro-off-grid renewable energy facilities. There are many but woefully underutilized renewable energy resources in developing countries, especially those in sub-Saharan Africa (SSA) [5].

The case of Cameroon is illustrative. While the country boasts abundant hydropower, wind, geothermal and solar irradiation resources, only its hydropower resources are exploited [3,6]. What factors account for the under-exploitation of renewable energy sources in developing countries such as Cameroon? A few studies have drawn attention to the significant influence of non-technical factors on the performance of renewable energy projects [4,7,8]. However, as the works of Abdallah et al. [4] and Bergaentzlé and co-authors [7] suggest, most works on the subject tend to attribute the problem to technological constraints. This tends to discount the effect of non-technical hurdles. Consequently, there are many gaps in knowledge of these factors and their real and potential influence on renewable energy supply and demand in these countries.

This review article constitutes a modest contribution to efforts to fill these gaps. It employs data on an off-grid [9] micro solar PV project in Esaghem, Manyu Division, Cameroon to promote understanding of the impact of non-technical factors on renewable energy development initiatives in a developing country.

The review is guided by the following question. What is the impact of political, economic, social, technological, ecological, cultural and historical (PESTECH) factors on renewable energy projects in rural Africa? More specifically, what are the implications of these factors on the implementation and maintenance of the Esaghem Village solar PV electrification project?

To address this question, the reviewers employed primary data from direct in-situ observations and project documents, and secondary data from conventional sources such as hard and soft copies of peer-reviewed and technical publications. The primary data collection process involved a number of innovative ethnographic tools, including but not limited to audio/video electronic recorders, palm top computers and conventional note pads. Once collected, the data were then transcribed and reviewed within the framework of the PESTECH model. In a recent article on this subject, Njoh [10] argued that "such a review promises to be valuable for efforts to maximize the utility of renewable energy in developing countries."

The review continues in the next section with an examination of the relevant literature with emphasis on the works focusing on the analytical frameworks for energy policy and technology analysis. The most relevant framework for the present study draws from the family of environmental scanning models (ESM) concerned with PESTECH factors. This is followed by a presentation of the Esaghem solar PV electrification project. The main part of the paper employs the PESTECH framework as an ESM model to analyse the project. The paper ends with some concluding remarks.

2. Renewable Energy and the Influence of Environmental Factors: The Literature

The body of works dedicated to assessing renewable energy as an important factor in efforts to attain Sustainable Development Goals has grown significantly in the recent past (see e.g., [11–15]). Also experiencing identical growth trends are works seeking to promote understanding of the environmental implications of renewable energy projects in developing countries [16,17]. However, only a few have sought to highlight the specific nature of these challenges and the specific ways in which they affect renewable energy project implementation and maintenance initiatives [3,18].

With the exception of Njoh et al. [3] and Abdallah et al. [4], most of these works tend to ignore the institutional context of such projects. Two studies, one by Painuly [19] and another, by Painuly et al. [20] are illustrative; they paid hardly any attention to institutional factors. Instead, they identified the lack of financial resources as the leading barrier to renewable energy projects in the developing world.

A more recent study by Foster et al. [21] also exemplifies this trend by focusing intensely on economic factors and their impact on renewable energy penetration. It suggested that, "the cost of fossil fuel power generation will respond to the large-scale penetration of renewables, thus making the renewable energy transition slower or more costly than anticipated" ([21], p. 258).

An exception, Njoh and colleagues [3], focused on institutional factors, particularly the actions of the state in the energy policy field. The study found that these actions occasionally have the paradoxical effect of hampering renewable energy initiatives. Pegels' work on South Africa identified costs and risks as barriers to renewable energy [18].

Similarly, the work of Fischer et al. on SSA drew attention to the region's paradox of a place suffering from energy famine despite boasting a rich reservoir of energy resources [22]. The authors identified four specific factors deserving of attention in renewable energy projects. These include the technology itself, the project's physical location, the partners and counterparts in the project, and the local jurisdiction. This last factor includes four elements, namely the general economic environment, the institutional landscape, the political state (stable or unstable), and the reliability of local regulations.

The work of Fashina and colleagues on Uganda sought to identify possible drivers of renewable energy in the country [23]. Seetharaman et al. ([24], p. 2) identified "economic, institutional, technical and socio-cultural barriers that hinder countries from moving from the high to the low emission pathway." They demonstrated that social, technological and regulatory barriers are instrumental in renewable energy initiatives. Two recent works respectively by Garcia-Alvarez et al. [25] and Qarnain et al. [9] are forceful in identifying regulatory frameworks as barriers to renewable energy initiatives.

On their part, Ahlborg and Hammar examined Tanzania and Mozambique; they identified among the main barriers, factors such as the lack of access to human capital, difficulties in planning, donor dependency, low rural markets, little interest from the private sector and lack of technical expertise [26]. Also worthy of note is the contribution of Rennkamp and Perrot who identified the facilitators and impediments to wind energy development initiatives in Brazil, India and South Africa [27]. Like most researchers before them, they focused exclusively on the technological dimensions of renewable energy.

Furthermore, most works on renewable energy in developing countries typically lack theoretical depth [3]. Studies applying borrowed renewable energy concepts, nomenclatures, classification schemas and models to the realities of the continent are rare. One such study employed a modified version of the “strengths-weaknesses-opportunities-threats” (SWOT), environmental scanning model (ESM) to analyse the sustainability of the sawdust cook stove in Africa [28].

The present study employs an ESM to analyse the impact of Political, Economic, Social, Technological, Ecological, Cultural and Historical (PESTECH) factors on renewable energy projects in a developing country. The empirical referent is a rural solar photovoltaic (PV) electrification project in Cameroon. By way of developing a conceptual framework for this project, the next section discusses the PESTECH model and its relevance to energy research.

Environmental scanning models (ESMs) focusing on organizations, technologies or products are commonplace in the business world. The best-known ESM is the Strengths-Weaknesses-Opportunities-Threats (SWOT), which was developed at the Stanford Research Institute in the 1960s to facilitate organizational decision making [29]. Although initially versatile, the SWOT model has since outlived its utility and is currently the object of fierce criticism. It is considered too simplistic because it contains only four dimensions. This has prompted efforts to develop more comprehensive environmental scanning models.

The 7-dimension PESTECH model proposed by Njoh [2] is a product of efforts in this connection. The seven dimensions of PESTECH are reflected in the acronym as follows: political, economic, social, technological, ecological, cultural and historical. Table 1 summarizes these components the corresponding relevant dimensions, namely political, economic, social, technological, ecological cultural and historical. The PESTECH model has been extolled for many reasons; more importantly, because of its more comprehensive focus, which qualifies it as a vastly improved variant of extant ESMs [10].

Table 1. PESTECH components and implications for energy supply/demand.

Item	Pestech Component	Pestech Elements Relevant to the Energy Domain	Sample Implications for the Energy Domain
1.	Political	▪ Government stability; ▪ Rules and regulations governing foreign investment; ▪ Import/export; ▪ Currency exchange; ▪ Government energy subsidies; ▪ Level of support for energy supply/demand.	Example: Government stability is very important for the energy sector. Instability, especially when it involves wars often results in destroying energy infrastructure, e.g., hydropower infrastructure.
2.	Economic	▪ Size; ▪ Growth rate; ▪ Availability of credits to private investors /individuals ▪ Level of disposable income; ▪ Gross domestic product; ▪ Per capita income; ▪ Level of employment.	Developing and maintaining energy systems requires considerable financial resources. The availability of such resources depends on the economic climate.
3.	Social	▪ Population size; ▪ Level of urbanization; ▪ Education level; ▪ Wealth distribution; ▪ Literacy levels; ▪ Level of urbanization.	Social factors such as those listed here impact the supply and demand for energy, especially electricity in the country.
4.	Technological	▪ Complexity of technology; ▪ Access to new technology; ▪ Level of innovation; ▪ Technological awareness.	Technological innovation has been very impactful on energy technology. The level of complexity affects the sustainability of the technology.

Table 1. (*Continued*)

5.	**Ecological**	▪ Natural resource availability; ▪ Solar irradiation levels; ▪ Size of rivers; ▪ Forest resources; ▪ Vegetation.	Ecological factors are determinants of the availability of renewable energy.
6.	Cultural	▪ Cultural norms and values; ▪ Attitudes towards green products; ▪ Support for renewable energy; ▪ Ethical concerns.	Culture is exceedingly important for the supply and consumption of any renewable energy resource.
7.	Historical	▪ History of the renewable energy source; ▪ History of the use of a renewable energy in a given polity.	The history of the use of specific natural resource determines the manner in which it is received in any given country.

Source: Compiled from the authors' field notes.

3. The Esaghem Solar PV Electrification Project

A succinct description of the Esaghem Village solar PV electricity project is provided by Njoh et al. [3]. The village is a mainly farming settlement in Eyumojock, an administrative sub-division of Manyu Division in the South-West Region, Cameroon. Manyu Division has assumed an unenviable place as a hotspot in Cameroon's ongoing armed conflict, which started in 2016. The conflict pits the country's francophone-dominated government troops against groups vying for the independence of its two Anglophone regions, the South-West and North-West regions. These comprise the former United Nations Trust Territory of British Southern Cameroons.

Esaghem is 11 kilometers from Mamfe, the Manyu Divisional Headquarters. It is surrounded by a dense evergreen forest (see Figure 1). Access to the village is possible by land through a 15-kilometer dirt road that is impassable in the rainy season, linked to a 2-kilometer footpath. The village, which is located atop a hill, contains 26 residential buildings, a communal hall and a population of 200.

Like most Cameroonians, Esaghem villagers have had biomass, particularly firewood, as their main energy source for cooking and heating. They have typically subsidized this with two other high carbon dioxide emission fuels, kerosene and gasoline used to power a communally-owned generator. They use the latter, which is noted for its noisiness and high maintenance costs, on very special occasions such as local community development meetings, funeals and traditional merrymaking festivities [3]. In addition, the closest spot to obtain gasoline for the generator is a dozen or so kilometers away in Mamfe.

Thus, mildly stated, Esaghem has always faced a serious energy problem. This problem attracted the attention of groups of the village's indigenes resident abroad. About a decade ago, one of these groups, which is based in the United States, decided to address the problem. Accordingly, they proceeded to mobilize resources to provide electricity to the village. As part of this process, the group constituted a technical committee, which was charged with the task of brainstorming and recommending an ideal energy technology for the small village.

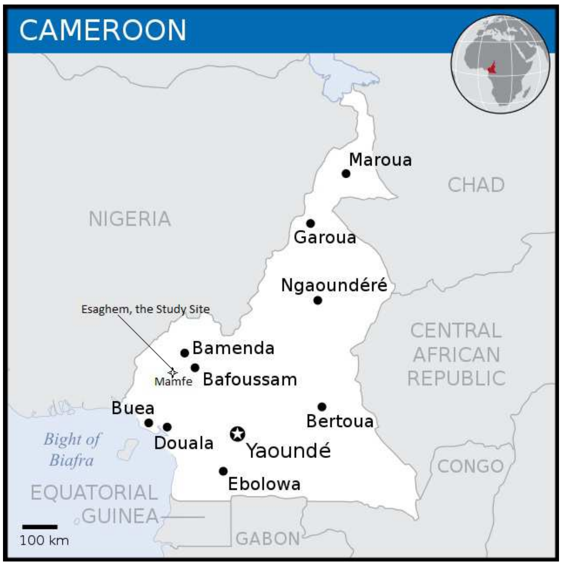

Figure 1. Map of Cameroon showing the location of Esaghem, the study site. Source: Adapted from [30].

The committee's electricity technology of choice was solar photovoltaic. This choice was influenced by the steadily declining cost of solar PV technology, and the ample availability of solar irradiation in the central African region of which Esaghem is a part. Another important reason for opting in favour of a solar PV system is its growing popularity as a renewable energy technology (RET). The system's popularity is a function of two factors: solar panels have become less costly, and solar systems as a whole, are easier to maintain.

The specific purpose of the project was to provide electricity for the following facilities:

- 26 homes and 1 community hall;
- A large screen TV for the communal hall;
- A communal borehole water pump;
- A communal cell phone re-charging station; and
- Post-implementation project maintenance.

With the irradiance of four peak-sun-hours per day, a 100-Watt solar panel can provide about 400-Watts hour (Wh) of energy per day; and based on a formula employed by Adeoti and colleagues in rural Nigeria, a typical residential unit requires 2325 Wh of electrical energy per day [31]. Therefore, each house requires six 100-Watt solar panels—that is, 2325/400—to provide the electricity it requires each day. It is logical to make these assumptions in the case of Esaghem, a rural community in Cameroon, Nigeria's eastern next-door neighbour. Accordingly, therefore, the community's 28 homes—that is, 26 homes plus 1 community center and a cellphone recharging station (assumed to comprise two homes)—results to 65,100 Wh per day (i.e., 28 × 2325/day). Assuming the energy production capacity of one 100-Watt solar panel to be 400-Watt-hours, 163 100-Watt panels—(162.75, to be exact)—are required to produce 65,100 Wh/day.

The implementation process which was slated to last for six months began on 9 January 2015. The main phases included the following five:

- Reconnaissance study of Esaghem Village to determine its suitability for solar electrification.
- Site surveying and collection of data on electricity demand.
- Conducting preliminary work including the sizing of equipment, installation of panels, batteries, inverter, controllers, fuses and wiring.
- Wiring the buildings.
- Testing and commissioning the solar PV system.

This last phase was concluded on 9 January 2016, one year to the day after work on the project began. Thus, instead of six months as originally projected, the project implementation lasted for one year.

Another element of the project worth noting is its cost, which amounted to four thousand, six hundred US dollars ($4600 US). This covered the cost of technical labor, solar panels, wires and cables, as well as shipment of some of the components from the US. The necessary engineering expertise and skills were provided pro-bono by a team of Esaghem natives resident in the US. The villagers donated the land to locate the solar panels and ancillary elements.

4. Technical Details

The Esaghem solar PV system was designed as a stand-alone, as opposed to a grid-tied, system. This nullified the need for grid-tied inverters. The system's Balance of System (BOS), which includes every component comprising the system besides the PV modules, is summarized in Table 2. The system contains elements, including the solar panels, batteries, charge controllers, solar inverter, wiring, light bulbs and brackets. The monocrystalline solar panel is rated at 0.1 kilowatt (100W), and guaranteed by the manufacturer to last about a quarter century. The monocrystalline, as opposed to poly-crystalline panels are not only more efficient; they are also more suitable for developing countries.

More importantly, monocrystalline panels are less costly than their closest competitors. They have also been characterized as being more suitable in tropical regions such as sub-Saharan Africa. Other important components of the system include two 12V 100AH, absorbed glass mat (AGM) batteries connected in parallel to produce a total of 24V. Overcharging and discharging are assured by a charge controller (LCD 30A 12/24V). The charge controller, as per manufacturer's specifications, requires about 12.5 hours to completely recharge a 50% discharged 100Ah lead-acid deep-cycle battery. The 12V DC voltage is converted to 220V AC with the use of a 0.1 kilowatt (100W) off-grid pure sine wave inverter. No cable under 6mm in diameter was used. Lighting was rendered possible by light emitting diode (LED) bulbs (7W to 9W). These bulbs outlast their competitors. Additionally, they consume less power and produce better illumination than incandescent bulbs.

Table 2. Balance of System Components for the Esaghem PV Solar System.

Item	Component	Remarks
1.	PV Module Mounting	These include the hardware that we used to attach the array to an aluminum pole positioned atop a hill overlooking Esaghem Village. The hilltop location permitted the solar panels to receive uninterrupted solar irradiation. Also, it permitted the flow of air, which is necessary to cool the modules.
2.	Combiner box	This was necessary to link the two 12-Volt panels in the system. Each of the panel's output was wired directly to the terminals inside the combiner box. The combiner box also contained the system's circuit breakers.
3.	Solar charge controllers	We included a solar charge controller in the system specifically to regulate the amount of current that the PV modules can possibly pump into the battery. By including this, we ensured that the batteries can never be overcharged. At the same time, we eliminated the chance of current from the battery leaking back into the PV array.
4.	12-Volts batteries	The purpose of this is to chemically store electrical energy in the solar PV system. Our choice of FLA batteries was predicated on the fact that they are considered the most cost-effective.
5.	Solar inverter	These units were included to convert the Direct Current (DC) from the 12-Volt batteries into Alternate Current (AC). This latter is used to run the system's electrical loads. Because the system is of the stand-alone variety, we used off-grid as opposed to grid-capable inverters.
6.	DC/AC Disconnects	These were included to, when necessary, turn off power to and from the inverter.
7.	Miscellaneous components	These include cables, connectors, conduit brackets, and light bulbs. These were necessary to link different parts of the system safely and securely.
8.	100-Wat solar panels	163 required to produce 65,100 Wh of energy per day based on the assumption that one panel produces 400 Wh of energy per day on average.

Source: Esaghem Solar PV Project Files [32].

5. Analysis and Discussion

The need to understand the influence of political, economic, social, technological, ecological, cultural and historical (PESTECH) factors on development initiatives cannot be exaggerated. The remainder of this paper reviews the specific ways in which each of these factors has affected and continues to affect the major phases of the Esaghem solar PV project.

5.1. Political Factors

Four factors rooted in the political domain have significantly affected renewable energy initiatives in Cameroon [3]. The first is the lack of precise and unambiguous rules, regulations and guidelines governing alternative energy initiatives in the country. This specific factor stifled the efforts to import solar electrification components, including the monocrystalline solar panels, the 12-volt, sealed lead-acid rechargeable DC batteries, charge controllers, and inverters. It did not help that information on how to fulfill the necessary custom's formalities was scarce at best and non-existent at worst. Although as far back as 2011, the Government of Cameroon (GoC) had waived the 19 percent Value Added Tax (VAT) on renewable energy components, the customs claimed to have no knowledge of this waiver and levied the project team the VAT [3]. The tendency to feign no knowledge of policies designed to reduce the cost burden associated with government goods and services is commonplace in the country.

The second political factor relates to the lack of active state support for renewable energy initiatives in the country. One manifestation of this phenomenon is the absence of government-sponsored research and development activities focusing on renewable energy. One implication of this is that Cameroon is relegated to the role of consumer in the global renewable energy marketplace. Such a role is highly detrimental to the country's development aspirations. For one thing, all components for any renewable technology must be imported. For another thing, consumers have only conventional sources to depend on to meet their electrical energy needs. For yet another thing, the energy consuming public of Cameroon is denied the opportunity to adopt renewable energy as a means of contributing towards efforts to reduce CO_2 emissions, and environmental pollution writ large.

The reliance on foreign sources for solar and other renewable energy components means the GoC has no way of influencing their costs. This explains, at least in part, the high cost of renewable energy technology in the country. More importantly for the purpose of the present analysis, it is precisely for this reason that we decided in favour of procuring the components for the Esaghem solar PV project from the United States. For another thing, failure on the part of the GoC to support the renewable energy sector has meant the absence of government centres or programmes dedicated to training renewable energy technicians. This explains our unsuccessful efforts to find skilled personnel for the project.

The third factor is over-centralization of Cameroon's politico-administrative structure. As noted by Njoh et al. [3], this structure is in conformity with Weberian bureaucratic principles. As originally conceived by Max Weber (1864–1920), the Weberian bureaucratic model has a pyramidal structure which ensures that all essential decisions within a polity are taken at the center. In Cameroon's case, the center is Yaounde, which, as shown in Figure 1, is geographically far-removed from Esaghem. Given the vastness of Cameroon's geographic area—475 square kilometers (184 square miles)—it is clear that Esaghem is not the only village that is far-removed from the national capital. This is where most government and parastatal agencies responsible for the implementation of energy policy in the country are located.

Here, it is worth noting that the Ministry of Energy and Water (le Ministère de l'Enérgie et de l'Eau (MINEE), the ministerial body in charge of the country's energy policy, is based in Yaounde. This body is represented at the sub-national level by regional delegations [3]. However, while the country has ten administrative regions, there are only four MINEE regional delegations (for the South, Centre, Littoral and North Regions) [32]. Thus, most areas in the country are terribly underserved in the energy domain. This situation is complicated by the fact that a significant amount of written material from the national capital is in French or in adulterated English that has been poorly translated from French.

The fourth factor rooted in the geo-political context of Cameroon with negative implications for the sustainability of the Esaghem solar PV project is the country's ongoing war [33]. Incidentally, the war began in Manyu Division, where Esaghem is located. The war's consequences for the Esaghem solar PV project have been far-reaching. These have included prolonged interruptions to electricity generation due to difficulties procuring spare parts and a lack of regular facility maintenance. The war has also led to a certain degree of population shrinkage in Esaghem although the specific magnitude of this phenomenon is difficult to ascertain; people tend toflee from the village when there is violence and return when things quieten down, if only briefly.

5.2. Economic Factors

Cameroon's economic problems have been worsening since 2017 especially due to the war aforementioned. Currently, the country has a GDP per capita of 1498 US dollars [34]. Thus, Cameroon qualifies as a lower-middle-income country. However, this classification is misleading as 23 percent of the country's population falls under the international poverty line of about 2 US dollars per day [35]. This statistic is also deceptive as it understates the country's poverty problem. Here, it is necessary to note that more than 8 million Cameroonians are classified as poor [36].

Most of these are located in rural areas such as Esaghem. Such locales boast hardly any communication infrastructure and depend on biomass and other dirty and unsustainable energy sources including kerosene and gasoline to meet their energy needs. Renewable and cleaner energy systems such as solar PV holds much promise for efforts to reverse this situation. A copious discussion by Østergaard and co-authors [37] focused on the sustainability dimensions of renewable energy in socio-economic development initiatives.

5.3. Social Factors

An important social factor with implications for the Esaghem Village solar PV project is the village's population size. As noted earlier the village contains a very small population of 200 that is thinly dispersed across a vast geographic area. The small population size had both negative and positive implications for the solar PV electrification project. On the negative side, the small size complicated efforts to ensure a continuous flow of funds to meet the post-construction maintenance cost of the project. Here, we hasten to reiterate the fact that Esaghem is a typical African rural village. It is comprised of peasant farmers with irregular, and occasionally unreliable, income sources. One implication of this is the fact that the villagers could not afford a backup generator for the solar PV system.

The cost implications are not limited to those associated with procuring the equipment but also include the cost of fueling and maintaining the generator. The dispersed nature of the settlement also contributed to significantly increasing the cost of the electric cables required for the project. To appreciate this assertion, it is necessary to note that the cost of an electric cable is a direct function of its linear dimension. Thus, for instance, if a cable two meters long costs $8.00, one that measures four meters long will cost $16.00.

On the positive side, the small population size significantly simplified the task of arriving at a consensus on any project matter. It is always easier to get fewer people to agree on any issue than to do so with many persons. Accordingly, it is thanks to the village's small population size that we encountered hardly any difficulties executing project-related tasks that required community participation. One example of these tasks is the manual transportation of solar PV components over dirt roads from Mamfe to the village. This entailed head porterage on foot and occasionally on motorbikes galloping on footpaths that meander almost endlessly through dense tropical forests.

5.4. Technological Factors

Renewable energy technology is of recent vintage throughout the developing world [20]. Hence, it is reasonable to expect that efforts to implement the technology would encounter some problems. These tend to be of the severe order in the sub-Saharan Africa region, and especially in Cameroon. Here, as Njoh and co-authors have observed the problem manifests itself in terms of a dire shortage of technicians skilled in the installation, maintenance and operation of renewable energy [3].

This is a function of the scarcity of programs designed to train renewable energy technicians and engineers. Only two institutions in the country, the National Advanced School of Engineering Polytechnic in Maroua, and the Advanced School of Public Works, Yaounde offer such training programs. The Maroua program is at the undergraduate (BSc.) level while that of the Yaounde is at the post-graduate (MSc.) level. Thus, there is no pre-university training in RET.

However, this constitutes only partial explanation for the absence of research, and the dreadful shortage of skilled professionals, on renewable energy technology. Another important explanation for this phenomenon is Cameroon's politico-administrative structure, which is fashioned on the bureaucratic model. This model is known to suffer from many problems such as bureaucratic inertia connoting a situation in which administrative systems develop a stubborn resistance to change and innovation [3,38].

5.5. Ecological Factors

The sub-Saharan Africa region where Cameroon is located, is richly endowed with abundant sunlight and solar irradiation because of its proximity to the equator. However, the intensity of solar irradiation varies with the season or period of the year. Cameroon enjoys two major seasons, the rainy season (April to November) and the dry season (December to March), per year. By some estimates, the central African region, including Cameroon, the Central African Republic, Gabon, the People's Republic of Congo, and the Democratic Republic of Congo, experience an average yearly solar radiation of 4kWh per square meter [11].

This information can be misleading because it does not account for the effect of the region's thick forests and other vegetation. With thick forests of the genre characteristic of Esaghem, the densely packed trees tend to obstruct sunlight and heat from reaching the ground surface. In our effort to deal with this problem, we located the solar panels for our project the highest point in the village. However, while doing so guaranteed access to the sun, it necessitated the use of more cables thereby significantly increasing the project cost.

5.6. Cultural Factors

Two cultural factors, the communitarian ethos and propensity for corruption, peculiar to Cameroon, proved critical for the Esaghem PV solar project. In practice, the communitarian ethos is at the root of the tendency of immigrants to organize themselves into groups known as hometown associations (HTAs) based on their places of nativity. It is thanks to this ethos that the Esaghem Village solar PV project came into existence. The project, as noted earlier, was funded by HTAs comprising natives of Esaghem based in the United States. The ethos also accounts for the ease with which we were able to transport the solar energy components and related supplies from Mamfe, the closest urban centre, some 15 kilometers away, over precarious terrain to the village. In this connection, a few residents of the village volunteered to transport the components as in-kind contribution towards the project's realization.

Volunteerism of the genre that the project benefited from is rooted in the African self-help tradition, which can be defined as non-market-oriented production of goods and services. As employed in efforts to realize the Esaghem solar PV project, self-help refers to the activities undertaken by communities to address the gap between felt needs and available goods and/or services [39].

Community self-help has long been employed as a strategy for providing public infrastructure and services in developing countries [40–42], and in locales with limited means in advanced economies [43]. Community self-help has a long history in Africa; it dates back to the pre-colonial era ([44], p. 7).

Colonial authorities were quick to recognize this forté of Africa's communitarian ethos, and proceeded to incorporate it into their development agendas. Joseph Nye, Jr. [45] echoes this point when he states (referring to Tanganyika, present day mainland Tanzania) that, communal labour was not a new idea. It was an integral part of the traditional system of many tribes and as organized by the chiefs, had been used by the colonial administration with varying degrees of success for a number of years.

5.7. Historical Factors

Africans dating back to antiquity have used the sun for lighting, heating, healing, cooking and food preservation. The need to benefit from the sun as a source of lighting prompted ancient Africans to schedule all activities and task whose execution requires bright light for daytime hours. Also, recognition of the importance of sunlight is at the root of the requirement for traditional African buildings to be fitted with openings. These openings are always so strategically located to let in not only sunlight but heat. The walls are usually of earth, which endows the building with thermostatic qualities.

Thus, they are able to absorb and retain heat necessary to warm the building's interior at night when temperatures drop. Throughout Africa, the sun has been used to dry and preserve food, including but not limited to meat, fish, vegetables, and fruits. In addition, Africans have used the sun to cook different types of food. For example, cooking certain types of fruits such as plums entails burying them in sun-heated sand until they are soft enough to be eaten. Also, meat, fish and some fruits are dried not only as a food preservation strategy but as an alternative means of cooking. Thus, the people of Esaghem are no strangers to tapping energy from the sun to meet important human needs.

Paradoxically, the authorities in Cameroon have made little effort to promote the use of energy from the sun for electrification and other beneficial purposes. The country's national grid, which is operated by Energy Cameroon (ENEO), a monopolistic parastatal corporation of an industrial and commercial nature, taps 74 percent of its energy from hydro sources. As of 2015, it had an installed generation capacity of 968 MW from 39 generation power plants, broken into 13 grid power plants, and 26 remote thermal plants. Table 3 summarizes the inventory of Cameroon's national electricity transmission network. ENEO serves 973,250 customers with as many as 45 percent based in the country's two largest cities, Douala and Yaounde.

Table 3. Inventory of the transmission network of Cameroon's national electricity grid.

Item	Facility	Quantity/Extent
1.	Grid power plants	13
2.	Remote thermal plants	26
3.	Substations	24
4.	High voltage lines	1944 km
5.	Medium voltage lines	15081km
6.	Low voltage lines	15,209km
7.	5.5–33 KV distribution networks	11,450 km
8.	220–380 KV distribution networks	11,158 km

Source: Authors' compilation based on field notes [32].

The need to develop the capacity to take advantage of alternative sources of renewable energy in the country cannot be overemphasized. This is due to the fact that the country's hydro-electricity sources are under significant threat from many factors.

6. Conclusion

The fact that only a fifth of Cameroon's rural population has access to electricity is indicative of a massive unmet need in the country's electricity sector. Efforts to address this need have typically been wrong-headed as they tend to concentrate on conventional energy sources, particularly hydropower. Yet, the sustainability of this source is at best questionable and affected by many factors. This paper has reviewed these factors within the framework of a seven-prong model covering political, economic, social, technological, ecological, cultural and historical (PESTECH) dimensions of renewable energy technology (RET). The decision to adopt the solar PV system was primarily dictated by ecological factors. It is necessary to note that deforestation and vegetation loss are causing the rapid shrinkage of the country's rivers. Accordingly, only efforts that sought to tap electricity from alternative sources have the best chance to succeed.

This paper has reviewed a project designed to generate electricity from the sun, which is ranked among the most abundant alternative energy sources in equatorial Africa of which Cameroon is a part. To be sure, the sheer abundance of solar irradiation was not the only impetus for the project team's preference for the sun as the energy source for the Esaghem electrification project. Rather, this preference drew inspiration from two sources. These include the international interest in reducing global pollution levels and the globally acknowledged need to guarantee access to clean electricity for all by 2030 as articulated by Sustainable Development Goal (SDG) #7. Thus, the solar PV project discussed here can be viewed as exemplifying efforts to meet this goal, and from which other rural communities in Cameroon and the developing world in general can draw some useful lessons.

At least four lessons can be drawn from the project to facilitate the implementation of similar projects elsewhere. Firstly, resource scarcity must be acknowledged as an endemic problem throughout developing regions. Consequently, project authorities must, as was the case in Esaghem draw on the goodwill and communitarian ethos that is a ubiquitous characteristic of most non-Western societies. Secondly, the problem of resource scarcity means project authorities must seek only the least costly alternatives. This means, among other things, taking advantage of the alternatives with the most abundant costless resources. In the case of Esaghem, our choice of solar energy was informed by the fact that sunlight is an abundant resource in the tropics. Thirdly, as terrible as this may sound, project authorities, while awaiting positive change, must be prepared to adapt to the culture of corruption that is prevalent throughout the developing world. Fourthly, project authorities must recognize and device means to handle the problem of shortage of skilled and competent technicians. Such a shortage is a problem we learnt the hard way in the case of Esaghem. Giving serious thought to effective ways by which such a problem can be handled in the field is an important lesson flowing from the project.

Author Contributions

- Njoh, the lead author, conceived, outlined various phases, edited/prepared the final write-up and oversaw the entire research project.
- Ngyah-Etchutambe conducted and summarized findings on the psychological and sociocultural state of the Esaghem community with respect to their preparedness for solar electrification project. She also assessed, supervised and reported on the training of the resident post-project maintenance crew. In addition, she prepared the preliminary drafts of the discussion section of the work.
- Soh-Agwetang collected material on the historical background on renewable energy in Cameroon. She also analysed and reported on data relating to hometown associations (HTAs) in Cameroon and the role of HTAs in the Esaghem solar PV project.
- Tarke collected, analysed and reported on the ecological geographic and technological background on renewable energy sources in tropical Africa. She also extracted, collated and tabulated relevant data from the project documents.
- Tah collected the data and reported on the technological aspects of renewable energy; he also conducted research and reported on, the financial feasibility, as well as the post-project maintenance, cost of the project.
- Asah assembled and prepared annotated bibliographic entries for the sources that informed the study. He also prepared the preliminary drafts of the literature review segment of the work.

Conflicts of Interest

The authors declare that there is no personal, professional or financial conflict of interest issue with respect to the entire study.

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