Energy Access in Small Island Developing States: Status, barriers and policy measures

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Abstract

The lack of access to modern energy services, sometimes also referred to as energy poverty, is a significant global development challenge. This paper provides an analysis of energy access in Small Island Developing States (SIDS), sheds light on current challenges and provides insights on opportunities to improve access to modern energy services in these countries. It provides an overview of energy access levels within the African, Caribbean and Pacific SIDS regions to refocus attention on their frail economies and dependence on imported fossil fuels. The focus here is on three specific factors that are still not well investigated: issues which relate to grid-extension, the lack of trained personnel for decentralised electrification and a high reliance on imported energy which drains Gross Domestic Product (GDP). A selection of SIDS case studies highlighting endeavours to expand energy access provide a basis on which key measures to expand electrification are suggested. Enabling conditions identified included a high level of commitment from the government and the setting up of an independent regulatory body with rulemaking and adjudicative powers. Additionally, the setting up of a cost-reflective tariff structure and appropriate fiscal framework are highlighted which can contribute towards electricity access expansion in island context.

Keywords: SIDS, energy access, electrification rate, barriers, challenges

1. Introduction

In any country or jurisdictional context, energy supply is necessary for socio-economic and human development (Mulder and Tembe, 2008), however, not all countries have access to adequate and reliable energy.

There is no general agreement of the term 'energy access' (IEA, 2014; Pachauri, 2011) and hence various scientific works have defined the term based on their understanding. Very often, it is defined in terms of the physical availability of energy carriers like electricity and fuels to meet basic household needs like cooking and lighting (Pachauri, 2011). A World Bank report defined energy access at household level as the amount of energy required to satisfy six basic requirements which are: lighting, food preservation, entertainment and communication, cooking and water heating, labour saving activities and for space heating and cooling (Tenenbaum et al, 2014). In the absence of a clear consensus of what 'energy access' is, AGECC (2010) defined universal energy access as access to clean, reliable and affordable energy for basic human needs, for productive uses and modern society needs, which this study adopts.

Access to energy is essential in addressing challenges relative to food security, education, healthcare, women empowerment, good governance and to expand agricultural and industry–based economies (Oparaocha and Dutta, 2011; Karekezi et al., 2012). A shortage of electricity as well as a lack of clean cooking fuel compel households to use traditional low-efficiency fuels like crop residues, dung, charcoal and fuelwood which causes household air pollution (HAP) and associated respiratory problems (Karekezi et al., 2012; Prasad, 2011) and ultimately leads to death of many women and children who are more exposed to this practice. Legros et al. (2009) reported that in 2004, Comoros estimated 100 deaths from HAP generated from the burning of fuelwood, Papua New Guinea (PNG), had a death count of 1600 from the burning of traditional fuels, and Haiti recorded a death toll of 3700 from the burning of charcoal and fuelwood.

To foster improvement of energy access on a global level, the United Nations launched in 2011 the Sustainable Energy for All (SE4All) initiative with one of its aims to ensure universal energy access by 2030. The SE4All goals are also laid down in the Sustainable Development Goals (SDGs), especially in SDG 7, underscoring the commitment of the United Nations to end energy poverty by the target year. According to the International Energy Agency (2016), there are 1.2 billion people without access to electricity and around 2.7 billion people still relying on traditional fuels for cooking and heating purposes in the world. While the majority of energy poor people live in sub-Saharan Africa and South-East Asia (Bazilian et al., 2012), a smaller, often overlooked portion is found in the African, Caribbean and Pacific (ACP) SIDS. Energy crisis in SIDS is underrepresented within scientific literature (Shah and Niles, 2016) and hardly understood by policy decision makers and development institutions alike. As such, as an outcome of good governance and conducive energy policies, some African and Caribbean SIDS member states (for example Mauritius, Seychelles and Trinidad and Tobago) have successfully electrified and provided modern cooking fuels to their population, but other SIDS like PNG, Solomon Islands, Haiti or Guinea-Bissau still face impediments in doing so, while all have the same inherent characteristics of SIDS[1] (Wolf et al., 2016). Thus, there is an opportunity and need to present an updated picture of the status of electricity access in SIDS and to find suitable solutions to the issue of low electrification rate in those SIDS member states which are deeply affected. Hence, the paper applies a case study method to draw achievements and weaknesses from the electrification programmes of selected SIDS member states and attempt to devise possible solutions and policy recommendations with lessons learnt that can improve the electricity access in SIDS member states with poor electrification. The paper attempts to determine how some SIDS have achieved electricity access, what are the experiences that can be retrieved from them and finally proceeds with policy recommendations based on these findings. The paper describes the objective of the work in the introduction, then provides the method for data collection, presents the energy access situation in SIDS and then focusses on selected SIDS to identify lessons and experiences.

2 Data Collection and Method

Country level data and literature work were sourced from a desktop search. Faced with the heterogeneity of data collected from various sources, a priority order was set up to maintain accuracy and authenticity of information collected (Gonzalez–Salazar et al., 2014). The first priority was given to official statistics and information from governmental authorities of SIDS member states and the second priority was given to reports from intergovernmental institutions, international agencies and development banks like the United Nations Environment Programme (UNEP), the International Energy Agency (IEA), International Renewable Energy Agency (IRENA) and the World Bank among others. Third priority was given to data provided

[1] More description of these inherent characteristics is given down in the text

by peer–reviewed scientific papers. All these data were processed into suitable forms and presented in dedicated sub–sections of this paper.

The purpose of the data collection was to firstly identify barriers to electrification in SIDS influenced by low electrification rates and secondly, achievements from SIDS which have successfully supplied affordable electricity to all households. From there, the paper brings out policy measures that can be applied in SIDS context to improve their poor energy situation. In general, to identify the concerned barriers, a case study method of some SIDS member states was used, where the energy situation of Haiti, Solomon Islands, PNG, Guinea–Bissau and Vanuatu were analysed which has limited access to electricity and Mauritius, Fiji and Cuba were taken for the experiences and success stories from their electrification programmes. Case study methodology was used for an in–depth longitudinal examination of the different strategies and plans via which some SIDS expect to expand electrification while, evaluating electrification programmes of SIDS which have been successful.

3 Energy Access situation – causes to present status

SIDS share similar economic, social and environmental vulnerabilities and were all dependent on colonial powers (Blancard and Hoarau, 2013; Everest–Philips, 2014; Raghoo et al., 2017). The lack of electrification in SIDS is rooted from colonial civilisation (Niles and Lloyd, 2013). When most SIDS member states obtained their independence from colonial powers, their energy sectors were highly petroleum intensive and unsustainable in the broadest sense (Niles and Lloyd, 2013). Soon after independence, there was a massive exodus of colonial civilians, military and political authorities which has resulted in significant damage of the country social fabric and economy through loss of expertise. At that time, most of the SIDS had no established framework or energy policies in place that could possibly improve electrification rate. The absence of a regulatory framework inhibited growth in this sector by providing disincentives for any partnership and private investment. Policymakers were faced with small financial reserves to re-launch economic activities and with the challenges that have risen from the physical geography and geospatial demography spread and settlement patterns across SIDS' land area, electrification programmes faced a real struggle. SIDS are also exposed to diseconomies of scale and have limited natural resources, growing populations, high transportation costs and a high dependence on external trade (UNEP, 2014) which have exacerbated their poor economic conditions and in the process, their energy sector has suffered. Besides, after independence political turmoil is some SIDS member states have provided a poor environment for investment in the energy sector, and as in the case of Haiti, natural calamities have caused massive infrastructural damage of energy systems which has plunged the country into an economic uncertainty.

Figs 1 and 2 and Table 1 provide demographic, economic and geographic features as well as the related electrification rates of ACP SIDS as at 2012[2]. With the exception of Haiti, Caribbean SIDS are better-off than African and Pacific SIDS with over 80% of their population having access to electricity. Cuba and Antigua and Barbuda have an electrification rate of more than 95%. African SIDS contemplate an average electrification rate of 73.6%. Mauritius and Seychelles enjoy nearly 100% electrification in both rural and urban areas (Surroop and Raghoo, 2017). Guinea-Bissau and Comoros have critically low national electrification rates of 20% and 45% respectively. Electrification rate in these countries differs in urban and rural areas. Only 6% of population have access to electricity in rural regions in Guinea-Bissau (IEA, 2014). Although, Mauritius has a land area seven times less than Guinea-Bissau and is a conventional island affected economically by their smallness and remoteness from international markets, it has a GDP per capita as at 2012 seventeenth times higher than Guinea-Bissau which is evident that electrification is essential for economic viability. In Pacific SIDS, the situation is inferior than the other regions with an average electrification rate of 72.9%. Energy poverty in the Pacific is comparable to sub-Saharan Africa, despite higher income levels (Dornan, 2014). PNG, Solomon Island and Vanuatu have critically low electrification rates which corresponding to very low human development indices (Dornan, 2014; UNDP, 2015). These three countries have a combined population of 8.1 million which is nearly five times higher than the population dynamics of other Pacific SIDS combined. Niue, Tuvalu, Nauru and Palau are fully-electrified islands whereby electricity is supplied predominantly by fossil fuels (Hourçourigaray et al., 2012). The remaining unserved population are unlikely to be reached by traditional grid extension method (Barnes, 2011) since they are remote and isolated from demand centres and thus, other alternatives have to be sought. In an analysis by Wolf et al. (2016) using Fiji and Mauritius as examples, it was seen that different administrative and institutional mechanisms might also be a cause for different energy performance among SIDS, which is a possible explanation why some SIDS are fully electrified and others not.

[2] Authors could not find latest data from reliable sources

Table 1. Demography, economy and electrification rates of SIDS of the Caribbean (Authors' compilation from Martin et al., 2013; UN, 2014; UNEP, 2014, UNEP, 2015)

Caribbean SIDS	**Surface area (km^2)**	**Population (000)**	**GDP (million US$)**	**Electrification rate (%)**
Antigua and Barbuda	422	89	1,176	99.0
Bahamas	13943	372	8,043	90.0
Barbados	430	283	4,533	95.0
Belize	22966	324	14.1	89.9
Cuba	109884	11271	71,017	97.0
Dominica	751	72	499	87.6
Dominican Republic	48192	10277	58,898	95.9
Grenada	344	105	783	86.4
Guyana	214969	795	2,851	77.5
Haiti	27750	10174	7,187	25.0
Jamaica	10991	2769	14,795	92.0
St Kitts and Nevis	261	54	765	94.0
St Lucia	539	181	1,318	94.2
St Vincent / Grenadines	389	109	694	93.0
Suriname	163820	535	5,012	84.0
Trinidad and Tobago	5130	1337	23,225	99.0
Total average				88.3

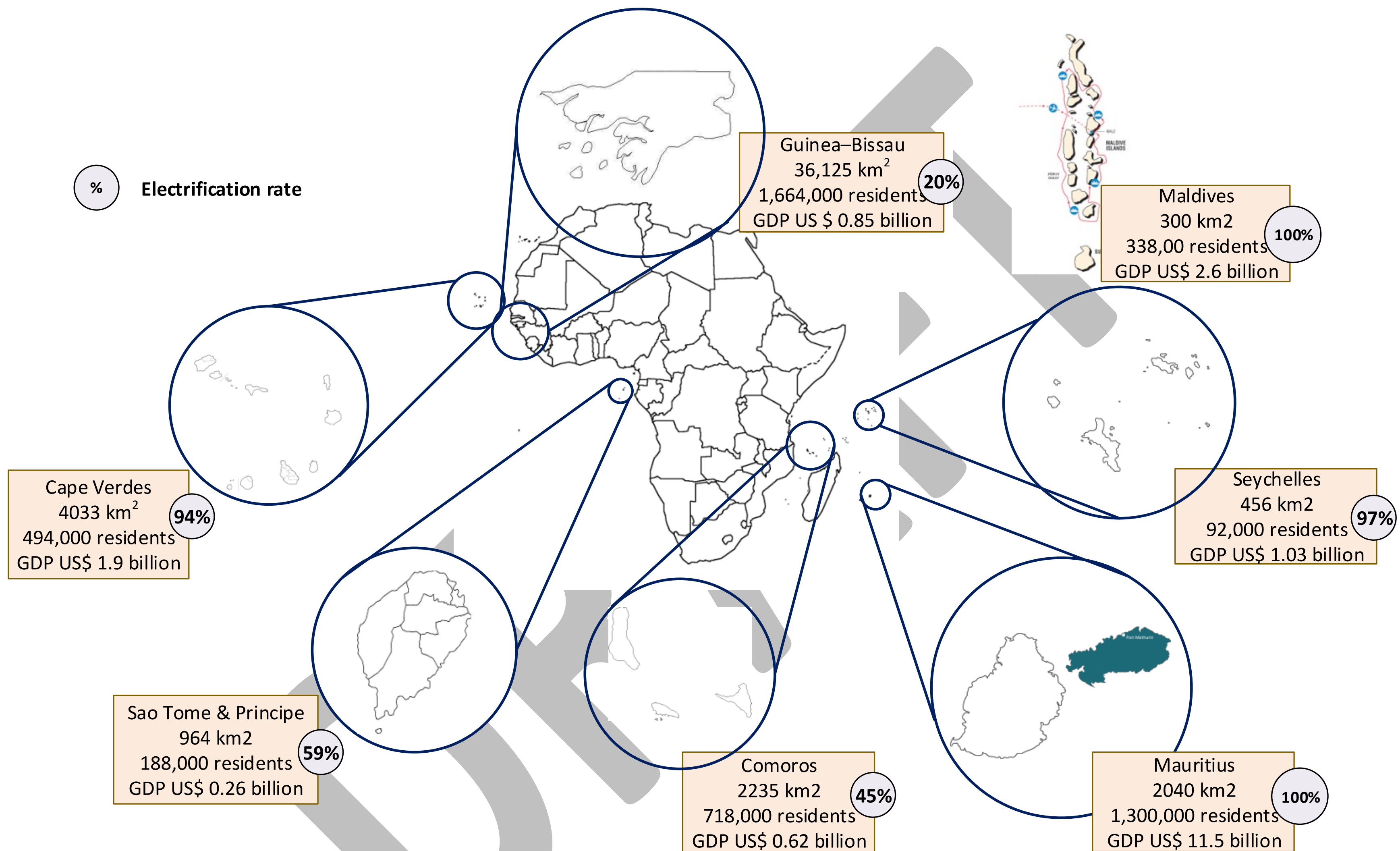

Fig. 1. Geography, demography, economy and electrification rate in African SIDS (authors' illustration based on data from IEA, 2014; UNEP, 2014; Maps from worldatlas.com; jpexcursion-rodrigues.com; gpsarab.com; mauritiusmap.facts.co; mapmakerdata.co.uk)

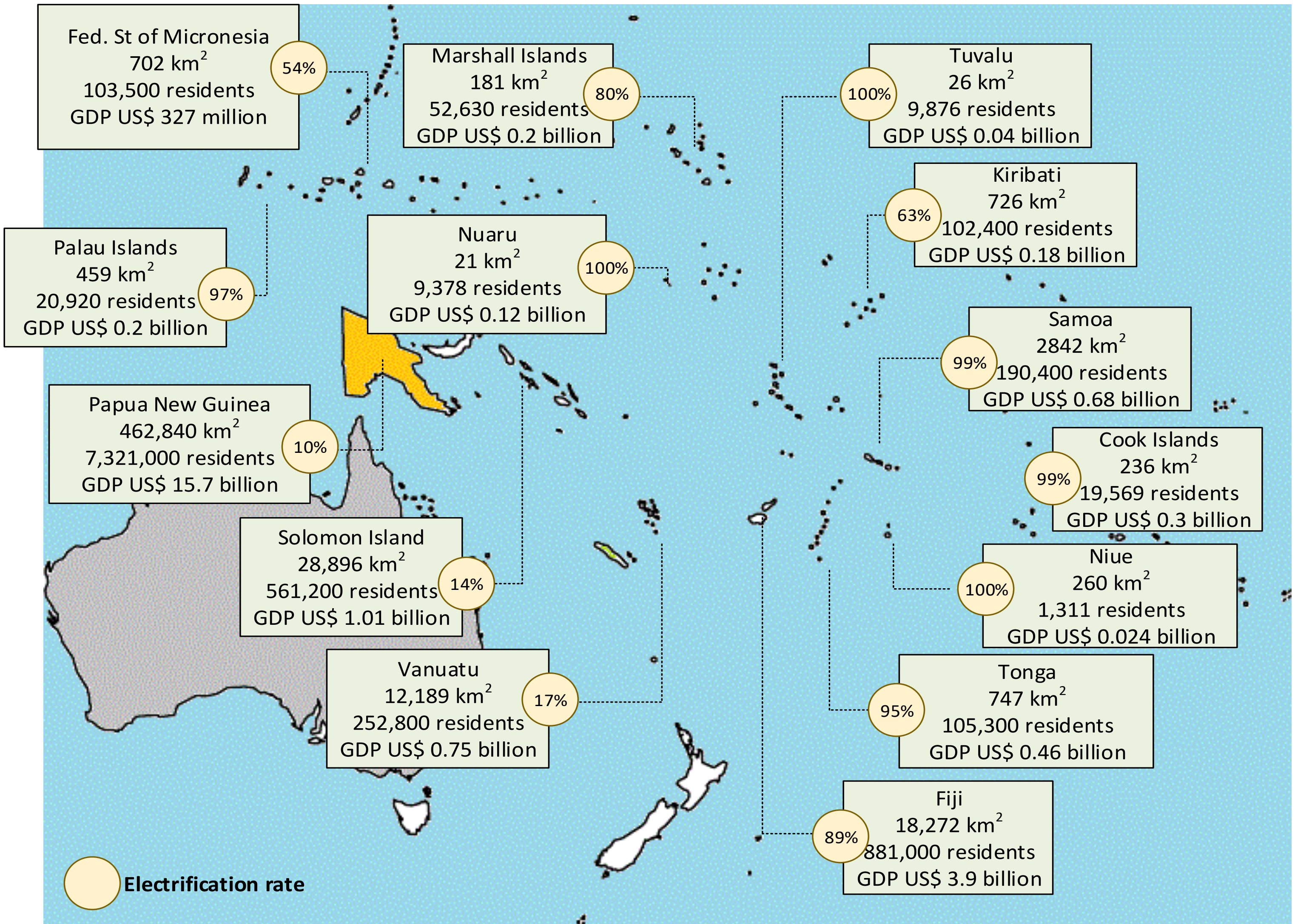

Fig. 2. Geography, demography, economy and electrification rate in Pacific SIDS (Authors' illustration based on data from Dornan, 2014 and UNEP, 2014; Map from http://www.worldatlas.com/)

4 Case studies: Electrification practices from selected SIDS

As previously mentioned, the paper uses case study method to identify experiences and lessons imparted by selected SIDS member states. Hence an analysis of the electrification programmes of eight SIDS member states is presented where, three of these states are electrified to a large extent and in five states, electrification rate is critically low.

4.1 Energy situation in energy poor SIDS

4.1.1 Haiti

The government of Haiti in partnership with the United Nations and other stakeholders has setup a 20-year vision to expand electrification by renewable energy. It is estimated that by 2030, 50% of energy supplied will be by renewable energy but no indication of overall electrification that can be achieved by renewable sources by that time is given. Haiti plans to develop sustainable energy sources while simultaneously considering demand side management strategies to set up a robust energy system. Among different renewable energy sources that can be developed, Haiti is currently focussing on hydro, wind and biomass. Feasibility studies to identify catchment areas for micro–hydro power plants were carried out by UNEP in collaboration with local non–profit organisations and were completed in mid–2015. Some micro–hydro power plants have also been installed for demonstration and testing. Data collection and analysis of wind energy is currently running. As far as biomass is concerned, Haiti has plans to invest in waste–to–energy projects converting municipal solid waste and biomass derived from vetiver (*Chrysopogon zizanioides*) processing into energy. However, local technical assistance is lacking and international expertise has to be sought for such projects. With financial aid from several donor agencies, Haiti plans to invest in mini grids powered by solar–diesel hybrid systems to provide affordable electricity to boost economic development in certain densely populated regions. Solar energy has started to gain ground in Haiti as buildings have been installed with PV mini–grids with state–of–the–art battery technology[3]. At supply side, the sale of clean energy products to substitute kerosene and candles for lighting, battery rental scheme and smart metering systems are being promoted. As the rural cooperatives systems of Bangladesh and the Philippines (Barnes, 2011), three communities have set member–owned cooperative with the intended aims to expand energy access, capacity building and micro–enterprise (UNEP, 2015). It is observed that Haitian

[3] Bismarck (2016) reported the how the application of solar PV with battery system in a Haitian hospital was helping towards cutting down carbon dioxide emissions and diesel costs and electrifying the building at the same time for healthcare services.

electrification strategy is mostly focussed on electricity generation and supply to fit capacity shortage. However, little is known on any active endeavours which focusses on tariff structures as many Haitian are unwilling to pay electricity costs and reduction of transmission losses which is highly significant in the country (UNEP, 2015). Grid extension initiatives for accessible regions and policy mechanisms for private sector participation is however, largely absent.

4.1.2 Vanuatu

Vanuatu's electrification programme relies to a great extent on grid extension and on off–grid electrification for remote areas. The Vanuatu Energy Roadmap 2013–2020 (VNER) is an active energy policy to support energy development in the country – the total investment required is in the order of $200 million which is described as a '*low cost electrification strategic approach'* (VNER, 2013). Table 3 provides details on targets for electrification in the country where the totality of the population is expected to have access to reliable electricity by 2030. Four regions made up the concession areas where most of the unserved household reside within the reach of electric networks. The Government of Vanuatu (GoV) plans to invest in renewable energy and to implement supply side management strategies to complement for capacity shortage by simultaneously maintaining affordability in the process. Pre–feasibility studies are ongoing to investigate the economic viability to extend grids to contiguous areas which are close to concession areas. Plans are to energise other regions that cannot be supplied by grid extension by decentralised options. Under consideration by the local government are basic power charging products, PV–diesel hybrid system, small hydro, biomass fuelled system and solar home system (VNER, 2013). While the GoV looks at the roadmap as 'achievable' there are however, some strategic challenges. Despite having good renewable energy sources (Isaka et al., 2013b), there is no comprehensive approach for the scaling up of these renewable energy sources from technical and economic viability to reality. Financial resources are from grants and established electrification schemes but complementary investments are also needed (VNER, 2013). Most of the funding from donor grants are for decentralised systems, inhibiting grid expansion projects. Additionally, plans fail to consider local training for sustained availability of technical capacity; management of land tenure issues and problems with regards to the lack of standards for renewable energy components which suits the maintenance capacity and environment of the country (Isaka et al., 2013b).

Table 2. Electrification targets in Vanuatu (Source: VNER, 2013)

Target year	Within concession areas	Close to concession areas	Off – grid areas	Public institutions
2020	90	90	100	100
2030	100	100		

4.1.3 Papua New Guinea (PNG)

PNG energy access situation is critical with no electrification target (Dornan, 2014). Even though the country has huge indigenous energy reserves in terms of natural gas, wind, solar, hydro and geothermal that can complement capacity shortages, barriers for the development of these sources are considerably high (Isaka et al., 2013a). Therefore, capacity additions are expected mainly from hydro, natural gas, coal and diesel. Despite the PNG Development Strategic Plan 2010–2030 (PNGDSP), the medium–term development plan 2011–2015 (MTP) and the Electricity Industry Policy (EIP) which dictates government plans and strategies to reduce technical losses, rehabilitate the energy system, move towards cost–reflective electricity tariffs and use fossil fuel sources for electricity provision, policy mechanisms are still broad and lack comprehensiveness. With no consensus among stakeholders on energy reform, private participation seems even more challenging. Electricity tariffs are basically high from extensive use of diesel generators and this has undermined affordability and willingness to pay among consumers. Regulatory capacity is weak and not independent causing political intervention in tariff setting. At supply side, the potential of non–hydro renewable energy has not been fully exploited even though in some regions there are some installations of solar heating systems (ADB, 2015). Electricity access is mostly focussed on urban areas rather than rural areas. Energy efficient initiatives are rather non–existent (Isaka et al., 2013a). It is clear that under these circumstances, electrification programmes are unlikely to survive. Energy governance in PNG include limited capacity within the energy division for research, energy planning and analysis, limited finances, little policy support for private participation and a severe lack of technical knowledge, training and capacity.

4.1.4 Solomon Islands

Solomon Islands have set the ambitious goals to attain 100% electrification rate by 2020 in urban areas and 35% electrification rate in rural areas. At this time, there is no indication on whether such goals are achievable or not. The Solomon Islands National Energy Policy (SINEP) 2014, which is a 10–year plan for energy development in the country, is quite broad in the sense that little is known on the methodology that the country will adopt to achieve these goals. One of the positive aspect of the energy system in Solomon Islands is that tariff are well structured and adequate (ADB, 2015). However, financial management of the Solomon Islands Electricity Authority (SIEA) remains poor unless the SINEP has plans to decrease arrears by other state–owned institutions and to increase payments collection by the industrial, commercial and residential sector. This clearly reflects the unwillingness to pay energy costs by consumers. Electrification in urban areas is expected to be achieved by grid extension, preferably from renewable energy technologies. Little is known on possible strategy for rural electrification. Private participation is severely hindered by the lack of incentives and poor investment climate. No regulatory framework to manage independent power producers and regulate power purchase agreements discourages project developers and investors involvement in the country. The country has good renewable energy reserves with large solar and biomass resources, but still such technologies are well underexploited. In spite of all these lacunas, SINEP includes plans for training of energy professionals with limited indication on their modus operandi and quality of training.

4.1.5 Guinea–Bissau

Guinea–Bissau has an electrification rate of 20% (IEA, 2016) which has shown little improvement over the past years. Since independence in Guinea–Bissau some forty–years ago, Guinea–Bissau has been faced with poor leadership and some level of corruption which has compromised the overall economic development, social stability and the least, energy sector development within the country. There is already a lack of institutional and administrative capacities that has influenced the coordination of actions for many projects or initiatives for the progress of the country. Guinea–Bissau has set up the Strategic and Operational Plan 2015–2020 which aims to uplift present social, infrastructural and economic conditions and to provide electricity access to households. With regards to the electricity sector, the main issues are: firstly, huge gap between supply and demand – while there is over 185MW of hydropower capacity installed, wear and tear of generation equipment and poor maintenance has caused a drop of over 80% on hydroelectricity generation capacity (Thiam, 2013). Thiam (2013) estimated a cost of over $620 million over a period of 20 years to enhance Guinea–Bissau energy sector where it is unlikely that governmental authorities can provide the necessary funds. Secondly, there is the prevalence of a ‘technological and scientific backwardness’ in the country such that, so far little attempts have been made in terms of research and assessment of the technical and economic feasibility of different renewable energy sources which can reduce capacity shortages, implementing energy efficiency initiatives, decreasing technical and non–technical losses and training for experts in the field. Thirdly, there is the case of affordability and poverty where households are relatively poor and cannot afford high electricity costs. The intervention of institutions like African Development Bank (AfBD), EU, ECOWAS, NGOs or United Nations for research and finance have been essential but more is required to be done for an accelerated development of the country. Authorities plan to solve energy access issues through decentralised systems but, social, financial and technical dimensions are inadequate or lacking.

4.2 An overview on the technical barriers for improving electricity access

This section takes the discussion further as grid extension and off grid electrification systems have some technical barriers that need to be addressed. High dependence on fossil fuels limit funds for renewable energy projects as SIDS have to disburse much in coping with fluctuating oil prices.

4.2.1 Grid extension

Extending electric grids to un-electrified regions is an easier way to achieve a higher electrification rate. Grid extension is easier to implement and is, generally, the choice of most households given that grid-based power supply is less susceptible to power outages, leading to increased reliability of electricity supply (Dornan, 2014). However, small and remote households in SIDS (particular in rural areas) make it unprofitable for power utilities to connect these households to the national grid. Some rural areas record a low electricity demand from low population density and low ownership of electrical appliances (Dornan, 2015a) and extending electricity networks to these regions is often not lucrative as tariff structures are inadequate and not sufficient to compensate accrued costs (Di Bella et al., 2015). Frequent tribal wars in some SIDS (PNG, for example) result in vandalism of properties and movement of people which makes any grid extension project difficult with an uncertain future. In some instances, political interference is a major impediment, especially during electricity tariff setting and materials procurement. Political involvement tends to subsidize energy costs excessively making electricity affordable to households but at the same time, impinging a disequilibrium on balance on payments and national budget.

4.2.2 Decentralised electrification

Decentralised (or off-grid) electrification is provided by stand-alone diesel or petrol generators or renewable energy technologies like solar, wind or biomass gasifier (Brew-Hammond, 2010). Decentralised technologies are favoured where economies of scale do not justify grid extension, especially in regions where demand is low and which are far from electrified centres. The challenges with diesel-powered off-grid systems are a dearth of trained personnel and a lack of funds for maintenance and reparation works on these systems (Dornan and Shah, 2016; UNDP, 2012). With the maturation of green technologies (solar photovoltaic, micro-hydropower and small wind turbines), decentralised renewable energy systems (DRES) have become a more attractive solution but the diffusion of DRES often face some hindrances. In a review, Yaqoot et al. (2016) identified and classified them into economic, technical, institutional, socio-cultural and environmental barriers. Among these barriers are the non-controllability and randomness of weather-dependent renewable energy sources as well as the lack of skilful technicians to install, operate and maintain DRES (Kuang et al., 2016) which may not exist in large numbers in SIDS. To drive DRES projects, project developers face a chronic shortfall of technical, financial and business development skills in SIDS which may increase perceived uncertainties and block the ability to take effective decisions (Beck and Martinot, 2004).

4.2.3 High fossil fuels dependency

SIDS are highly dependent on fossil fuels (mostly oil) (UNEP, 2015). As, political unrest in major oil exporting countries are driving oil prices volatile, SIDS member states are becoming highly vulnerable. A slight increase in international oil price can disrupt balance of payments and induce trade deficits, inflation and high imports bills for SIDS (Davies and Sugden, 2010). Thus it is no surprise that SIDS, from time to time, have to seek financial assistance from development banks or other countries, increasing foreign debts in the process. For example, Marshall Islands nearly avoided 'an economic state of emergency' in 2008 following the inability of state-owned utility company to purchase diesel (Dornan, 2015b). Already a large spending from the national GDP is dedicated towards oil purchasing (for example, 15.4 % of

GDP in Solomon Islands; 27.9 % of GDP in Palau[4]). Besides oil price dampening, further disbursement in the energy sector for electrification purposes can trigger much criticisms as progress and financial consideration to other priority development sectors can be undermined. Additionally, to ensure supply of energy to consumers, government has to inject funds through subsidies or tax reduction which are normally contributed by taxpayers who might not have reliable access to energy (Dornan and Shah, 2016). If SIDS shift to renewable energy, among the first benefits would be huge savings in the order of $10 billion which represent nearly 3.3% of the total GDP SIDS generally spent on importing fossil fuels (Blechinger et al., 2016).

Table 3. Summary of barriers for improving electrification (by either generators or renewable energy technologies) in major affected SIDS – Guinea-Bissau, Haiti, Vanuatu, PNG, Solomon Islands (Data compiled from Isaka et al., 2013a; 2013b; 2013c; UNEP, 2015; VNER, 2013; ADB, 2015)

Country	Barriers
Africa	
Guinea-Bissau	(i) Grid-extension barriers; (ii) Political instability – inadequate investment climate in energy sector; (iii) Poor regulatory framework undermining off-grid expansion possibilities; (iv) Lack of technical capacity; (v) Already high spending on energy imports; (vi) Lack of evidence–based renewable energy resource assessment
Caribbean	
Haiti	(i) Grid-extension issues; (ii) Unwillingness to pay electricity bills; (iii) Government spending on energy is high; (iv) Frequently hit by natural calamities which paralyse energy system; (v) Poor regulatory framework to incentivise private participation; (vi) Lack of technical capacity; (vii) Finance–budgetary measures and funds from donors not sufficient
Pacific	
Vanuatu	(i) Lack of training to enhance local capacity; (ii) Economic vulnerability in grid-extension possibilities;

[4] World Development Indicators, World Bank; authors' calculations

	(iii) Poor institutional framework to look after off-grid extension possibilities; (iv) Difficult to secure funding for electrification programmes
PNG	(i) Vandalism by tribal people resulting in destruction of energy facilities; (ii) Poorly built houses make electric connections unsafe; (iii) Limited technical capacity; (iv) In-efficiency in distributing funds for energy sector development (v) Rehabilitation of electricity tariffs to make it more cost–effective
Solomon Islands	(i) Poor financial management of regulatory institutions; (ii) Grid-extension issues; (iii) Lack of technical capacity; (iv) Weak institutional capacities hindering private sector participation.

4.3 Experiences from electrified countries

4.3.1 Fiji Islands

Fiji do not have 100% electrification rate, but based on last three consecutive consensuses, electricity access has increased from 48% to 67% to current 89% (Prasad et al., 2017). Fiji uses a mix of grid connected and distributed systems to provide electrification. 75% of Fijian population is supplied by grid connected electricity and 14% by off-grid systems (Prasad et al., 2017). Since grid–based and off–grid systems are managed by two different entities namely the Fiji Electricity Authority (FEA) and the Fiji Department of Energy (FDoE), this has ensured fairness, consistency and optimum use of financial resources. While addressing technical and market barriers to renewable energy, Fiji plans to increase the share of renewable energy to 90% by 2020, and certainly achieve full electricity access. FDoE is favouring solar home systems in regions where grid cannot be extended to strengthen the country's resilience against escalating oil prices (Prasad et al., 2017). In terms of policy measures, the Fiji National Energy Policy dictates development with regards to rural electrification, grid–based electrification, energy efficiency, transport sector, renewable energy and biofuels – and has lastly been revamped to cater for latest trends and developments in the energy sector in the country (Wolf et al., 2016). To better coordinate rural electrification, the FDoE has established the Rural Electrification Unit, to guide the Rural Electrification Policy which aims to drive actions for rural electrification. Besides planning and setting up independent stations in rural villages, this energy division in the FDoE has also worked out on the affordability issue of electricity to households. While initially the cost of electrification projects borne by customers were in the level of 33% (and the rest borne by government), these charges were decreased to 10% to finally reach a cross–subsidisation mechanism where only 5% is borne by the customer. Consequently, this has increased the number of energy consumers. Fiji has the lowest electricity price in the Pacific, which is nearly two to four times cheaper than other Pacific countries (Prasad et al., 2017).

4.3.2. Mauritius

Mauritius achieved full electricity access by late 1980s in both rural and urban regions, supplying 355 GWh of electricity to all requiring sectors at that time (Deepchand, 2002). Mauritius electrification programme is considered one of the most successful programme in Africa. Their electrification programme was framed into three aspects which are: (a) transparent energy planning process with explicit focus on the poor, (b) the use of bagasse and coal to increase generation capacity and (c) strict monitoring on the disbursement of funds for electrification (Hurdowar, 2005). The Mauritian government exclusively focussed on the provision of electricity to the poor to raise standard of living and improved livelihood, and moved to industrial and commercial sectors at a later stage. By first extending grid to all villages, new customers could be connected even though electricity was used mostly for lighting. When the residential sector had some electricity, the emphasis was on the commercial and industrial sector, even though the residential sector was not overlooked (Hurdowar, 2005). With industrialisation that followed and higher disposable income, households became more affluent, which led power plants to increase generation capacity. Without catering for the increase in electricity demand, Mauritius would have been plunged into a state of limited electrification, threatening the economy. While oil generators were proposed to meet rising electricity demand, the decision was however taken for the use of bagasse and coal (Deepchand, 2002). Through a number of policies[5] implemented, sugar mills were incentivised to generate electricity using bagasse which could be fed to the grid. Sugarcane was however seasonal and during off–season, and as coal is a solid fuel as bagasse, coal was used in the same boilers to generate electricity –ensuring continuous supply of electricity year round. All these initiatives needed huge funding which was sourced from loans from the World Bank and funds from government budget. Since there was no implementing agency, the national utility

[5] Sugar Sector Action Plan (1980), Sugar Sector Package Deal Act (1985), Sugar Industry Efficiency Act (1988), Bagasse Energy Development Plan (1991)

company was ‘ring–fenced’ by the government, making the management of funding for electrification programmes under the responsibility of the utility company (Hurdowar, 2005). With the company a separate entity, the company gets shielded from political influence and can seek for loans and implement conducive policies which are suitable for households as well as ensuring the sustainability of the programme.

4.3.3 Cuba

Cuba’s electrification rate stands at 97% and their future strategy for electrification lies in decentralised systems. Nearly sixty years ago, Cuba had an electrification rate of 56% because firstly, households could not pay for electricity costs and secondly, grid were not fully extended (IAEA, 2008). The then government, took the initiative to extend electricity access where it was economically feasible and reached nearly 71% in the next fifteen years. However, economic crisis caused electrification programme to slow down and migration of people to electrified regions and increased in the usage of appliances led to an unprecedented rise in energy demand. Thus governmental authorities resorted to a number of policy based measures for institutional reforms, adopted a number of energy efficiency and conservation measures and started to implement actions for the widespread adoption of decentralised electricity options. In this context, institutional reforms included the setting up of a National Energy Commission (NEC) with overviews actions to reduce energy use from oil in industrial sectors. Additionally, setting up of a tariff structure depending on consumer type, voltage, time of consumption for all consuming sectors and obligatory payment of electricity costs by companies were implemented. The Cuban Electricity Regional Use Programme implemented a number of energy efficiency initiatives like subsidies on energy efficient lamps, energy conservation campaigns and for replacing refrigerator gaskets. These energy efficiency measures resulted in the displacement of nearly 150MW electric generation capacity (IAEA, 2008). To limit transmission losses, huge investment costs and other inefficiencies of grid based electricity, Cuba opted for decentralised electrification (around 40%) using gensets, small hydro and solar PV systems increasing resilience to extreme weather conditions (Käkönen et al., 2014). Cuba has exceptionally developed capacities and experience of the production of solar PV systems, solar water heaters, windmills, turbines for mini-hydropower plants and along with the availability of highly qualified personnel the country has been able to decrease dependency on international trade over renewable energy equipment (IAEA, 2008; Käkönen et al., 2014; Suárez et al., 2012).

Table 4. Some experiences from above case studies – Fiji, Mauritius and Cuba

Country	Experiences
Fiji	(a) Efforts to reduce oil utilisation is ongoing where over 60% of electricity is already supplied by renewable sources – more renewable energy implies more resilience to fluctuating oil prices (b) Target setting allows to view progress in electrification trend and renewable energy development. (c) Responsibilities were divided among energy institutions which allows optimum utilisation of funds and other resources; Policy actions with regards to electrification seemed to be better coordinated. (d) Subsidies and revision of electricity costs to ensure affordability of electricity to poor electrified households.
Mauritius	(a) Breaking electricity requiring sectors into tiers and establishing guidelines for supply to each sector accordingly – as Mauritius did by supply poor households followed by industrial sectors (b) Ring–fencing of funds and stringent follow up for the disbursement of funds (c) Maximising of locally available resources for capacity addition – considering bagasse as a resource and coordinate programmes to valorise the latter.
Cuba	(a) Energy efficiency has enormous driver that can boost the continuous effort for improving electricity access (b) Institutional reforms plays a big role for the successful implementation of electrification programme (c) Off–grid is potentially the best solution towards limiting damage in cases of extreme weather conditions (d) The development of locally trained personnel, scientific and technological capacity for renewable energy technologies and eventually help the country in being less reliant on external trade

5 Discussion and policy recommendations

From the above case studies and analysis, the following recommendations were proposed.

5.1 Political will

One driving factor to widen electrification in SIDS could be an effective multi-sectoral tool, backed up by a firm leadership and adequate regulatory measures and policies. A UNDP study in the Caribbean concluded that a "*lack of political will is a recurrent and underlying theme of all studies and evaluation of reform and institutional development in the Caribbean*" (Everest-Philips, 2014). Political barriers are important constraints which need to be addressed to expand electrification rate by renewable energy technologies (Blechinger et al., 2015; Blechinger and Shah, 2011). A forward-looking and committed government is key to drive electrification programmes towards successful ends. Moreover, a long-term commitment towards electrification is a critical component to overcome economic, financial, technical, institutional and social barriers in specific programmes. In Mauritius, for example, 58.8% of households were electrified in 1968 and electrification rate steadily reached 98.2% by 2000 even though at that time there was no proper policy planning in the country (Hurdowar, 2005). The World Bank (1978) stated that the success of the Mauritian electrification programme was the political will of the Mauritian government and the level of commitment of the national utility company. In Guinea-Bissau, political unrest and frequent military conflicts since independence (di Paz, 2010) has reduced commitment level in energy planning which surely is the main reason why Guinea-Bissau records a low level of electrification.

5.2 Independent institutions and a proper regulatory environment

To minimise any political interference in the energy sector, and to let experts do their work effectively and in operational autonomy, it seems that the establishment of an independent regulatory body to monitor performance of utilities and power producers is important. An independent regulatory body is a multi-member body that have both rulemaking and adjudicative powers (Morrison, 1988). Regulations should be very clear on the recruitment of members to serve the panel and nepotism and patronage politics should be avoided in all cases. This body will enable the setting up and enforcement of an institutional framework and energy policies depending on country's strengths and weaknesses and allow the optimal use of resources (World Bank, 2010). A comprehensive energy policy is also important as it dictates the government actions and future plans to address issues on energy development through legislations, treaties, incentives for investment, taxations and public policy strategies.

Independently selected regulators have the necessary expertise and academic competence to meet feasible electrification goals with a clear and understandable methodological approach on how these goals can be achieved. These bodies can also offer continuous training programmes. Legislative and regulatory frameworks ensure safe, reliable and good quality electricity is supplied as well as consumers are connected to safe electrical installations and to good practices in electrical systems. For grid-extension, such framework should include procedures for the effective implementation and monitoring of electrification programmes as well as clearly defined roles and responsibilities of each stakeholder (contractors, service providers, beneficiaries and so on). Regulations should boost development schemes, tackle land disputes and illegal tapping of electricity among others. Another important function of a regulatory body, mostly neglected within the energy sector, is the setting up of standards, codes and certificates for infrastructural works and equipment (Shah et al., 2014). For grid extension for instance, low costs overhead cables instead of an underground network; construction, poles and other infrastructure of high quality that can resist cyclonic weather can be favoured. The absence of suitable codes and standards hinder the dissemination of DRES as they can foster the diffusion of poor quality systems which is a technical barrier. This technical barrier has been the root of poor dissemination of solar water heating and solar heating systems in USA as suggested by a study (Yaqoot et al., 2016). In cases where off–grid option is more plausible, these institutions can play a decisive role in strategic energy planning of decentralised system. The Energy Revolution in Cuba is the best example here, where decentralised power generation has been implemented spearheading electrification in remote areas (Käkönen et al., 2014). Such institutions can play an important part in energy system planning especially when trying to study and implement the right technology type (grid extension, stand–alone PV systems or PV–hybrid systems among other) to meet the demand of consumers based on demographic spread in the most cost effective way (see Bertheau et al., 2016; Zeyringer et al., 2015). Adequate electrification cost, affordable to consumers is essential, else consumers will not be able to manage energy expenses which will eventually dis-equilibrate the energy system as despite having an energy demand and adequate supply, low affordability of costs will maintain low electrification.

5.3 Subsidies

A study by Matakiviti and Pham (2003) in Fiji in 2002 showed that the costs incurred per consumer living in a rural area connected to stand-alone diesel generators was 70 % less than when connected to the national utility company, but upfront costs associated with decentralised systems are high and unaffordable to some households which means subsidies or an adequate tariff structure are required. Tariff should be set based on location, consumer type (domestic, commercial or industrial) and time of day. Tariff should be cost-reflective and ensures complete cost recovery over operation, maintenance and other costs. Moreover, a well-designed and non-discriminatory system of subsidies, should be implemented bearing in mind target efficiency, equity and effectiveness of the subsidy (World Bank, 2010) as well as how the subsidy can be phased out when it is no longer socially and economically efficient. In Fiji for example, a cross-subsidisation mechanism is used where government bears most of the cost for electrification and the remaining amount are borne by households (Dornan, 2014; IEP, 2013). This subsidy system is not mean tested, that is high income households benefit from it (Dornan, 2014) and is thus an economic inefficiency from the government disbursing where it is not required.

5.4 Financing

It is more complicated to achieve universal energy access in countries which have a very low electrification rate than in countries which have a medium level of electrification. A country with a minimum of 50 % household electrified means an adequate number of taxpayers and electricity consumers to provide funds for electrification (World Bank, 2010). Thus, Solomon Islands, Comoros, Haiti, Vanuatu and PNG are deeply disadvantaged since their electrification rates are critically low and fail to raise financing through this opportunity. In this context, government has to boost private participation through incentives, tax rebates and other attractive options to raise funds. In Mauritius, a number of Acts and regulations were promulgated and amended along with several programmes to attract investment with respect to renewable energy. Moreover, domestic tariffs were initially designed as a decreasing block rate tariff (the higher energy consumption, the cheaper the price of electricity) (Louw, 2014) promoting electricity consumption and an increase in the sale of electronic appliances to improve standard of living. Eventually, this initiative helped in raising fund for electrification projects in Mauritius. The tariffs were finally shifted to increasing block rate and ring–fencing of funds is another feasible option.

6. Conclusion

The paper offers policymakers an idea of the energy situation in SIDS and a better understanding of the barriers and solution for SIDS. Lack of energy access in SIDS is real but sparingly discussed in the literature. It is suggested that SIDS insufficient energy regimes can be traced back to their independence period. The inability to extend grids, high upfront costs for rural electrification, inadequate policy mechanisms, a limited knowledge base and the continued high dependence on energy imports in SIDS have aggravated the present energy situation and reduced the scope for improved electrification. Research outcomes proposed the following main policy recommendations which are:

- A change in the politics of energy where governmental authorities can commit to resolve energy crisis in their countries through adequate regulatory measures and policies. This can entrain the setting up of independent institutions to deal with all electrification activities in SIDS. An independent regulatory body can set up an institutional framework to foster progress in electrification by using optimum financial reserves and to coordinate tasks among stakeholders which will undoubtedly yield better results.
- Measures to establish well–planned and affordable subsidies and tariff based on a number of determinants (location, consumer type, time, effectiveness of the tariff among others) which will increase electricity demand at consumers', end. While energy demand is increasing on one side relieving people from poverty, utility companies are faced with an increase in revenue. Strategies to better manage funds are important – ring-fencing is proposed in this paper.
- The intervention of private participation is also important, either by reducing capacity shortage for grid connected power generation facilities or in establishing decentralised generation. Policies have to be designed to provide sufficient room for the private sector to invest and to grow sustainably. It is in these cases that adequate incentives, tax rebates and other market tools can be of great use.

SIDS are often intricated by unique challenges, different from continental areas, which make some of the techniques that big countries have applied often not sustainable in their case. Hence, a need to implement policy based on territorial analysis and available resources which can be fulfilled by this institutional body. With this analysis, it is expected to trigger endeavours within the SIDS and global scientific community to develop, to a greater extent the energy access status and to improve the livelihood of local citizens. The findings here can also be extended from other island–like regions which may not be SIDS *per se*.

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