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Article

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Research paper

Policy pathways for renewable and sustainable energy utilisation in rural coastline communities in the Niger Delta zone of Nigeria

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ABSTRACT

This paper presents the major barriers to sustainable rural electrification in the Niger Delta zone and suggests practicable policy pathways to tackle the barriers to the aggressive utilisation of renewable energy technologies in the Niger Delta zone. The barrier to the penetration of renewable energy technologies in the Niger Delta zone can be grouped into policy and institutional, technical, data and information gathering, socio-cultural and behavioural, economic and financial, political and market barrier, and inadequate decision space. The suggested policy pathways are driven from both the energy access and affordability considerations. Potential stakeholders, as the key drivers of the policy pathways, are identified with their various attributes and roles. It is shown that both positive energy policies of the Federal Government of Nigeria towards renewable energy penetration and the support from the oil producing and allied companies towards their operational areas would see the aggressive adoption and assimilation of the renewable energy technologies to meet the energy needs of the Niger Delta zone. This comprehensive paper will serve as a reference for policy players in the quest to address the energy problems in the coastal communities. It is anticipated that policy briefs, directed at the relevant stakeholders, would be crafted in deeper fashion to identify various actors and teasing what can be done in the sustainable energy space.

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1. Introduction

It is a general consensus that the rural communities are in serious need of modern energy for a meaningful development. Electricity is considered as the most demanded modern energy and it forms the nucleus of the Sustainable Development Goals (SDGs). Therefore, there is a strong need to provide electrical energy globally to about 1.3 billion people that live without the electrical energy (Karakaya and Sriwannawit, 2015). Of this total, over 600 million are in sub-Saharan Africa countries, and Nigeria accounts for about 93 million; Nigeria has the world's largest electricity access deficit, only after India, which has manifested in poor development progress (The World Bank, 2017). However, while India has shown significant commitments towards achieving universal energy access by 2030, Nigeria's efforts show that more Nigerians will be living without electricity by the year 2030. For example, a majority of the Nigeria rural communities lack adequate and clean energy supply, which has hamper growth in many of the productive sectors, namely the education sector, the health sector and the agricultural sector. Nigeria is useful-energy starved as only about 10% of the rural dwellers and 40% of the

urban dwellers have access to the national electricity grid supply; with the highest duration of power outage per capita in Africa (The World Bank, 2017). The rural communities are the worst hit by the deficit access to electricity in Nigeria, as about 59% of the rural dwellings live without electricity, with electricity availability of 16.1% (The World Bank, 2018).

Climate change poses a challenge to many parts of the Niger Delta zone, largely due to oil and gas exploration, geographic exposure, poor socioeconomic status, large size of population dependence on agriculture, weak adaptive capacity and gross energy deficit. These challenges form the bases for the search for clean, adequate, affordable and sustainable energy solutions, as stipulated in the No. 7 of the 17 Sustainable Development Goals (SDGs) (United Nations Development Programme, 2015). There is a growing interest in the development and deployment of renewable energy technologies (RETs) globally as a result of the rapidly declining cost of RETs, the for climate action and energy security (Aslani et al., 2013; Fakehi et al., 2015; Diemuodeke et al., 2016; Mondal et al., 2016). Energy security and environmental friendliness require the deployment of clean energy system through primary energy source diversification. The acceptance of renewable energy technologies (RETs), as clean energy supply, is gaining general acceptance worldwide, and their applications have proven results (Hepbasli, 2008; Mondal et al., 2016).

In an effort to increase the power generation capacity in the country, the Federal Government of Nigeria (FGN) established the

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Table 1

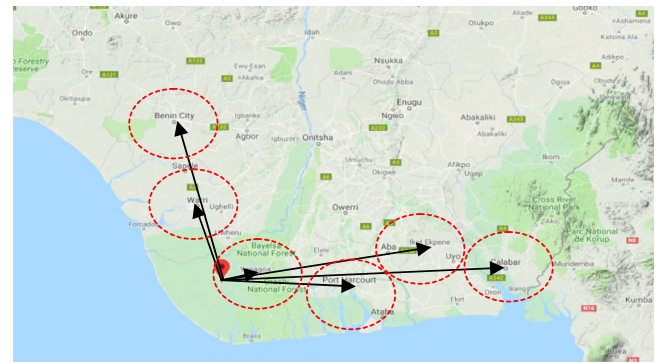
National renewable energy and energy efficiency policy targets (Federal Ministry of Power, 2015).

S/No	Renewable energy technology	Policy target		
		2015	2020	2030
1	Hydropower – large and small – (MW)	2,261	6,156	12,801
2	Biomass (MW)	5	57	292
3	Solar (PV/Thermal) – (MW)	117	1,343	6,831
4	Wind electricity (MW)	55	631	3,211

Niger Delta Power Holding Company (NDPHC), as part of the Independent Power Project (IPP) policy, to intervene in important projects in the power sector. NDPHC is expected to add 4774 MW of electricity to the national grid, which will see the total electricity generation capacity to 15,170 MW, generation at 100% installed capacity, will still guarantee a huge deficit of 9,830 MW since the current estimated electricity demand is 25,000 MW. Though Nigeria's electrification rate is on a steady increase, the rate of growth falls short of meeting electricity demand as the country's electrical energy generation growth rate is put at 93% over 20 years horizon, whereas Indonesia and Bangladesh growth rates are, respectively, put at 372% and 451% in the same time horizon (GIZ, 2015). The Federal Government of Nigeria (FGN), for example, through the National Renewable Energy and Energy Efficiency Policy, has shown commitment to have RETs in its energy mix as shown in Table 1 (Federal Ministry of Power, 2015). However, the penetration thus far has been very poor, RETs contribute only 13% (hydropower contributing 99% of the 13%) of the total installed power capacity in Nigeria. This shows a huge gap between the policy targets with the reality. The rural communities are the worst hit by the access deficit of electricity in Nigeria, with the Niger Delta zone having a peculiar energy challenge due to its rugged geographic terrain.

The FGN has embarked on some renewable energy projects in the country. Table 2 shows some ongoing renewable energy projects in Nigeria according to a report presented in Okoye et al. (2016) and Nwofo (2014). These projects are expected to be developed within five years, which will lead to available clean, sustainable and cheap electricity generation for the majority of the rural dwellers. However, none of the ongoing projects are sited in the Niger Delta zone, which is faced with myriad of energy and environmental crises as a result of the oil and gas exploration in the zone. Though there is a blueprint for the development of the zone, the blueprint lacks sustainable development since it did not adequately consider sustainable energy intervention. It is a consensus that the availability of sufficient clean energy supply is indispensable for sustainable economic development of any society (Olatomiwa et al., 2015a).

The Niger Delta zone (the South–South Geopolitical zone) occupies about 7.5% of Nigeria's geographical area ($\approx 69,283 \text{ km}^2$), and houses 6 states (Akwa-Ibom, Bayelsa, Cross-River, Edo, Delta and Rivers) of the 36 states in Nigeria – the circles in Fig. 1 indicates strategic towns in the Niger Delta zone. The zone is rich in both renewable and non-renewable natural resources – large proportion of Nigeria's oil and gas reserves and production is from the region. A significant proportion of the Niger Delta is domicile in rugged coastline terrains, which, normally, do not support grid-connected electricity supply, with just 8.5% rural electrification and 42.8% blackouts (The World Bank, 2018). The Niger Delta rural poor dwellers rely heavily on firewood, kerosene, candle, battery/dry cell touch and others to meet their heating and lighting needs. The absence of the grid electricity supply has not only left the rural coastline communities socially backward, but has left their economic potentials untapped; coupled with the negative effect of climate change caused by the oil and gas production activities.

**Fig. 1.** Strategic towns in the Niger Delta region.

The lack of electricity in majority of the rural communities in the Niger Delta zone favours the lighting options driven by kerosene lamps, candle, wood and other fossil powered conventional lighting devices, with the consequences of climate change and health challenges. Replacing fossil powered lighting devices with modern lighting appliances is an important aspect of meeting the SDGs' objectives (Shahzad et al., 2018). The fossil-based lighting devices are attributed to public health and safety risks (Mills, 2016). Photovoltaic (PV) driven lighting appliances enhance community life through: socialising, longer hours of studying and reading, cooking, commerce, night-time security, health care and many others (Alstone and Jacobson, 2018).

Studies have shown that the Niger Delta is rich in renewable energy sources, which can be harnessed to solve all energy related challenges facing the Niger Delta region (Diemuodeke et al., 2017; Ohunakin et al., 2014; Nwokocha et al., 2018; GIZ, 2015; Diemuodeke et al., 2016; Okoye et al., 2016). For example, it is estimated that the Niger Delta region receives annual averaged solar energy of about 4.13–4.71 kWh on a square metre horizontal surface per day (Diemuodeke et al., 2017). It implies that the Niger-Delta zone has the potential to generate about 3700 MWh/day of electrical energy, if only one-ten thousandth (0.01%) of the total surface area of the Niger-Delta zone is utilised for solar-electricity generation (solar Photovoltaic) with a conversion efficiency of 12%. The implication is that about thirty-six million persons¹ could meet their daily energy needs for electric lighting, which supports the Sustainable Development Goals' objectives – e.g. universal access to electric lighting.

Studies have, also, shown that the Niger Delta zone annual averaged wind-speed ranges between 4.855–6.261 m/s at 50 m hub height, with average power production of 120 W/m^2 (Okeniyi et al., 2015). The implication is that the application of wind energy technology also has the potential of meeting the energy requirements of the Niger Delta zone. Similar studies in the Niger Delta zone have equally identified other renewable energy sources, e.g. energy from the ocean temperature, energy from the solar heat, energy from flowing river stream, energy from tidal wave and energy from ocean wave, which all have proven energy generation technologies (Oko, 2016).

Olatomiwa et al. (2015b) studied the economics of rural electrification with hybrid renewable energy systems for the six geopolitical zones of Nigeria, which include the Niger Delta zone (the

¹ PV energy generation per day = $4.42 \times 0.0001 \times 69238 = 3674770 \text{ kWh}$; from Diemuodeke et al. (2017), estimated energy demand for lighting per household is 0.51 kWh/day for off-grid rural household, thus, the number of the households that will meet their lighting energy demand will be $3674770/0.51 \approx 7,205,431$ households. Number of persons per household is estimated to be five (5) persons (The World Bank, 2018), therefore, number of persons that will benefit from PV supported lighting will be $7205431 \times 5 = 36027155$.

Table 2
Ongoing solar electrification projects.

S/No	Project	State	Geopolitical zone	Capacity (MW _p)
1	Solar Energy Plant	Katsina	North-West	20
2	Solar Farm Synergent Group	Kaduna	North-West	50
3	Solar Power Plant Nigeria-German Energy Partnership	Katsina	North-West	60
5	Solar Farm Nigeria solar Capital Project and Gigawatt Solar	Bauchi	North-East	100

South-South geopolitical zone). The economic evaluation suggests that PV/diesel/battery hybrid energy is optimum even at a high cost of fuel. The hybrid energy system has better environmental performance over the dominant fossil fuel driven energy systems in the Niger Delta zone. The hybrid system becomes particularly important for is distributed generation as against grid-connected systems that are not available in the majority of the rural communities. Other studies have also shown that renewable energy technologies have potentials for the sustainable development of rural communities in the Niger Delta zone, namely powering of mobile communication systems (Olatomiwa et al., 2015a), health-care facilities (Franco et al., 2017) and educational facilities (Hong et al., 2014). While there are potentials in sustainable development of the Niger Delta zone through the renewable energy system applications, the enabling policies and political will for the adoption and utilisation of renewable energy systems is lacking. Here lies the necessity to develop appropriate sustainable energy policy pathways for the sustainable development of the Niger Delta zone.

However, it does not require rocket science to conclude that sustainable rural energy intervention promises are yet to manifest in the rural poor dwellings, Niger Delta region of Nigeria for example. The aim of the paper is, therefore, to identify major barriers to sustainable rural electrification in the Niger Delta region and to suggest policy pathways to tackle identified barriers for the aggressive development of the Niger Delta zone.

2. Methodology

Fig. 2 shows the graphic representation of the research methodology used in the current study. The qualitative information gathering approach was used in the current study, which involves a one-to-one interview, focus group, field note and literature in the public domain. The information used was gathered from the outcomes of workshops/seminars, conferences, expert opinions, secondary data (e.g. Okoye et al., 2016; Olatomiwa et al., 2015b; Franco et al., 2017; Hong et al., 2014; Olatomiwa et al., 2015a; Ikejamba et al., 2017) and research findings from the Climate Impacts Research Capacity and Leadership Enhancement (CIRCLE) sponsored research on the application of renewable energy technologies for climate change mitigation. The gathered information was synthesised to develop policy pathways for the aggressive adoption of renewable energy technologies in the Niger Delta development blueprint.

3. Results and discussion

Barriers to sustainable energy utilisation in the rural communities were identified, and possible policy pathways were suggested to remove the identified barriers for the aggressive adoption and application of renewable energy technologies in the Niger Delta zone of Nigeria as shown in Fig. 3. The policy pathways here suggested could be adopted in other countries in the global south.

3.1. Identified barriers

The identified barriers to the application of sustainable energy utilisation in the rural coastline communities could be grouped into policy and institutional, technical, data and information gathering, socio-cultural and behavioural, economic and financial, political and market barrier, and inadequate decision space. The identified barriers are discussed as follow.

Policy and institutional barrier. Institutions are embodied with the framework of policies and standards that regulate the practice (technical and economic) and patterns of social behaviour towards sustainable energy systems. Identified barriers are: disarray between energy policies and development blueprint, no dedicated training institutes for RETs, lack of research and development centres, disarrayed regulatory bodies for quality assurance and quality control, and no organised programmes to disseminate RETs information.

Technical barrier. The technical aspect of sustainable energy systems emphasises location-specific design requirements, namely the availability of design parameters, technology acceptability, simplicity, and operation and maintenance of the energy system. To this end, barriers identified are: lack of local experts, lack of maintenance facilities in the rural communities, no training facilities for renewable energy technicians, lack of maintenance culture, no grid extension, inadequate knowledge among RETs adopters, and energy mismanagement.

Socio-cultural and behavioural barrier. The social-cultural and behavioural side of sustainable energy entails the consideration of social and cultural dimensions in energy deployment as they impacts on local employment, social status, cultural deviation, and energy technology access pattern. Barriers identified in this context are: doubt about the quality of RETs, negative perception about RETs, perceived high system cost, lack of effort in tailoring and educating the rural dwellers, complexity perception (low-level energy applications), stiff competition for available land, supremacy of personal and religious values, and vandalism by militants.

Economic and financial barrier. This involves the economic viability and financing mechanisms of sustainable energy deployment in the rural coastline communities. Some of the identified barriers are: high initial capital investment, high unit cost of electricity, lack of available financing models, lack of private participation, and lack of financial supports for RETs.

Political and market barrier. This entails the political will of a subsisting government to drive rural sustainable energy technologies through government instrumentalities with considerations of the available local market social-economic characteristics. Identified barriers in this context are: unsustain Government policies, political instability, inconsistency in Government policies, lack of enforcement of available energy policies, unfavourable energy cost competitiveness, limited access to RETs, discontinuity or absence of medium- and long-term government plans, vested interest, and lack of evaluation and control mechanisms.

Inadequate decision space. Many sustainable energy interventions in the Niger Delta failed because of limited space of decision making, which constrain quality energy intervention policies. In most cases, some of the decisions are taken wilfully on the political ground without adequate consideration of the technical and social needs of the beneficiaries. The key barrier identified here is non-involvement of experts and professionals in the energy field in energy decision making.

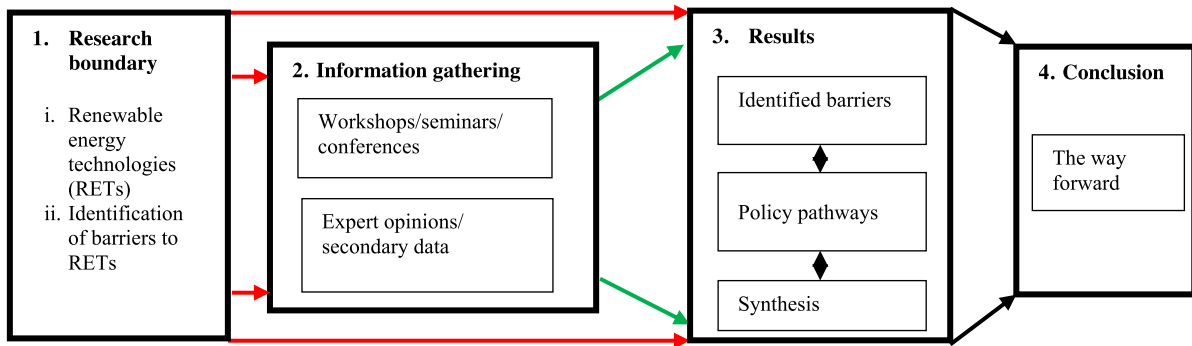


Fig. 2. Research methodology.

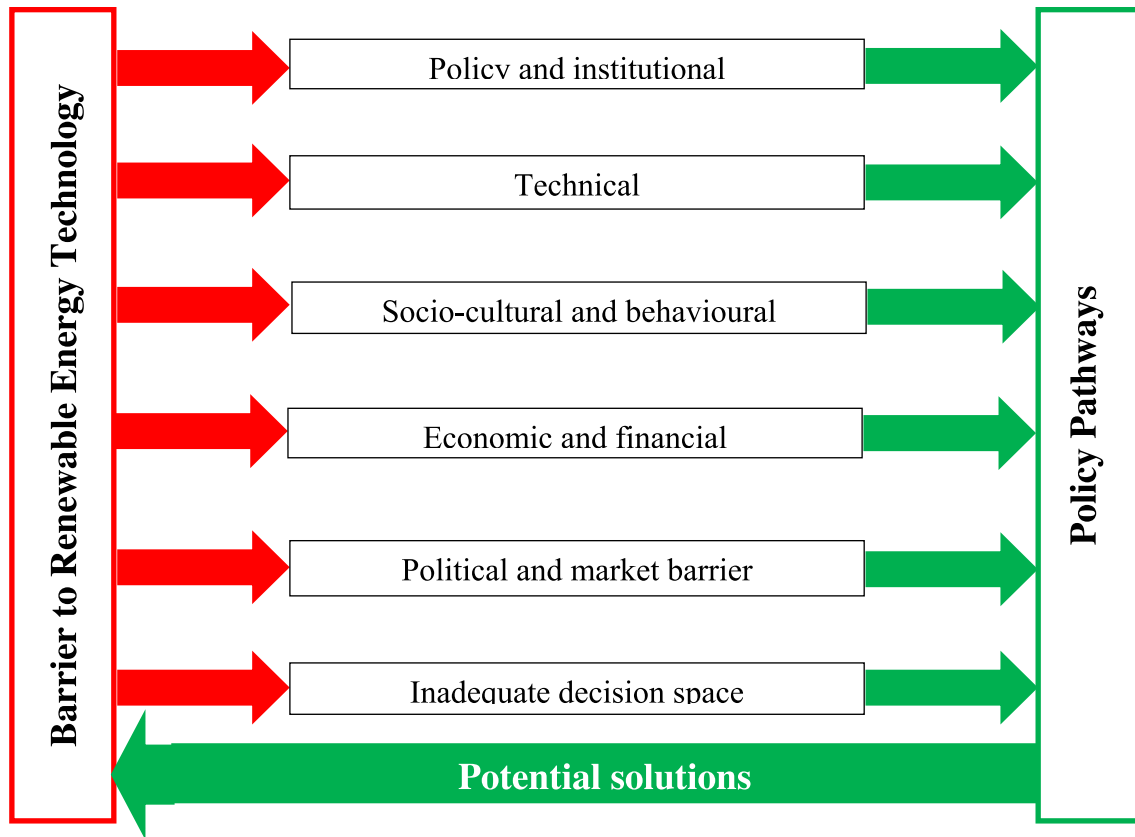


Fig. 3. Identified barriers and policy pathway.

3.2. Policy pathway

It was, however, observed that available evidence suggests that the Niger Delta region is in a better position to surmount the identified barriers associated with the RETs applications in the rural coastline communities with practicable policy framework. The practicable policy framework for the adaptation and assimilation of RETs in the Niger Delta zone should be driven on an efficient policy pathways by the identified major stakeholders – The Government of Nigeria (GoN), Niger Delta Development Commission (NDDC), Non-Governmental Organisations (NGOs), Oil Producing and Allied Companies (OPACs), such as petrochemical and cement factories and the local communities (LOCALS). The identified stakeholders in the application and utilisation of the RETs are expected

to function in complementarity as depicted in Fig. 4. The stakeholders are defined as follow.

LOCALS: The desire is for the rural coastline communities to attain universal energy access by the year 2030, which implies access to affordable, adequate, clean and sustainable energy. The energy access will unveil socio-economic potentials of the coastline communities, and also ameliorate the impact of climate change since climate change is partly attributed to the desires to have adequate energy. The locals should be adequately featured in the energy planning phase and throughout the energy intervention programme’s life-span for a successful intervention.

GoN: The GoN, which include Federal Government of Nigeria (FGN), the State Governments and the Local Government Authorities, is looking for the best option, through her energy policy, to electrify the rural communities, especially those in the remote and rugged terrains. The GoN’s sincere political will to drive the process of

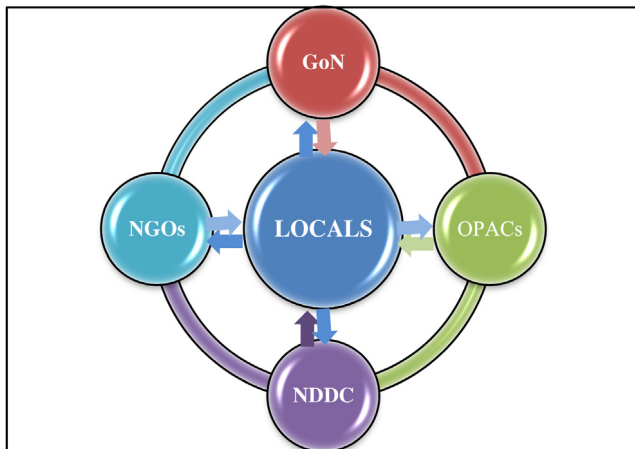


Fig. 4. Identified stakeholders in RETs application.

energy planning, implementation and control will guarantee the success of rural energy intervention programmes.

OPACs: The OPACs are duty bound to operate in a conducive and safe environment. However, there exists a moderate militancy concerns in the Niger Delta, which studies have attributed to the dwindling economic landscape of the OPACs' host communities (Umar and Othman, 2017). The dwindling economic landscape could be associated to the gross deficient modern energy in Niger Delta zone.

NDDC: The Niger Delta zone is under the developmental control of NDDC. Clean and affordable energy, which is the No. 7 of the 17 Sustainable Development Goals (SDGs), has been identified as the heart of the SDGs. Therefore, NDDC should be desirous to pursue clean and affordable energy for a sustained development of the Niger Delta region.

NGOs: The NGOs – for examples United Nations Development Programme (UNDP), World Bank, Global Environmental Facilities (GEF) – have been involved in the advocacy for rural electrification and development in Nigeria; therefore, efficient policy pathways for energy development in the rural coastline communities is a priority for the NGOs.

The GoN and the other identified stakeholders can accelerate the acceptance and utilisation of RETs by launching policy-supported rural electrification programmes. The policy-supported rural electrification programmes are expected to cruise in the following pathways:

3.2.1. Addressing the unit cost of energy-rural communities' dwellers income disparity

The rural coastline communities have a weak economic base, which has manifested in their monthly income. Some of the fast growing and matured renewable energy technologies that support off-grid applications (e.g. solar and wind) have relatively high cost per unit energy; hence, a majority of the rural dwellers are not in the economic position to pay for the energy needed, if made available through the RETs. Therefore, the GoN should make palliative credit policies and finance mechanisms towards subsidising the price of a unit energy consumed in the rural communities. This would be achieved by a synergy among the identified major stakeholders and the renewable energy entrepreneurs.

3.2.2. Aggressive campaign for the utilisation of RETs

The GoN, the NDDC and the OPACs should work with recognised energy professionals and NGOs to establish RETs information dissemination units in all the LGAs and political wards in the Niger

Delta region. The renewable energy application and adaptation campaign should be aggressively done through the mass media, flyers and community based campaigns.

3.2.3. Establishment of RETs research and development centres and programmes

The GoN should establish a RETs research and development (R&D) centre in the Niger Delta region; funded by a tri-party contributory financial agreement model, to comprise the GoN, the NDDC and the OPACs. The R&D centre will be saddled with the design and selection of the best RET and/or the combination of RETs for the region in terms of the region's peculiar environmental conditions. The Universities in the region should be encouraged, through the provision of training/research grants, to run dedicated renewable and sustainable energy technology programmes to train high level renewable energy technology professionals.

3.2.4. Training and retraining programmes for RETs personnel on technical management of RETs

The GoN and OPACs should encourage the NGOs and other renewable energy supporters, through tax exemption and provision of training kits, to establish renewable energy training centres across the zone – in each of the senatorial districts, preferably. The training centres shall be responsible for the transferring of technical and management skills to low- and medium-level RE personnel.

3.2.5. Aggressive campaign for effective energy management on the consumer-side

The National Renewable Energy and Energy Efficiency Policy of the FGN (Federal Ministry of Power, 2015), on the use of energy efficient appliances, should be democratised to the LGAs through aggressive campaign for effective energy management. Furthermore, some of the ENERGY STAR certified lighting, appliances and fans should be subsidised by both the GoN and OPACs, and made available in local shops across the LGAs.

3.2.6. Capital deployment for RETs entrepreneurs

The FGN should establish a dedicated RET Finance Bank committed to the financing of renewable and sustainable energy projects. This is aimed at making available effective liquidity instruments to interested energy entrepreneurs to encourage increase participation in the renewable energy ventures, since the RETs require high initial capital investment.

3.2.7. Establishment of Renewable Energy Development Trust Fund

The FGN should establish Renewable Energy Development Trust Fund (REDTF), which will be financed by tax imposed on the use of petroleum and gas based power plants, namely gas turbine power plant, steam turbine power plant, and diesel and petrol generators. Specifically, a certain percentage of the net income generated by the petroleum and fossil based power plants should be committed to the REDTF. Furthermore, all imported electric generator sets into the country should be levied with carbon emission duty and remit same to the REDTF.

3.2.8. Granting of special RETs operational licence to the OPACs

The FGN should enact a special obligatory policy requiring the OPACs to establish renewable energy electricity generation micro grids within their area of operations as community development strategies. However, the end-users will be required to pay for the amount of electricity consumed at a pre-determined subsidised price. Specifically, the rural dwellers' economic affordability index should be jointly established as the monthly payment and coded in a pre-paid electricity utility card.

3.2.9. Establishment of RE regulatory unit

The FGN should establish a RE regulatory unit, coordinated by the Standard Organisation of Nigeria, to control the standard of RE components imported into the country or produced in the country. The RE regulatory unit shall also ensure that all mini-grid RE projects get appropriate certifications.

3.2.10. Strengthening the position of RE applications in the NDDC development blueprint

The NDDC is desirous to pursue clean and affordable energy for a sustained development of the Niger Delta zone. However, the available development blueprint does not adequately capture the adaptation and applications of renewable energy in the energy mix. Therefore, as a matter of urgency, the Niger Delta development blueprint should be revised to include a special unit, within the NDDC authorities, that will be responsible for the implementation of renewable and sustainable energy projects. The unit should also be saddled with the responsibility of interfacing with the identified stakeholders.

3.2.11. Special security for protection of RE installations

The FGN should establish a special security outfit (Renewable Energy Installations Protection Guards), under the control of the Nigeria Security and Civil Defence Corps, through a legislative pronouncement, to protect major RE installations across the Niger Delta zone. The members of the special security outfit should be recruited from the host communities, since their destiny is in their hands. All the identified stakeholders should be involved in the development of the operational strategies of the special security outfit.

4. Conclusion

Most of the currently exploited energy resources in the Niger Delta are firewood, charcoal, gas and petroleum products. During the utilisation of these energy sources, carbon dioxides, carbon monoxides, sulphur oxides, nitrogen oxides, particulates and water vapours are released to the atmosphere with harmful environmental effects, such as the greenhouse effect and ozone-layer depletion, which cause climate change. Outside the environmental and health concerns, the Niger Delta rural coastline communities lack in roads, running water and ultimately supply of electricity. The extension of the national grid to the rural coastline communities is considered impractical due to the rugged terrain and dispersed settlements associated with the Niger Delta zone. Meanwhile, electricity is required for such basic developmental services such as pipe borne water, healthcare, telecommunications and quality education. More so, the poverty eradication and Universal Basic Education programmes of the FGN, which are targeted at the rural communities, need electricity to be successful. The lack of sustainable energy in the rural coastline communities in the Niger Delta has not only left the communities socially backward, but has left their economic potentials untapped. There is a universal agreement that the rural communities are in serious need of modern energy, which can be driven by renewable energy technologies. The supply of sustainable energy to the Niger Delta rural communities can only be achieved through workable rural energy intervention programmes. However, practicable energy policy framework and political will are required to successfully drive the universal access to modern energy by the year 2030.

This paper, therefore, identified the major barriers to sustainable rural electrification in the Niger Delta zone and suggests practicable policy pathways to tackle the barriers to the aggressive utilisation of renewable energy technologies in the Niger Delta zone. The barriers to the penetration of renewable energy technologies in the Niger Delta zone can be grouped into policy and institutional,

technical, data and information gathering, socio-cultural and behavioural, economic and financial, political and market barrier, and inadequate decision space. The policy pathways are driven from both the energy access and affordability considerations. Potential stakeholders, as the key driver of the policy pathways, are identified with their various attributes and boundary. This comprehensive paper, which will serve as a reference for policy players, may be considered as a problem defining paper that articulates all stakeholders with their various roles in the quest to address the energy problems in the coastal communities. It is, therefore, anticipated that policy briefs, directed at the relevant stakeholders, would be crafted in deeper fashion to identify various actors and teasing what can be done in the sustainable energy space.

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