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Using power sector reform as an opportunity to increase the uptake of renewable energy in the power sector: Responding to peak oil and climate change in Caribbean and Pacific small island developing States, between 1970-2010

Keron Niles and Bob Lloyd

Abstract

Small island developing States (SIDS) have narrow resource bases and are usually extremely reliant on fossil fuel based energy for transport and electricity generation. These island economies are thus particularly vulnerable to the impacts of peak oil and also to climate change, impacts which are likely to not only hamper economic development but also adversely affect the quality of life of local inhabitants. In order to reduce the vulnerability of SIDS to peak oil, an urgent transition to renewable sources of energy is necessary. This paper propounds that the reform of power sector that took place in Caribbean and Pacific SIDS (particularly between 1970 and 2000) should have been viewed as an opportunity to re-orient power producers away from the proclivity to utilise conventional fossil fuel uses. Reasons why reform measures did not result in a substantive transition are put forward. Moreover, recommendations towards facilitating a transition to renewable energy in the power sector through future reforms are proposed.

Keywords: Island, SIDS; peak oil; fossil fuels; renewable; electricity.

1. Introduction

Weisser (2004a) suggests that the narrow resource base of small island developing States (SIDS) restricts their ability to invest in renewable energy technologies and typically contributes to a high degree of dependency on fossil fuels, particularly for electricity generation. Moreover, SIDS face challenges related to developing viable internal markets, particularly for power generation, largely due to diseconomies of scale, very high transportation costs and vulnerability to natural disasters (The University of the West Indies Centre for Environment and Development, 2003), which are expected to become more intense and more frequent (Intergovernmental Panel on Climate Change, 2007). These difficulties have the combined effect of making power production not only very expensive but also financially risky in the long term (Weisser, 2004a). This paper will look at a few of the impacts of peak oil and climate change on Caribbean and Pacific SIDS so as to highlight the urgent need to transition to renewable energy in these nations.

For the purposes of this paper, the term Caribbean is used to refer to the primarily English-speaking islands nestled in the Caribbean Sea that form the regional grouping known as the Caribbean Community (CARICOM)[1] and the term Pacific Island States refers to those self-governing nations enveloped by the Pacific Ocean that are members and beneficiaries of the programmes of the Secretariat of the Pacific Community (SPC).[2]

Keron Niles and Bob Lloyd are both at the Department of Physics, Energy Studies, University of Otago, New Zealand. E-mails: keron.niles@googlemail.com and boblloyd@physics.otago.ac.nz

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[1] According to Article 3 of the Revised Treaty of Chaguaramas, 2001 (establishing the Caribbean Community including the CARICOM Single Market and Economy), the Caribbean Community (CARICOM) comprises Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname and Trinidad and Tobago. Haiti gained membership in 2002.

[2] The South Pacific Commission membership includes the 22 Pacific Island countries and territories along with four of the six original founders (the Netherlands and United Kingdom withdrew in 1962 and 2004 respectively when they relinquished their Pacific interests; see http://www.spc.int/en/about-spc/introduction.html). From among these nations, this paper will only focus on those countries that are self-governing, namely: Cook Islands, Federated States of Micronesia, Fiji Islands, Kiribati, Marshall Islands, Nauru, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

2. Peak oil and climate change impacts on SIDS

2.1. Peak oil

Peak oil refers to the transition from a period of easily attainable and affordable oil, to a period characterised by a declining annual supply of petroleum (Heinberg, 2006). This scenario reflects the reality that fossil fuels, like many other natural resources, are finite, and are destined to become scarce. In the case of oil and gas, it is not merely the absence of fossil fuels in situ that brings about a shortage of supply, but rather the depletion of easily attainable petroleum. Peak oil is meant to point to the realisation of a global maximum of oil production (Aleklett *et al*., 2010) before the extraction of petroleum declines due uneconomical or prohibitive extraction costs.

Some commentators do not share these views. Maugeri (2012:6) believes that problems related to global oil supply are driven by factors above the ground and not below it and relate to "political decisions and geopolitical instability." In fact, Radetzki (2010:6569) argues that the world's "oil resource base is adequately large and growing" and Smil (2005) foresees that a combination of technical innovation, modest growth rates of future consumption and efficiency gains will delay the onset of global peak oil production for the rest of the 21st century. On the other hand traditional proponents of peak oil dismiss such claims especially as relating to the recent tight oil boom in the US as overly optimistic (Heinberg, 2013).

Nonetheless, rather than attempting to predict the precise timing of the exhaustion of world petroleum supplies, the authors seek to highlight the impact that high oil prices (which we believe are being driven and sustained primarily by declining supplies of easily attainable oil), has on the power sector in Caribbean and Pacific SIDS. This view reinforces the opinion of the International Energy Agency (IEA) that the "era of cheap oil is over" (International Energy Agency, 2008:15). Prolonged high prices can be attributed to the fact that the energy returned on energy invested (EROEI) for oil is declining (Hall *et al*., 2008; Murphy and Hall, 2010). In this regard, while there have been surges in unconventional oil and gas production in recent times, particularly in the USA, this is unlikely to be sustained, since the EROEI of alternative fossil fuel resources (like tar sands and shale gas) is relatively low (Guilford *et al*., 2011). Heun and de Wit (2012:148) agree and assert that decreasing values of both EROEI and the embodied energy (or "emergy") of US oil production over the past four decades help to explain why "over time it is costing more and more energy to get energy."

The above analysis is both critical and relevant to the future of electricity provision in SIDS. As illustrated in Table 1, most SIDS are still largely, if not entirely, dependent upon fossil fuels for electricity generation. Unless the power sector in these nations finds some means to wean off this addiction to petroleum[3] within the relatively near future, this vulnerability will result in a belated scramble to transition to renewable energy sources (in the medium- to long-term) (Girvan, 2009; Lloyd and Subbarao, 2009). The susceptibility and relative helplessness of the electricity sector in SIDS to a peak oil event is unique and worthy of examination due to the fact that diseconomies of scale (due to limited demand) will probably result in even greater average fuel price increases for SIDS.

2.2. Climate change

The vulnerability of SIDS is acknowledged in the Preamble to the United Nations Framework Convention on Climate Change (UNFCCC) which recognises that "low-lying and other small island countries, countries with low-lying coastal, arid and semi-arid areas or areas liable to floods, drought and desertification, and developing countries with fragile mountainous ecosystems are particularly vulnerable to the adverse effects of climate change" (United Nations Framework Convention on Climate Change, 1992:2). Indeed, inundation due to rising sea levels has already displaced and prompted the relocation of communities in Vanuatu and Cuba (Sem, 2007; United Nations Framework Convention on Climate Change, 2007) and of entire islands in the Pacific, such as the Carteret Islands of Papua New Guinea (The Office of the United Nations High Commissioner for Refugees, 2009).

Moreover, it is the exposure of small islands to climate change impacts that makes the possibility of decreased access to energy resources an even greater concern, as liquid fossil fuels are often required, *inter alia*, to operate emergency earth moving and food distribution vehicles and equipment, and electricity is needed for emergency communications and to power hospitals. In such a scenario, without a transition to renewable energy, peak oil itself may reduce the adaptive capacity of SIDS to respond to climate change. More frequent and intense natural hazards may complicate the transportation of fuels to small islands even further (Organization of American States, 2000) and could potentially increase the cost of insurance to shipping companies and thus decrease their willingness to deliver to remote locations, especially during periods of high oil prices where there are many potential buyers with greater demand and purchasing power. In such cases, climate change impacts may well weaken the resilience of SIDS faced with the reality of peak oil. These interlocking, mutually reinforcing, anthropogenically-driven forces of climate change and peak oil both weaken the ability of island economies to respond to either.

[3] Adapted from a Quote from President George W. Bush, featured in Heinberg (2006); Boston World Oil Conference, Time For Action: A Midnight Ride for Peak Oil, Boston (2006), Association for the Study of Peak Oil and Gas, USA.

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Table 1. Net electricity generation by type in selected SIDS

Country	Net installed capacity in 1970 (in MW)	Net installed capacity in 2008 (in MW)	Percentage distribution (2008)			Absolute change (in MW) in net installed capacity from 1970 to 2008[3]
			Thermal[1]	Hydro	Non-hydro renewable[2]	
Antigua and Barbuda	14	13.1	100.0	0.0	0.0	−0.9
Bahamas, The	174	233.9	100.0	0.0	0.0	59.9
Barbados	39	115.3	100.0	0.0	0.0	76.3
Belize	7	24.6	35	65	0.0	17.6
Cook Islands	2	3.7	100.0	0.0	0.0	1.7
Dominica	5	9.9	63.2	36.8	0.0	4.9
Fiji	54	106.2	29.0	71.0	0.0	62.2
Grenada	5	21.7	100.0	0.0	0.0	16.7
Guyana	160	93.5	100.0	0.0	0.0	−66.5
Haiti	43	53.2	61.6	38.4	0.0	10.2
Jamaica	405	835.4	95.8	2.1	2.0	430.4
Kiribati	1	2.5	100.0	0.0	0.0	1.5
Nauru	8	3.7	100.0	0.0	0.0	−4.3
Niue	—	0.3	0.3	0.0	0.0	0.3
Papua New Guinea	69	338.2	69.6	30.4	0.0	269.2
St. Kitts and Nevis	6	14.8	100.0	0.0	0.0	8.8
St. Lucia	7	37.8	100.0	0.0	0.0	30.8
St. Vincent/Grenadines	4	15.1	82.2	17.8	0.0	11.1
Samoa	6	12.1	54.7	45.3	0.0	6.1
Solomon Islands	3	8.9	100.0	0.0	0.0	5.9
Suriname	260	180.2	44.6	55.4	0.0	−79.8
Tonga	2	4.6	100.0	0.0	0.0	2.6
Trinidad and Tobago	334	846.3	99.9	0.0	0.1	512.3
Vanuatu	4	4.9	100.0	0.0	0.0	1.2
Pacific Total	149	495	60.9	37.1	2.1	346
Caribbean Total	1,463	2494	92.6	6.7	0.7	1,031
Combined Caribbean & Pacific Total	1,612	2990	87.3	11.7	0.9	1,378

Notes: [1] Electricity generated from coal, oil, and gas. [2] Includes electricity generated from geothermal, solar, wind, and biomass and waste. Generation below 0.1% is recorded as 0.0% [3] It should be noted that the values calculated for Antigua and Barbuda, Belize, Dominica, Guyana, Suriname and Vanuatu may not be accurate as these are based upon United Nations Statistical Office Estimates.
Source: KEMA (2010).

2.3. Energy consumption in SIDS

Energy consumption in Small Island Developing States is as diverse as the islands themselves, and largely influenced by endogenous and external factors, including, *inter alia*, the size of the territory, population size, and income levels. What these nations do tend to share however, is their dependence on fossil fuels. A Benchmark Study of Caribbean Utilities conducted in 2009 found 98% of primary energy consumption in the region to be fossil fuel based (see Figure 1) (KEMA, 2010). Similarly, a Pacific Regional Energy Assessment noted that Pacific Island Countries are "overwhelmingly dependent on imported petroleum fuels for commercial energy for transport, electricity, business and households though hydropower has been a significant contributor in the larger countries" (Wade *et al*., 2005:25). In this regard, fossil fuels have been estimated to comprise around 85% of total energy consumption in the Pacific, with oil accounting for 76% of that fraction (Asia-Pacific Economic Cooperation and

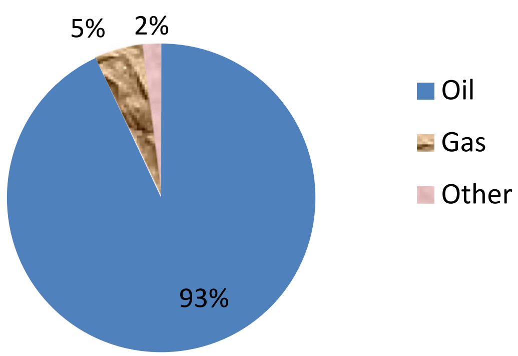

Figure 1. Primary energy consumption in the Caribbean, 2009.
Source: KEMA (2010).

Asian Development Bank, 2009; Secretariat of the Pacific Community, 2010) (see Figure 2). Energy consumption in either region can therefore be described as "petroleum intensive." One notable difference between the two regions is that biomass is still commonly used for domestic cooking

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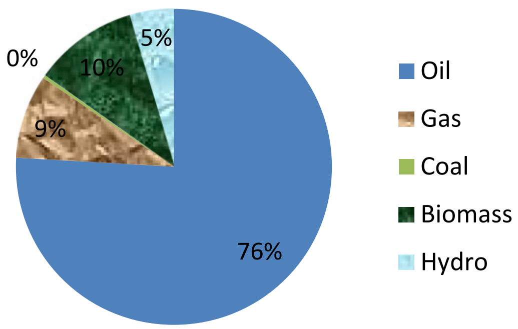

Figure 2. Energy mix in the Pacific, 2006.
Source: Secretariat of the Pacific Community (2010).

and some agricultural drying (particularly for copra), though the degree of utilisation varies by country (Wade *et al*., 2005).

3. A closer look at the power sector (1970-2010)

3.1. Past power sector reform in SIDS

Often in the past, due to factors including growing demand for electricity, budgetary pressures or loan requirements of international financial institutions (IFIs), many SIDS have been forced to commercialise, privatise or restructure their electricity generation, transmission and distribution sub-sectors. In the period "between 1990 and 1999, private participation took place in the electricity sectors of over 75 developing countries and the total private investments amounted to approximately US$160.7 billion in 695 projects" (Jamasb, 2006:15). Even further, "more than two-thirds of total investments and projects between 1990 and 1999 were in pure generation facilities" (Jamasb, 2006). Thus, within the power sector, the electricity generation sub-sector specifically has undergone a great degree of reform worldwide, partly due to the fact that transmission and distribution are often viewed as natural monopolies (Weisser, 2004b) and have tended to remain in government hands.

Appendix I illustrates the degree of power sector reform that has occurred in the Caribbean and Pacific. Suffice to say, there have been a greater number of reforms (particularly in the form of privatisation) in the Caribbean region. This regional trend could be related to the specific structural adjustment programmes of the International Monetary Fund in Latin America and the Caribbean, through which the deregulation and privatisation of state owned enterprises, particularly utility companies, was made a condition for receiving financial assistance (Klein, 2007; Wamukonya, 2003). To facilitate these changes, the policies and legal framework regulating transmission and distribution have often changed to qualify for support from international development partners and institutions.

The result in many SIDS is an electricity sector structure designed for economic efficiency, with the cost-cutting imperatives of the organisations responsible for generating, transmitting and distributing the power in mind (to enable loans to be repaid more easily) and not one designed from a need or desire to ensure that these nations possessed a sustainable and environmentally benign supply of electricity. The section which follows outlines the progress towards a greater uptake of renewable electricity in both regions between 1970 and 2010.

3.2. Power generation in the Caribbean and Pacific (1970-2010)

The dependence of SIDS on conventional (mainly liquid) fuels is reflected in the modes of electricity generation used in such nations from 1970 to 2010. As is illustrated in Table 1 below, though the magnitude and nature of electricity generation is rather heterogeneous, there is an overall trend towards conventional thermal generation.

When the regions are disaggregated and one observes the energy sources used for power generation in 1970 and 2008 it is clear that the nature of a transition to greater utilisation of renewable energy sources differed in each region. In the Pacific, power generation from renewable energy sources (both hydro and non-hydro) increased between 1970 and 2008 (see Figures 3 and 4). Fossil fuel based power production also decreased during this period. Hence, one could argue that some degree of transition towards greater utilisation of renewable electricity generation occurred in the Pacific. Nonetheless, it should be noted that because of the growth of electricity usage between the two dates, the actual absolute installed capacity of fossil fueled electricity generation increased by 195MW.

In the Caribbean, the percentage of conventional (i.e., fossil-fuel based) electricity generation increased between 1970 and 2008 from 86% to 92% (see Figures 5 and 6) and grew in absolute terms by 1,052MW. During the same period, the proportion of power generated from hydroelectric sources was halved from 14 to 7%. Power production from non-hydro renewable energy sources (such as solar and wind energy), which did not exist in 1970, did represent one per cent of electricity generation in 2008.

Another observation that can perhaps be made is the emphasis that was placed on the development of hydroelectric resources in the Pacific (see Figures 3 and 4). Greater deployment of hydropower may be positive and desirable as a renewable source of energy, but Heinberg (2005:150) highlights that "hydroelectric dams typically pose a range of environmental problems: they often ruin streams, cause waterfalls to dry up and interfere with marine habitat." The deleterious environmental impacts of

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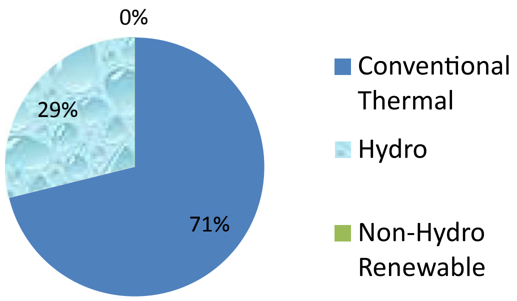

Figure 3. Installed capacity mix in the Pacific (1970).
Source: Energy Information Administration (2011).

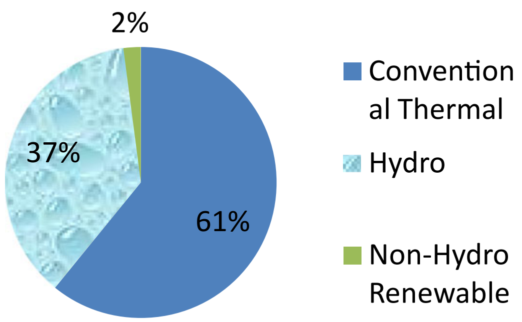

Figure 4. Installed capacity mix in the Pacific, 2008.
Source: Energy Information Administration (2011).

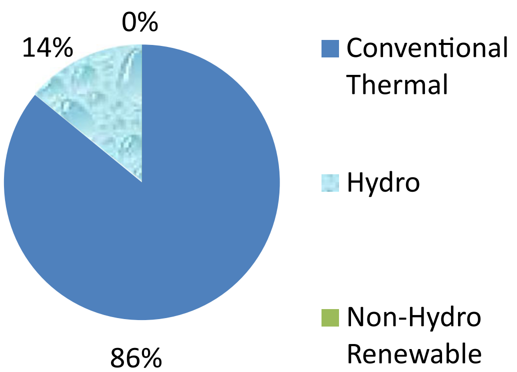

Figure 5. Installed capacity mix in the Caribbean, 1970.
Source: Energy Information Administration (2011).

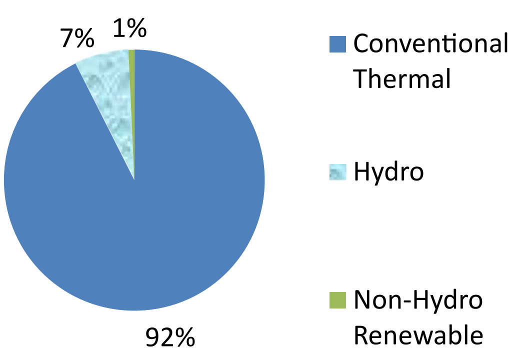

Figure 6. Installed capacity mix in the Caribbean, 2008.
Source: Energy Information Administration (2011).

hydropower are exacerbated by the fact that hydroelectric dams, especially those in tropical environments, are not carbon free but rather emit carbon dioxide and methane, the latter of which causes considerably more atmospheric warming than the former (Giles, 2006; Barros *et al*., 2011; Gunkel, 2009; Wehrli, 2011).

In six of the ten countries where hydroelectric developments occurred, the growth in electricity production between 1970 and 2010 was accompanied by a decrease in the proportion of power generated from other renewable sources, resulting in some cases in an actual decrease in the proportion of power generated from renewable energy sources during the period. Figure 7 shows the degree of transition to renewable electricity. Fiji managed to make the greatest transition to renewable (albeit carbon-emitting) electricity generation, as this Pacific nation progressed from having negligible power production from renewable sources in 1970 to a situation where 71% of its electricity was generated from hydroelectricity in 2008.

In spite of the deployment of hydropower and other forms of renewable electricity, fossil-fuel based power generation in Caribbean and Pacific SIDS is predominant. Between 1970 and 2010, the uptake of renewable energy was greater in the Pacific than in the Caribbean, although this was achieved primarily through the deployment of hydroelectric technologies. In the Caribbean, the percentage of hydropower being utilised was halved and fossil fuel-based power generation increased. Thus, the attempts to reform the power sector (particularly those made in the 1990s) did not result in a transition towards a greater deployment of renewable electricity. In fact, the uptake of renewable energy in the power sector was greater in the Pacific where there was less privatisation and deregulation of electric utilities. This result is unsurprising, since deregulation has always emphasised improvements in economic efficiency, not achievement of environmental goals or resilience in the face of possible future fossil fuel supply disruptions.

4. Recent and future reform of the power sector in SIDS

4.1. Recent reform measures in Caribbean and Pacific SIDS

Since both climate change and peak oil are expected to exacerbate the effects of fossil fuel dependence in SIDS, in lieu of basing future reforms on increasing operational efficiency and economic returns, any further restructuring of the power sector should focus primarily on boosting the uptake of renewable energy and include policy mechanisms geared towards increased deployment of sustainable energy technologies. Such mechanisms might include:

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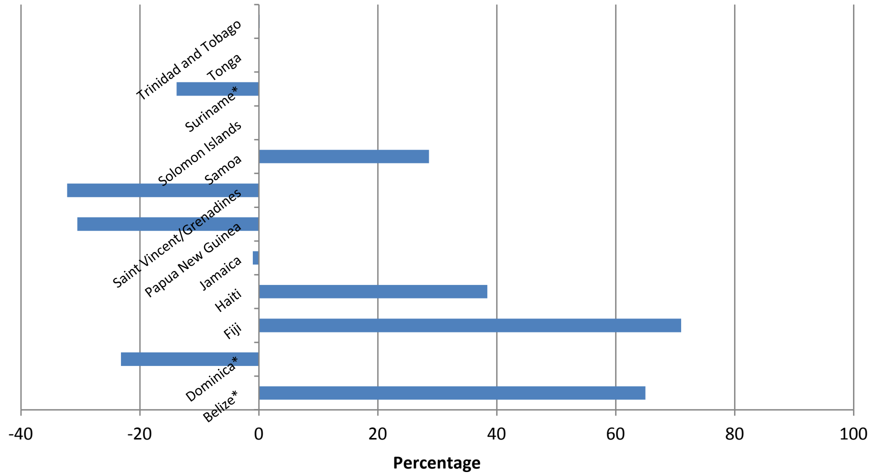

Figure 7. Change in renewable electricity generation, 1970-2010.
Note: * Values are based on estimates from the United Nations Statistical Office.
Source: KEMA (2010); Energy Information Administration (2011).

Table 2. Renewable energy quotas as indicated in Caribbean national energy policies (as of January 2010)

Country	Renewable energy target/quota	Sector/Subsector	Deadline
St. Vincent & the Grenadines	30%	Electricity	2015
	60%	Electricity	2020
St. Lucia	“At least” 5%	Electricity	2013
	“At least” 15%	Electricity	2015
	“At least” 30%	Electricity	2020
Jamaica	11%	Overall Energy Sector	2012
	12.5%	Overall Energy Sector	2015
	20%	Overall Energy Sector	2030
Guyana	32% Hydro Power	Electricity-Installed Capacity	2015
	11% Bagasse		
	57 % Diesel		
	80% Hydro Power10% Bagasse	Electricity — Generation Mix	2015
	10% Petroleum		
St. Kitts & Nevis	100%	Electricity (Phase 1 — of Geothermal Project)	2011

Source: Government of St. Lucia (2010), Government of Jamaica (2009), Government of St. Vincent and the Grenadines (2010), Klass (2010).

- Quota based measures, such as a renewable portfolio standard, where electric utilities are required to produce a specified percentage of their total power generation from renewable sources.
- Tariff based measures, such as a feed-in-tariff or net metering, where persons are remunerated per kwh of electricity they produce
- Fiscal or tax based measures, such as removed or reduced taxes on renewable energy technologies, and/or conversely, higher taxes on carbon-emitting or fossil fuel based technologies.

As of 2010, quota and tax based policy measures seemed to be most favoured in Caribbean and Pacific SIDS (see Table 2, Table 3 and Table 4). The majority of quota based measures was contained in national energy policies; in most cases, these measures are not legally binding and were not accompanied by punitive measures for power producers unable to meet their quotas. That said, the approach of St. Lucia is somewhat unique as this policy gives state authorities the right to allow independent power producers (IPPs) to make up the shortfall should utility companies fail to meet their quota of renewable electricity generation. It might also be interesting to note that quota based measures in SIDS are usually unaccompanied by tradable “green” certificates that could be used on the international carbon market, perhaps due to the relative smallness of these electricity markets. Tariff based systems have been utilised in a few SIDS, such as Barbados and Grenada,[4] however, these have been administered and implemented by electric utility companies in lieu of state authorities.

[4] As an example, the Grenada Solar Power Ltd. (GRENSOL) uses one to one net metering, where the amount paid for electricity is based upon the difference between the amount of electricity produced via a Solar Home System and the amount consumed by the end user.

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Table 3. Renewable energy quotas as indicated in Pacific island national energy policies (as of January 2010)

Country	Renewable energy target/quota	Sector / Subsector	Deadline
Fiji	90% of grid connected 55% of off-grid supply	Electricity	2011
Tonga (Energy Road Map)	50%	Electricity	2012
Marshall Islands	20%	Electricity	2020
Samoa	20%	Electricity	2030
Tuvalu	100%	Electricity	2020
Palau	20%	Electricity	2020
Federated States of Micronesia	30%	Overall energy sector	2020

Source: Government of Fiji (2006), Government of Samoa (2007), Government of Tuvalu (2009), Palau Energy Policy Development Working Group (2009), The Government of the Federated States of Micronesia (2010).

Table 4. Renewable energy fiscal policy measures as indicated in national energy policies (as of January 2010)

Country	Fiscal policy measure
St. Vincent & the Grenadines	Components for renewable energy systems exempted from customs duties on case by case basis Compact Fluorescent Lamps are fully exempt from excise tax and VAT
Jamaica (National Energy Policy)	Import Duty reduced from 30% to 5% on all renewable energy devices Zero rating for GCT purposed on renewable energy equipment
Trinidad & Tobago (National Budget: October 2010-September 2011)	Solar Water Heaters: • No VAT • Tax Credit: 25% value of equipment (for Residential Use) • 150% wear & tear allowance (acquired by Commercial enterprises) Wind Energy: • No VAT or import duty on turbines & supporting equipment • 150% wear & tear allowance (on turbines) Energy Efficiency: 150% tax allowance on cost of energy audit 75% accelerated depreciation on energy efficiency systems

Source: German Technical Cooperation (2007), Government of Jamaica (2009), Government of Trinidad & Tobago (2010).

4.2. Future reform measures in Caribbean and Pacific SIDS: Key considerations

To encourage the proliferation of renewable electricity installations in SIDS, future legal and fiscal reforms should require the internalisation of "external costs"[5] associated with electric power production, such as carbon emissions. Ideally, the policy regime for the electricity sector (inclusive of subsidies, taxes or environmental levies) could also account for the carbon dioxide emissions per kilowatt of electricity generated in order to incentivise carbon neutral generation (den Elzen *et al*., 2009). At present, the electricity markets in SIDS (and elsewhere) do not fully account for the external costs associated with the production or consumption of fossil fuels. The exclusion of such costs from the market means that the effects of these adverse implications of fossil-fueled electricity generation on the environment and society (and on future generations) are not reflected in the prices paid by end-users (Daly and Farley, 2004; Organization of American States, 2000). As a result, these far-reaching implications are usually ignored by power producers and consumers alike, as well as the energy pricing regimes (i.e., electricity tariffs) in SIDS. Future fiscal reforms should include reversing or modifying stipulations that give conventional energy technologies an unfair advantage over renewable alternatives. To this end, Weisser (2004b:111) noted that "direct and indirect subsidies still exist for conventional power generation technologies giving them a head start over renewable energy technologies."

To "level the playing field" and to support the use of renewable energy in the long-term, short-term tax incentives can help to encourage the deployment of alternative energy devices, as done in Trinidad & Tobago and Jamaica, for example (Table 4). In the medium to long-term, renewable energy deployment must be sustainable without special fiscal support or significantly inflating electricity tariffs. Avoiding adverse impacts upon end-user tariffs is particularly important since electricity rates for many SIDS (especially in the Caribbean) are among the highest in the world (Caribbean Community (CARICOM) Secretariat, 2013). Net-billing or feed-in tariffs can help to

[5] External costs, often referred to as market externalities, refer to "an unintended and uncompensated loss or gain in the welfare of one party resulting from an activity by another party" Daly and Farley (2004:433).

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reduce or stabilise the cost of renewable energy deployment to the end user and should therefore be considered. Simultaneous deployment of both conventional and renewable energy (through the use of hybrid systems) can also serve to make the process of transitioning to renewable energy more manageable for end users (in terms of avoiding large cost increases) and for the utility (in terms of learning to cope with supply-related issues).

Hybrid systems that make use of renewable and conventional energy (like hydro or wind and diesel or natural gas) have been shown to be not only feasible in remote or island environments (Flowers *et al.*, 2000; Xydis, 2013) but desirable, particularly when deploying intermittent technologies such as solar PV or wind, since diesel or hydro can be used for back-up generation or energy storage. Even though concerns related to the lack of technical capacity to operate and maintain energy technologies in island nations are significant and valid, it is possible to have a system that is run primarily using renewable energy that utilises fossil fueled power as a backup (Hydro Tasmania, 2011; Xydis, 2013). Such a configuration would allow for a reduction of fossil fuel consumption along with an increase and optimisation of renewable energy deployment.

Future reforms are also likely to feature plans to increase natural gas-fuelled electricity use, not only because of its lower price on the international market in recent times in comparison to oil but also because it emits less carbon dioxide into the atmosphere than oil (International Energy Agency, 2011). Plans are currently afoot to construct a pipeline (of approximately 300km) between Trinidad & Tobago[6] and Barbados, which will be used primarily for power generation (Niles, 2013). Wright (2010:49) refers to natural gas as “a transition fuel as we move away from oil towards a new energy agenda that will include renewables.” Other commentators point to the “supply-chain issues” with gas for island nations, as it is often harder to source than oil due to the small quantities used in the Caribbean and Pacific (Niles, 2013). More importantly, a transition to natural gas, even if for an intermediary period, has the potential to further exacerbate dependence on fossil fuels (Campbell, 2000; Hall *et al*., 2008; Hall and Klitgaard, 2011). Heinberg (2005:129) argues that increasing the uptake of natural gas may waste time and financial resources in “the enlargement of an infrastructure that will soon be obsolete anyway.” If state authorities in island nations do decide to enhance their use of natural gas, even as a transition fuel, it seems clear that this would need to be part of a wider programme of fuel and energy diversification that would include increasing the uptake of renewable energy (Tertzakian and Hollihan, 2009).

Future power reform may involve private sector participation in the generation of electricity in SIDS. Even if governments do not wish to privatise local electricity generation, few local utilities in SIDS, if any, are in possession of the financial resources necessary to transition to larger scale renewable electricity generation on their own (Whyte, 2001; Weisser, 2004b). As a result, contemporary reforms of the electricity sector in SIDS have at times served to facilitate the inclusion of firms and organisations wishing to supply electricity to the grid (primarily, but not limited to independent power producers (IPPs)).[7]

In such cases, the introduction, or restructuring of regulatory authorities that establish guidelines governing the generation of electricity by utility and non-utility power producers alike is critical (Niles, 2013). Moreover, the introduction of IPPs can be used as a vehicle to promote and bolster a transition to renewable electricity generation. As an example, in the case of the electricity sector in Fiji (which is currently undergoing reform), IPPs are only likely to be considered if generating from renewable energy sources (Niles, 2013).

Additionally, future power sector planning could increase the resilience of the power sector, not only by reducing dependence on imported fossil fuels but by taking active steps to reduce possible damage to infrastructure that could occur if extreme weather events become more frequent and intense. Such measures might include greater use of underground transmission lines and the installation of wind turbines that can be lowered in times of tumultuous weather. Diversifying electricity production away from conventional fuels can, by extension, reduce the short and long term vulnerability of the power sector to climate change and peak oil impacts.

4.3. Barriers to reform

Some alternative energy technologies have inherent barriers to their use. Though environmentally benign, some wind and solar energy devices require large parcels of land. They also deliver intermittent energy, meaning that additional funds are required for a backup supply (via diesel or hydro) or energy storage (usually in the form of batteries). Furthermore, a lack of local technical knowledge about the installation, upkeep and repair of renewable energy technologies, along with a dearth of spare parts, makes the proliferation of such devices in SIDS difficult. Fossil fueled devices usually do not require much land and have both low operating costs (due to widespread knowledge of the technology) and an abundance of spare parts.

Difficulties related to reform geared towards greater deployment of renewable energy (Weisser, 2004b; Painuly,

[6] At the end of 2010, Trinidad & Tobago was said to have 13.46 tcf of proven natural gas reserves. It should be noted however, that the country’s reserves stood at 14.42 tcf in 2009, and is as such, said to be in decline. For more see: Williams (2011).

[7] In the case of Fiji, power is supplied to FEA by Tropik Woods and at times by the Fiji Sugar Corporation. As these are both state-owned entities, they cannot be referred to as independent power producers.

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2001; Lloyd and Forest, 2010; Intergovernmental Panel on Climate Change, 2011) include:

1. Problems related to access to land
2. Low human resource capacity
3. Lack of financial and technical resources
4. Problems related to technology deployment

In a number of island economies, the process through which land is accessed or acquired in order to conduct resource and feasibility assessments and install renewable energy technologies can be a complex challenging process (Niles, 2013) particularly in SIDS where land is scarce or traditionally owned (Kopi, 2004).

Low human resource capacity in many SIDS hinders the technical ability to utilise and manage renewable energy technologies and can result in ill-informed decision-making as well as poor policy design and implementation. Weisser (2004a:137) goes further, and adds that "a lack of qualified personnel trained as energy policymakers, energy planners, project organisers, energy economists, energy managers, engineers and technicians, remains a constant obstacle to providing a balanced assessment of planning choices." Additionally, loss of local technical expertise and specialist knowledge via emigration is a major concern in SIDS and is often a prime operational consideration when attempting to undertaking feasibility studies and then implementing major power projects (Niles, 2013).

The narrow resource base available to SIDS has far reaching implications regarding the avenues for development within SIDS. In terms of the technical resource constraints faced by such countries, a principle reason responsible for the lack of growth in terms of the application and use of renewable energy technologies in SIDS has been the paucity of technical and policy knowledge related to such devices in island economies (The University of the West Indies Centre for Environment and Development, 2003). As a result, the acquisition and utilisation of renewable energy technologies for power projects in SIDS has been primarily driven by donor funds and activities (The University of the West Indies Centre for Environment and Development, 2003). In such cases the technological applications put forward by donor countries have often had a strong "technology push" rather than a "recipient pull" (Martinot, 2001).

In the past, the thrust or promotion of purportedly green technologies by donors has often meant the insertion of "unproven" technologies, such as tidal energy production, biomass gasification and even Ocean Thermal Energy Conversion (OTEC) on small island nations. The failure of such technologies (especially in terms of the technical knowledge required for their operation and maintenance) (Niles, 2013), among other things, has had a detrimental effect on the push for renewable sources of energy and helped to reinforce the view that fossil fuels were the only viable option. Commenting on the acquisition and installation of renewable energy technologies in Pacific island countries (particularly by donor organisations), Lloyd (1994:21) suggests that perhaps "the most important lesson is not to place untested options in remote areas. Renewable energy technology should be fully operational on a commercial basis in developed countries before deployment to remote rural environments in developing countries." Thus, while SIDS can and perhaps should encourage the testing and scientific studies of "young" or prototype technologies within their shores, such devices should not be deployed based on the interests of or pressure from donors or the private sector. Rather, future reform measures should include policy stipulations pertaining to the standards, maintenance, operation and appropriateness of technologies being deployed.

5. Conclusions

SIDS are especially vulnerable to both climate change and peak oil and the associated impacts. In order to reduce the vulnerability of SIDS to peak oil, an urgent transition to renewable sources of energy is necessary. We assert that measures that internalise the external costs of petroleum usage along with incentives to exploit renewable resources will be required to make alternative technology use economically viable.

Power sector reform is an opportunity, in and of itself, to re-orient power producers away from conventional fuels. Transforming the legislative and policy parameters governing the electricity sector could promote investments in renewable energy technologies by utility and non-utility generators. A reconfiguration of the power sector could be a way to diversify power production, in order to reduce the vulnerability of the entire sector to volatile fuel prices and supply shortages. In an era of more expensive oil, future reform measures should focus on reducing the reliance of the power sector on fossil fuels and increasing supply resilience, and not simply at reducing costs and increasing economic efficiency in order to qualify for loans from international financial institutions. The difficult task of creating avenues for sustainable and independent (non-donor biased) supplies of renewable energy equipment and infrastructure to developing countries, particularly for small scale application, can perhaps be investigated as the subject of future research (Bruce, 2007).

Quota-based policy mechanisms geared towards increasing the uptake of renewable energy have already been deployed in a number of Caribbean and Pacific SIDS, but they are usually not legally binding nor accompanied by punitive measures related to shortfalls in renewable electricity generation. Enhancing the enforceability of existing quotas could help to hasten the pace of a transition to sustainable energy. Increased use of fiscal and tariff-based policy mechanisms (geared at least towards "leveling

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the playing field" between conventional and alternative energy technologies) may also be helpful.

Although renewable energy has problems of its own (such as its land intensiveness and intermittency of supply), a transition to greater use of renewable energy can help to mitigate the effects of peak oil on the power sector in SIDS amid rising demands for energy in such nations. Acquisition of renewable energy technologies would not only help to reduce the vulnerability of the electricity sector to rising oil prices but would also represent sectoral reform to enhance the supply of electricity to SIDS in times of fuel shortages and natural disasters. This may indeed prove to be invaluable if, as expected, climate change impacts do become more frequent and intense.

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Appendix: Electricity utilities in Caribbean and Pacific SIDS: Ownership and reform, 2010

Country	Name of utility	Ownership		Notes on reform measure	Other relevant information
		State (%)	Private (%)		
Pacific power utilities					
Niue	Niue Power Corporation (NPC)	100	0		Responsible for generation, distribution and retail of electricity in Niue
Cook Islands	Te Aponga Uira	100		Privatisation attempted in 1990s but unsuccessful.	13 Outer Islands Run by island councils
Nauru	Nauru Phosphate Corporation (NPC)	100			Responsible for generation, distribution and retail of electricity
Kiribati	The Public Utilities Board (PUB)	100			Supplies electricity and water and manages sewerage: only to South Tarawa
	Kiribati Solar Energy Company (KSEC)	100			Involved in Rural Electrification using renewable energy, particularly via sale or lease of solar PV systems and relevant components
Fiji	Fiji Electricity Authority	100		World Bank funded reform study on-going	Supplies Viti Levu, Vanua Levu and Ovalau. (Public Works Department responsible for rural electrification)
Federated States of Micronesia	4 utility companies: i. Chuuk Public Utilities Corporation (CPUC), ii. Kosrae Utilities Authority (KUA) iii. Pohnpei Utilities Corporation (PUC) iv. Yap State Public Service Corporation (YSPSC)	100			Each Utility supplies its own district — different tariffs apply for each.
Marshall Islands	2 Utility Companies: i. Marshalls Energy Company (MEC) ii. Kwajalein Atoll Joint Utilities Resources Inc (KAJUR)	100			MEC — Responsible for generation, distribution and retail of electricity on Majuro, Jaluit & Wotje. KAJUR — the utility company providing Power, Water & Sewerage services to the island community of Ebeye, the Marshall Islands 2nd largest urban center located in Kwajalein Atoll.
Palau	Palau Public Utilities Corporation (PPUC)	100			PPUC supplies Koror, Babeldaob, Kayangel, Peleliu & Angaur
Papua New Guinea	PNG Power Ltd (PPL)	100		Formerly the Papua New Guinea Electricity Commission (ELCOM) Elcom, until 2002.	Responsible for the generation, transmission, distribution and retailing of electricity throughout PNG
Samoa	Electric Power Corporation	100		Formerly Public Works Department (known as the Electric Power Scheme) until 1972.	Responsible for the generation, transmission, distribution and selling of electricity in Samoa.
Solomon Islands	Solomon Islands Electricity Authority	100			Responsible for the generation, transmission, distribution and sale of electrical energy in the Solomon Islands.
Tonga	Tonga Power Limited (TPL)	0	100	Awarded Concession Contract in 2008 by the Electricity Commission of Tonga.	Is a regulated state owned enterprise and serves Tongapatu and main islands of Ha'apai, Vava'u and Eua[v].
Tuvalu	Tuvalu Electricity Corporation	100	0		Responsible for the generation, transmission, distribution and sale of electricity. "Serves nearly all islands in Tuvalu" (Wade *et al*., 2005)
Vanuatu	Union Electrique de Vanuatu (UNELCO)	0	100		UNELCO awarded concessions to operate and serve Efate, Santo Tanna and Malekula islands

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Appendix *Continued*

Caribbean power utilities				
Antigua & Barbuda	Antigua Public Utilities Authority (APUA)	100	0	Responsible for the generation, transmission, distribution and sale of electricity. Also responsible for water and telecommunications services.
The Bahamas	The Bahamas Electricity Corporation (BEC)	100	0	BEL is the primary distributor of electricity in Belize.
	Grand Bahama Power Company (GBPC)	0	100	Supplies electrical power to the island of Grand Bahama
Belize	Belize Electricity Limited	27	73	Responsible for generating electricity and the primary distributor of electricity in Belize (inclusive of power purchased from various generators)
Barbados	The Barbados Light & Power Company Ltd (BLPC)		100	Responsible for the generation, transmission, distribution and sale of electricity in Barbados.
Dominica	Dominica Electricity Services Ltd (DOMLEC)	20	80	Responsible for the generation, transmission, distribution and sale of electricity in the Commonwealth of Dominica
Grenada	Grenada Electricity Services Ltd (GRENLEC)	10	90	The sole provider of electricity in Grenada, comprised of the islands of Grenada, Carriacou and Petite Martinique
Jamaica	Jamaica Public Service Company Ltd (JPSC)	19	81	The sole distributor of electricity in Jamaica
St. Lucia	St. Lucia Electricity Services Ltd (LUCELEC)	48	52	The sole distributor of electricity services in St. Lucia
St. Kitts & Nevis	St. Kitts Electricity Department	100	0	A Government department operating under the direction, control and budget allocation of the Ministry of Public Works, Utilities, Transport and Posts. Responsible for the generation, transmission, distribution and sale of electricity
	Nevis Electricity Company Ltd (NEVLEC).	100	0	The sole commercial generator, transmitter, distributor and seller of electrical energy in Nevis
Trinidad and Tobago	Trinidad and Tobago Electricity Commission	100	0	Responsible for the design, construction, operation and maintenance of the country's electrical transmission and distribution network. T&TEC purchases the bulk electric power from independent generation companies for resale, and is also responsible for securing fuel supplies for the generation companies.
	POWERGEN	51	49	Responsible for the generation of electrical power to the national electrical grid of Trinidad and Tobago
	Trinity Power	0	100	An Independent Power Producer that Generates approximately 225MW[vi]
St. Vincent Electricity Services Ltd.	VINLEC	100	0	The sole provider of electricity in St. Vincent and the Grenadines.

Notes: i. Wade *et al*. (2005). ii. http://www.rep5.eu/. Accessed on December 8, 2010. iii. KEMA (2010). iv. http://www.mecrmi.net/KAJUR.htm v. http://www.tongapower.to/. vi. http://www.energy.gov.tt/resources.php?mid=9.

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