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Sustainable Energy for Emerging Nations Development – A Case Study on Togo Renewable Energy

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***Abstract* — This paper explores the need for an appropriate energy delivery, placing emphasis on the role of the indigenous people in developing their future needs. The case study is based on Togo renewable energy sustainability and employs qualitative and quantitative research to achieve the result. The study stems from the fact that Togo like most African countries has a lot of natural resources such as solar, wind and hydro-electric power required to implement a nationwide sustainable energy system. Yet only 27% of Togolese have access to electricity. The research incorporates critical elements such as the identification of local energy needs, the use of low-cost, effective, and locally made appropriate technologies, and the encouragement of capacity building. The study results show the strong will to develop renewable energy technologies however key barriers are due to inadequate framework regulations that governs the energy sector; lack of policies and strategies that encourages the use of feasible technologies and the lack of capacity development. The results findings will be discussed in details and conclusions drawn in this work presentation.**

***Index Terms*—Renewable energy, Sustainable development, Rural communities, Resilient renewable energy systems, Togo.**

I. Introduction

Energy is important for the growth of any nation. Good access to clean energy is fundamental for sustainable development due to its direct impact on all aspects of life: economic, social, and environmental. To date, despite its huge natural resources, nearly 600 million people in Africa have no access to electricity with over 68% living in Sub-Sahara Africa (SSA) [1, 2]. On a regional basis, Sub-Saharan Africa and South Asia have the most electricity deficit as shown in Fig.1 below [10].

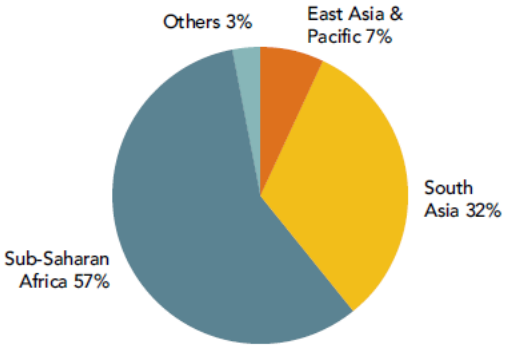

Figure 1. Electricity Access Deficit 2014 [10].

Togo, in West Africa, relies on three main sources of energy: biomass (71%), petroleum (26%) and electricity (3%) as shown in Fig.2 below [3, 4, 7, 11]. Its energy consumption (based on biomass, refined petroleum products and Electricity) is illustrated in Fig. 3 below with an estimate of 0.40 Tonne of Oil Equivalent (TOE)/habitat (ha) compared to 0.45TOE/ha in West Africa, 0.67 TOE/ha in Sub-Sahara Africa and 1.80TOE/ha in the world [4]. It does not produce any petroleum and meets consumption via imports. Togo also imports electricity from Ghana, Cote D'Ivoire and Nigeria. The total energy imported in the year 2016 was estimated at 486.39 GWh [12].

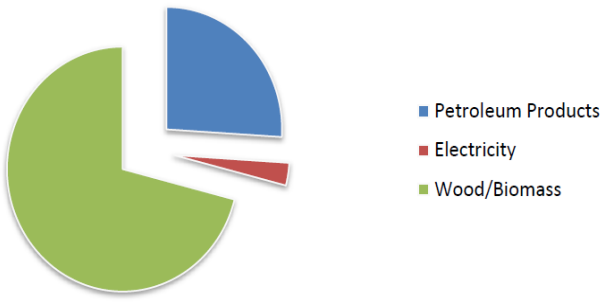

Figure 2. Togo's energy balance at 1650 KTOE in 2008 [4].

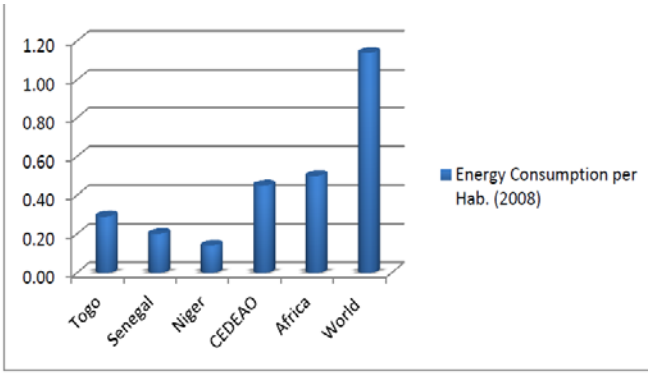

Figure 3. Energy consumption per habitant in 2008 [4].

Ghana supplies a significant percentage of Togo's electricity needs through the interconnection of the countries national grids [5]. Transmission primarily runs from north to south at a voltage of 161kV in the country. The Northern interconnection with Ghana and Burkina Faso, running from Dapaong, is not currently connected to the rest of the high-voltage network [5]. Distribution in the country is done between 33 and 20 kV and its network has deteriorated in the past years due to lack of maintenance and investment [5].

Electricity in Togo is supplied by two companies: the Togolese Electricity Company (CEET) in charge of distribution and sale and the Benin Electricity Community (CEB), a jointly-operated public entity between Togo and Benin in charge of generation (except generation of low voltage) and high voltage transmission of electricity [5]. Besides these, there are industrial and individual independent producers who produce their own supplies using generators, an example being the NIOTO agri-food company which meets its own energy need using cotton waste [5, 11]. Table I. below gives a clear detail about the energy consumption in Togo based on the Electricity Company of Togo's 2016 activity report. However most of these clients are based in Lome, capital town located in the southern region of Togo [12] as illustrated in Fig.4 below.

TABLE I
2016 ENERGY CONSUMPTION BY CUSTOMER CATEGORY (KWH) [12]

Customer Category	Yearly Total (KWh)	Percentage
Private Organisations	702 678 412	72.46%
General Administration	42 116 715	4.34%
Government Societies	77 680 256	8.01%
Government Organisations	24 873 634	2.56%
Local Communities	20 439 705	2.11%
Free Zones	62 775 226	6.47%
International Organisations	19 013 826	1.96%
Concession CEET (1)	20 168 885	2.08%
Grand Total	969 755 659	100%

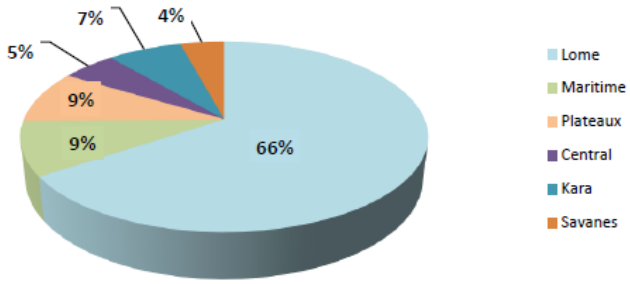

Figure 4. Distribution of the number of clients by region [12].

To reduce the dependency in importation, the government made a concentrated effort in 2009, by signing a five-year performance contract with CEET and selected Contour Global, an international power company to operate a 100MWh power plant which will generate and sell approximatively 780gigawatt hours of power per year to CEET for the next 25 years [6]. This helped lower imports to 486.39 GWh in 2016 compared to 744.95 GWh in 2015; a total reduction of 34.71 percent [12].

Despite the effort made to improve the energy situation in the past few years, a workshop in 2014 held by the energy sector stakeholders and actors to discuss the framework for a smart energy path revealed [7]:

- The electrification rate is weak at 24% (with only 3% in rural areas)
- Electricity only delivers 3% of energy needs
- Biomass fulfils 71% of energy needs
- Energy dependence on external market is high (about 70% of electricity consumed)
- There is little generation or procurement of renewable energy

This clearly shows the need to build resilient renewable energy system (RRES) that will help minimize issues related to the lack of energy. This can be done by introducing other sources of available and affordable energy such as solar and hydro power [8, 9] to improve the energy situation. As the research progress, a framework that will underpin the drive toward building the RRES in Togo will be developed. The developed framework could be replicable to other emerging nations with similar needs, issues and resources.

In summary, around 80 percent of Togo's inhabitants' lack access to energy, one of the key resources for development in today's world. This deficit in power slows down economic activities and hinders the economic development of the country. Preliminary data collection (literature, field visit observation, interviews, workshop) have showed that the majority of the population have no access to basic needs. Consequently, they lack potable water, energy for their daily life and activities such as lightning (for schools, homes and offices), transformation and processing units for their produce, cooling systems for food conservation and refrigeration systems in hospitals for vaccines storage.

Despite this lack of energy, Togo has significant potential for renewable energy as the literature and field visit have

revealed. The study is ongoing but preliminary result based on data collection and analysis are discussed in this paper.

II. METHODOLOGY

The study initially took a comparative approach between the urban and rural areas of Togo to find out in-depth views from both sides and how the lack of energy affects the population. Rural areas of Togo were found to be the most affected economically, socially and environmentally. A mixed method approach has been adopted in this research to give room to the use of different world views assumptions, methods and several types of data collection and analysis. The study is ongoing, the result presented in this paper are mostly based on qualitative data. Primary, secondary and tertiary data sources have been utilized.

A. Field study in five rural areas of Togo

Field study was done in 2014 and 2015 in five rural areas of Togo namely Dapaong, Mandouri and Mango located at the north, Kaboli in central region and Notse in the south: Primary data is based on interview, questionnaires, field note and observations. This entails interacting with the local community through structured open-ended interview questions to get an in-depth understanding of the needs, practices and problems. These formed the basis for analysis to identify the potential issues and solutions. Questions were asked one after the other to allow the participants to answer each question. The time scale for the interview per participant was about 45min and they were given the option to request a stop at any time. In total 31 participants were interviewed.

B. Stakeholders Workshop (2014)

Aside from speaking to the indigenous population, discussions and interviews with policy makers, stakeholders and actors were conducted to get an in-depth understanding of current practices and the level of support require to drive the development of renewable energy. These included:

- Representatives from relevant ministries, namely, the Ministry of Energy and Mines, Ministry of Environment and Forest Resource, Ministry of Agriculture;
- Representative from the electricity company of Togo (CEET);
- Politicians such as members of parliament;
- African Biofuel and renewable energy company which work to promote renewable energy and energy efficient technologies;
- Representatives from non-governmental organisations (NGOs), academic institutions, Economic Community of West African State (ECOWAS) and Food and Agriculture Organisation (FAO).

These were based around understanding the current energy situation as well as to identify views relating to the introduction of renewable energy technologies. Furthermore, three workshops activities were also conducted with three different communities (Mandouri, Mango and Kaboli) to get an in-depth understanding of existing resources, the types of activities and businesses conducted in those communities and potential requirement to improve their living standards. The details are discussed in section IV.

C. Publications and archival reports

Secondary data is based on journal publications, conference proceedings, national and international standards as well as governmental and non-governmental reports. A desktop study/literature review using journal publications, article and online books formed the basis for thorough review towards writing of the report. Conference proceedings data such as conferences, symposia, workshops, expositions, exhibitions were very informative for the research. Tertiary data collection made use of database resources from archival review such as world resources institutes which produce high quality research, including reports, working papers, issue briefs and fact sheets for information gathering and analysis.

III. ANALYSIS AND RESULT

The result and analysis presented in this section are based on a combination of field visit observations, workshop, interviews and literature search as noted above. The interview targeted key people from international organizations with potential of financing renewable energy (RE) projects, policy makers, non-governmental organizations (NGOs), private organizations, academic institutions, and selected indigenous populations.

The study identified that those most affected by the lack of energy are living in rural areas of Togo especially in the northern region with no access to the electricity grid. Overall, 60 percent of Togo's population lives in rural areas where access to basic services such as health, education, drinking water and electricity is lacking. In fact, 74.3 percent of the rural population lives in poverty [4]. This lack of energy leaves the youth with no other choice than to migrate to urban areas in a search for employment, education or better living standards which result in urban areas being overpopulated. Table II below shows more details regarding the rate of access to electricity by regions.

TABLE II
RATE OF ACCESS TO ELECTRICITY BY REGION [12]

Region	Population	Area (Km^2)	Rate of Access to Electricity			Increase rate (%)	
			2014	2015	2016	2014-2015	2015-2016
Maritime Lome	1,857,592	280	80.46	85.94	92.47	6.81	7.59
Rest of Maritime	1,218,067	5,820	14.81	17.50	19.76	18.16	12.93
Plateaux	1,626,774	16,975	11.47	12.72	14.46	11.39	13.20
Central	730,921	13,317	14.85	17.32	18.36	16.69	5.99
Kara	910,813	11,738	17.55	18.92	20.29	7.79	7.27
Savana	979,761	8,470	8.91	10.46	11.20	17.40	7.27
Grand Total	7,323,928	56,600	30.27	33.03	35.81	9.09	8.42

Findings from the interview carried out in 2015 as illustrated in the methodology section above showed that renewable energy (RE) is more used compared to the past 5

years. Some installations were in place thanks to the West African Economic and Monetary Union (WAEMU) project named "PRODERE" ("Programme regional de Developpement des Energies Renouvellables et d'Efficacite Energetique") that is Regional Program for the Development of Renewable Energies and Energy Efficiency. The project started in 2013 and ended in 2016. This made it possible to build 19 pumping wells and 1500 free solar panels in 22 villages with no access to the grid. These provide water and street light at no cost to the local community except maintenance fees. A discussion with the beneficiaries showed that the availability of water due to solar pumping is helping children gain more time to study and concentrate in doing their assignments as children do not waste time anymore fetching water. This is a fact that could result in better results.

Data collected from three workshops activities (Mandouri, Mango and Kaboli) and conducted interviews mentioned in the section above, also revealed rivers namely Kpendjal, Ouale and Sansargou (in Madouri); Oti (in Mango) and Mono (in Kaboli) amongst other in the country. This means small scale hydropower installations could be constructed to help improve energy situation in these districts. Furthermore, data collected based on physical observations and discussions with local communities through workshop activities, revealed the presence of abundant solar within the selected communities such as Mandouri, Mango and Kaboli as shown in Table III below. In addition, most of the people living in those communities are involved in agricultural activities, fishing, and livestock, and lack equipment like transformation unit, processing unit, refrigeration systems, to process or store their produce that could improve their livelihoods. For instance, Ahmed and Fernando research revealed that significant implications for improving household incomes as well as food and nutrition security were achieved for agricultural groups with the use of solar-powered drip irrigation systems in rural Benin [13]. Furthermore, Kirubi et al. study found that access to electricity in Kenya extended operating hours of businesses and longer hours for household to produce hand-made goods. It also allowed small and micro-enterprises use electrical equipment and tools. This boosted productivity by 100 to 200 percent depending on the task at hand and the revenue of the enterprises by 20 to 70 percent depending on the product made [10].

This implies that developing solar-powered transformation and processing unit or even irrigation system with solar water pumps, for instance could improve energy access in Togo and could add value to the agricultural sector, thereby improving living standards of these societies. Moreover, equipping the hospitals with good refrigerators could immensely reduce the number of deaths recorded every year due to the lack of vaccines and medications storage.

TABLE III
SUMMARY OF DATA COLLECTED FROM THE WORKSHOPS

Location	Available resources for energy generation	Activities/ Businesses	Requirements for energy use
Mandouri	Many medium size rivers (Kpendjal, Ouale and Sansargou), Abundant solar radiation, Biomass	Agriculture, livestock, commerce, fishery and artisan	Transformation/ processing units, refrigeration/cooling systems for food conservation and storage and vaccines storage, grinding systems, irrigation for agriculture, potable water, aquaculture, school lightning, leisure center.
Mango	Oti river of length 520km passes through Mango, Solar radiation, biomass	Agriculture, livestock, commerce, fishery	Refrigeration system, peeling, drying and grinding systems, Irrigation for agriculture, aquaculture, processing, storage systems, potable water supply
Kaboli	Mono river, Abundant solar radiation, Biomass	Agriculture, livestock, commerce, fishery	Transformation/ processing units, Refrigeration system, Irrigation for agriculture, aquaculture, processing, storage systems, potable water supply

The interviews also revealed that there are no adopted rules and regulations within the energy sector that helps or favors the population such as standardized Power Purchase Agreements and Power purchase tariffs, no incentive measures in taxation, the energy sector is not liberalized to enable people to invest. Lowering taxes on the equipment as well as introducing adequate laws to promote development of RE was one of the key suggestions from interviews with privates' organizations and non-governmental organizations. The need to strengthen management, prioritize RE, promote diversification and research were also listed amongst others.

Discussions in the stakeholders' workshop also revealed that some of the key actors within the energy sector were quite reluctant to encourage the development of renewable energy technologies. Reasons explaining this reluctance has not yet been fully understood. However, privates' organizations reactions suggesting the potential for personal interest involved being at risk is quite high because some key actors within the energy sector make a lot of money out the current system in place and will not want to lose their business or benefits. This assertion was highlighted by one of the NGOs as a barrier despite their efforts to promote the use of RE technologies.

Other findings based on interviews, publications and archival reports showed lack of awareness about the concept of renewable energy (such as RE sources, technologies and the advantages this can offer). This suggests that the concept of RE is still not well understood due to the lack of education on the topic, and most people are ignorant of the benefit this could provide. This could be resolved by raising awareness through campaign and workshop. In addition, RE capacity

development activities/programs could be introduced to educate selected youths amongst their communities that could replicate their learnings to the rest of the community.

Finally, data from the interviews also showed that the lack of energy does not only affect people in rural areas, but also people in urban areas. The majority have limited access to energy and face lot of load shedding with lot of power failure issues which ends up damaging their equipment's (because of the high starting current when power is restored that feeds the machines and equipment before stabilization). This power failure also retards their work progress and leading to lose of unsaved data that are being worked on.

IV. CONCLUSION AND RECOMMENDATIONS

Energy plays a huge role on all areas of society including health, education, business, households and industry. Resilient services from energy, water and health can result in several negative effects such as inability to store vaccines in hospitals leading to high number of recorded deaths; decomposition of product due to the lack of refrigerators, transformation and processing units; lack of clean water for the community causing health issues; loss of equipment and work data because of power failure and lot of tree cutting (as firewood is used for cooking) exposing villagers not only to pollution but also to cold and wind during harmattan.

There is a clear rural energy gap in the agriculture sector, which needs to be bridged to increase the economic development. Simply an increase in growing food will not be enough to resolve issues but providing a much more social and environmentally friendly way of increasing food production, storage, processing and distribution will be the best approach. Therefore, the development of RE in Togo has the potential to benefit human health, the environment, and the socio-economic development. This will have massive impact on the day to day life of the population and help indigenous people run small, medium enterprises and micro businesses in their communities to generate income.

As mentioned above, lack of policy and regulations are barriers preventing the development of RE. The 2017 World Bank "State of electricity access report" mentioned the growing role for the private sector to finance interventions, assuming the incentives are in place for investors to earn returns on their investments [10]. This implies that if adequate policies and regulations are to be put in place facilitating the promotion of RE, private investors might develop the will to invest in RE businesses.

The importance of raising awareness and educating everyone about RE including illiterate was highly recommended. Partnering with relevant countries that could help train experts (through product grant mechanisms, grants scholarships to university student to travel out for training in RE) could help the development of RE. It was also said that government could encourage tree planting to boost environment protection by putting in place some sort of reward (e.g. if x village plant 100 trees, they will be rewarded by the installation of water pump).

Developing the use of RE (mainly solar and hydropower) in Togo, will have a large positive impact on alleviating the country's energy issues due to the lack of resilience for energy systems. This could also promote employment, boost entrepreneurship activities, increase success rate, provide clean and sustainable energy, balance city and rural areas thereby reducing rural exodus, contribute to professional activities, reduce poverty, improve productivity, contribute to industrialization development, and reduce energy bills amongst other. For example, tremendous savings has been made by an owner of a clinic who usually paid 1.2 million F CFA in energy bill per year for about 40 rooms at the clinic when switched to solar energy. Within less than 3 years the clinic lowered energy bill down to 800,000 F CFA per year thereby a saving of about 400,000 F CFA every year [14].

In all, developing RE (especially solar photovoltaic followed by hydroelectric power), will contribute to regional development, improve living conditions and boost national economy.

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