Policy Development for Innovative Renewable Energy Implementation in Island Regions

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Abstract

Island regions and isolated communities represent an understudied area of not only clean energy development but also of innovation. Caribbean states have for some time shown interest in developing a regional sustainable energy policy and in implementing measures which could help to protect its member states from volatile oil markets while promoting reliance on local resources. Here we examine four prominent advancements being made by both public utility companies and independent energy companies in both utility scale and distributed generation technology within the Caribbean coming upon a number of considerations that should be entertained during the development of supportive and enabling policy. We find that different degrees of regulatory and legislative sophistication have evolved in the energy sectors of different islands. In order to advance alternative energy technologies different islands thus have very different policy focuses moving forward over the short term. We also conduct a cost benefit analysis of these projects which shows that these early, innovative alternative energy projects show themselves to be profitable and to be significant sources of emissions reduction and job creation. This lends support to the potential benefits of regional energy policy.

Keywords: Renewable Energy Technology, Enabling Policy, SIDS, AOSIS

1. INTRODUCTION

Island regions represent an understudied area of potential energy development. Due to the absence of local fossil fuel resources, the lack of economies of scale and transportation issues, these regions generally rely on imported petroleum for electricity generation. The longevity of such energy policy is being brought into question by many island states given the geopolitically unstable nature of fuel resources, the importance of maintaining competitiveness in manufacturing and the susceptibility of islands to climate change impacts. Petroleum products are the islands' main source of energy with 90% of commercial energy supplies being imported into the region (Loy, 2007). Energy expenditure is such a large part of national budgets that though having a total electricity capacity of less than 6 GW, the region spends over $4B USD a year on oil imports (OLADE, 2009). Estimated to be growing at 3.7% per year, regional demand for energy would have doubled by 2028 (Nextant , 2010). As a consequence some islands spend as much as half of their export revenues on imported fossil fuels. Many Caribbean island residential electricity tariff rates are above 0.35 US$/kWh (CARILEC, 2010), finding themselves amongst the highest rates in the world. This economic situation stifles the region's manufacturing sector and is compounded by the geographic parameters of smallness and

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remoteness which often characterize Small Island Developing States (SIDS), inherently restricting the ability to pursue economic development without substantial external support by limiting domestic resource pools, local absolute demand and market sizes (Weisser, 2004) (Weisser, 2004b).

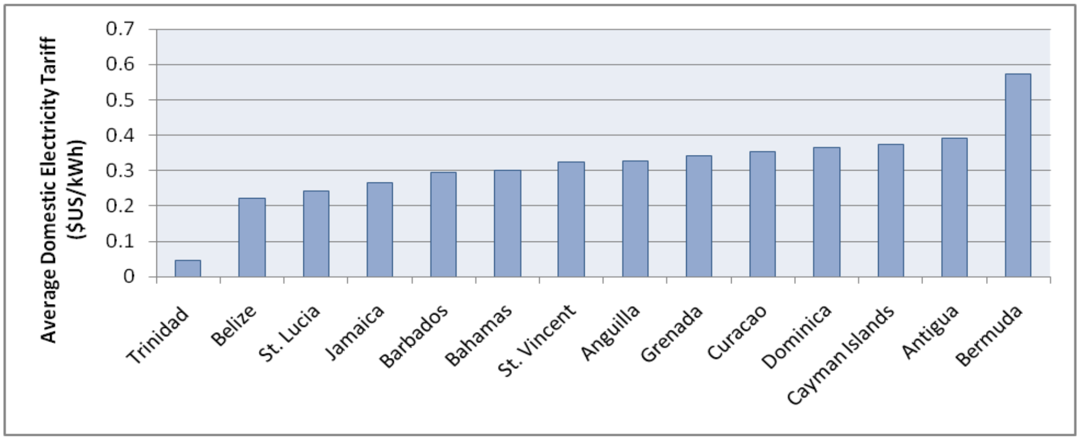

Figure 1 Domestic Retail Electricity Rates in Caribbean Islands (CARILEC, 2010)

In response, the Caribbean's power supply sector is currently witnessing important changes in its energy regulatory framework, as evidenced by recent developments in government policy. There has indeed been a major effort by governments to enhance the relationships with regional oil and natural gas producers including Trinidad and Tobago, Venezuela and Puerto Rico through agreements such as the recent PetroCaribe Oil Alliance. More pertinently, governments and utility companies are also making firm strides towards renewable energy technology (RET) deployment – another approach to addressing independence and security. There are a number of energy policy reports such as the CREDP Caribbean Energy Policy 2007 (Loy, 2007) and the Organization of American States' (OAS) Sustainable Energy Policy Initiative Report for Latin America and the Caribbean 2007 (CARICOM, 2007) that regional development agencies have developed to support this end. Nevertheless there remains outstanding a number of barriers that hinder the advancement of renewables in the region.

In this study we outline four prominent advancements being made by both public utility companies and independent energy companies in both utility and distribution scale technology within the Caribbean. We explore the history of utility ownership and current operations as well as the history of regulatory bodies and their interactions with utilities to create a picture of trends in the energy landscape. Through this comparative case study analysis we come upon a number of considerations that should be entertained during the development of policy that can address barriers to RETs and thereby create an enabling environment for their integration (Mitchell, et al., 2011). We learn also that there are in fact a number of differences between the structures and operations of various national power sectors in the region with regard to privatization, regulatory oversight and government involvement. Sensitivity to these nuances is important and may be an important part of regional policy framework creation.

2. CASE STUDIES

Grenada, Barbados, Jamaica and the Netherland Antilles are the Caribbean islands that have been selected for study based on the fact that represent progressive islands in the region with regard to renewable energy developments, having at the very least shown signs of Government intent to pursue renewable energy and simple signs of utility willingness to cooperate through their implementation of grid interconnection policies. These islands define a spectrum of population size, industrialization, economic complexity, energy demand. From studying the development of renewables on these islands a telling picture for the region evolves.

	GRENADA	BARBADOS	JAMAICA	ARUBA	CURACAO
Area (km^2)	344	430	11,000	180	444
Population	110,000	285, 000	2,800,000	103,065	142,180
GDP per capita	$5,969	$14,307	$4,390	$23,831	$20,567
Regulatory Agency	None	Fair Trading Commission	Office of Utility Regulation	None	None
Utility	Grenada Electric Services Ltd (GRENLEC)	Barbados Light and Power Company (BL&P)	Jamaica Public Services Company (JPS Co)	W.E.B. Aruba N.V.	Aqualectra
Installed Capacity (MW)	49	239	820	149	226
Peak Demand (MW)	30	165	600	77	130
Annual Electricity Sold (GWh)	195	1,068	6,000	782	530
Average Rate (US$/kWh)	0.34	0.29	0.26	0.26	0.35
Official Renewable Energy Share	Less than 1%	Less than 1% (15% with Solar Water Heating)	5% (Hydro 4%, Wind 1%)	13% (wind)	5% (wind)
RPS Goal	None	20% by 2020	20% by 2030	None	None

Figure 2 Summary Characteristics of the Case Study Islands

2.1. Photovoltaics in Grenada

Since its establishment in 1960, Grenada Electricity Services Ltd (GRENLEC) has been the sole provider of electricity to the isle of Grenada and its smaller sister islands Carriacou and Petite Martinique. Originally incorporated as a private liability company subsidiary to the UK's Commonwealth Development Corporation (CDC), its shares were purchased by the local government in the 1980s. In another major ownership shift, the company was divested in the mid 1990s, and is currently half owned by WRB Enterprises, a US based utility company, and half by the government, insurance board, employees, local and regional investors (GRENLEC, 2011). Today GRENLEC owns and operates one main 39MW diesel engine generating station in Grenada with two smaller stations in the sister islands meeting the peak daily load of 30MW and producing 195 GWh/yr (GRENLEC, 2009).

GRENLEC currently enjoys a monopoly within the Grenadian energy supply sector as the N. 25 1960 Electricity Supply Ordinance gave it the sole and exclusive license to generate, transmit, distribute and sell electricity in Grenada for a period of 80 years with effect from incorporation (REEP, 2009). Electricity rates in Grenada are comprised of a fixed non-fuel charge and a variable fuel surcharge. The Electricity Supply Act of 1994 makes provision for an adjustment of the non-fuel charge only when the rate of inflation is over 2% and mandates that GRENLEC use a three month average for computing the fuel charge. Aside from these simple rate change mechanisms, the other legal basis for GRENLEC adjusting electricity price is through an RPI-2 formula and to aid recovery after a natural disaster. While these laws benefit the customer by guarding against sharp increases in the cost of fuel paid in any given period they also encourage GRENLEC to be concerned about efficiency (GRENLEC, 2008). The limited regulation also encourages a risk aversion to new investments that could affect overhead and the monopoly status does nothing further to support exploration of new resources. The average domestic electricity rate of $0.34 USD/kWh is one of the highest in the Caribbean region (CARILEC, 2010) and is based on an effectively 100% diesel fuel mix.

In 2005, shortly after the devastation of Hurricane Ivan, as the cost of electricity soared to an all time high, a local Grenadian family founded Grenada Solar Power Ltd (GRENSOL) through private financing in order to promote the use of solar energy on the islands. After the early success of three pilot projects, the company succeeded in encouraging GRENLEC to expand its interconnection policy so that since 2007 there has been a 1:1 net metering at retail rates for systems less than 10 kW (Hosten, 2009). GRENSOL was also successful in securing a 5% duty and 5% handling waivers after negations with the government to reduce the cost of importing materials (Burkhardt, 2008). We discuss the cost effective nature of GRENSOL systems given these allowances in the subsequent section.

GRENSOL systems in fact tend to perform very well given the solar regime in the Eastern Caribbean and the total 25 grid tied systems now installed across the island equate over 120 KW (GRENLEC, 2009). This modest market penetration has come despite the struggle for support that GRENSOL has faced since the beginning of its operation in Grenada. Not only has there been a lack of financial support from the government in the promotion of resource diversity, but the net metering policy that has been developed by the utility company GRENLEC is limited, capping potential access to larger customers on island. It appears that these concerns both stem from a lack of relevant policy which itself is a symptom of two key weaknesses in the local power sector's structure, namely the nature of GRENLEC ownership and the lack of utility regulation.

Firstly, GRENLEC is a predominantly foreign owned and privatized company. WRB Enterprises also owns majority shares in other US and Caribbean telecommunication and desalination utility companies (bNET, 2004). Given this vested interest in utility provision, WRB may be reluctant to endorse the use of RETs, thereby risking the strength of its hold on its own sales market, until it feels adequately equipped to provide this type of generation in a profitable way. As can be seen from the cost analysis performed below, technologies such as photovoltaics are not yet cost competitive when compared to the avoided cost of current electricity production in Grenada. Furthermore the renewed Electricity Supply Act of 1994 extended GRENLEC's exclusive rights to generate, transmit, distribute and sell electricity the years 2073. There is thus little impetus for GRENLEC to divest sales by introducing third party generators (GRENLEC, 2007).

There is thus a clear concern about the way that the Electricity Supply legislation has been structured since it has enabled a monopolistic fossil fuel biased power sector in which the introduction of renewable technologies is unlikely to be part of the utility's capacity expansion strategy without external forcing. In addition to these weaknesses, there is not an overarching body that governs the business of GRENLEC to prod investment and operations in directions for public benefit (Weisser, 2004(b)). In recent times the Grenadian Government has taken modest steps towards involving itself in the control of the island's electricity utility. Since late 2003, the Ministry of Agriculture, Land, Forestry, Fisheries, Public Utilities and Energy as well as the Marketing and National Importing Board have taken official responsibility for the energy sector and the formulation of policy. This makes Grenada one of the few countries in the Eastern Caribbean with a specialized energy desk within the government (Loy & Farrell, 2005). While a policy is yet to be realized through these divisions, the Ministry of Finance and Planning has begun the process of developing a National Energy Policy.

In addition to its own attempts at asserting itself in the business of its country's power sector, the Grenadian government has since 2009 been in talks with the other Eastern Caribbean States (Dominica, St. Lucia and St. Vincent and the Grenadines) to develop a regional regulatory authority to oversee the services of energy providers within the sub region. These states, together known as the OECS, are moving closer to the formulation of a regulatory authority, known as the Eastern Caribbean Energy Regulatory Authority, to oversee the services of energy providers within the sub-region.

2.2. Solar Water Heating in Barbados

The Barbados Light & Power Company Limited (BL&P Co.) is currently the sole electricity utility provider in Barbados, having started operations in the early twentieth century under complete ownership of a London based holding company. In the 1950s the company was divested and its shares are now owned primarily by Barbadian investors, of which the National Insurance Board is the largest. The minority shares are owned by Canadian International Power Co. Ltd. The company is a monopoly given that the current valid legislation does not make provision for power generation by IPPs, prohibiting sale or injection into the grid any such electricity. BL&P Co. was regulated by the Barbados Public Utilities Board, established through the Public Utilities Act of 1951 which presided over its periodic rate cases from 1955 to 2001 (Leacock, 1976) but the need soon arose for a new body with a broader mandate to deal with other public utility issues such as consumer rights and competition. The Fair Trading Commission was established in 2001 through the Fair Trading Commission Act.

Currently the $0.29 USD/kWh domestic electricity rate is one of the lowest in the Caribbean region (CARILEC, 2010). However given its reliance on imported oil for electricity production, the Government of Barbados has long been an advocate of developing renewable sources of energy. In fact, during the 1980's and early 1990's, BL&P even purchased electricity produced from bagasse during the sugar crop season by a number of local factories (BL&P Co., 2011). Since then the government has also experimented with wind turbines and photovoltaic installations and discussions are currently being held with regard to a potential 10MW landfill gas generation plant at Mangrove Pond Landfill and a 10MW wind farm. This historical government interest in renewables has yielded only 40kW of PV deployment (BL&P Co., 2011). Far more successful has been the commercial development of the solar water heating industry.

Commercial Solar Water Heating finds its origins in the 1970s as a simple local church initiative to provide vocational training for young men. A demonstration at the official residence of the then Prime Minister led to his government's support of initial fiscal incentives to promote the use of solar water heating technology (Solar Dynamics, 2010). Firstly, under the Fiscal Incentives Act of 1974, government exempted the raw materials needed for SWHs from import tariffs and placed a 30% consumption tax on electric water heaters (BIDC, 2010). Further, under a 1980 Income Tax Amendment, the full cost of SWH purchase and installation up to $BD 3500 was allowed as a home-owner tax deduction. This tax deduction was reinstated in 1996 following its suspension during a period of economic recession that extended from the 1980s. In addition to these financial incentives, the government also actively engaged in purchasing large numbers of SWHs for housing development projects, further stimulating the industry. In fact, the government has purchased over 1200 units for five different housing development projects from the mid 1970's to date (Perlack, 2003).

As interest in the new technology grew, other competitors quickly joined the market and by the beginning of the 1980's two other developers, SunPower Corporation and AquaSol Components Limited, had established themselves as industry players. By 2003 there were over 35,000 solar water heaters installed in Barbados, representing a 30% penetration. Of this consumer base, 70% of the systems are in residential homes and 30% in commercial properties, predominantly hotels.

Solar Dynamics secures about 60% of this market (Perlack, 2003). More recent quotes put the total at 45,000 installations island-wide (Epp, 2009). Since late 1990s production expansion Solar Dynamics has progressed from a Barbados based company to one with manufacturing operations in Barbados and Saint Lucia, a distribution center in Jamaica and agents in the Bahamas, Belize, Dominica, Grenada, Guyana, St. Maarteen, St. Vincent & the Grenadines, St. Kitts & Nevis and the British Virgin Islands (CARICOM Energy Programme, 2010).

The willingness of the government to support the solar water heating industry is one of many signs of its interest in being involved in the business of energy. Furthermore, unlike the case of most Eastern Caribbean States, the government has a majority stake in the local utility, BL&P Co. with the National Insurance Board being the largest shareholder. It is interesting to note that the utility started out under the ownership of a London based holding company and the government along with other local investors chose to buy shares in the company in the 1950s. Since the 1980s the company has experimented with harnessing various forms of indigenous energy sources, such as bagasse, wind and solar. While few of these projects have come to fruition in a major way, this tendency highlights utility, and by extension, government interest in energy security and power sector functionality. However the intentions of the government do not seem to be supported by significant legislative and comprehensive policy backing and this may be part of the reason why aside from Solar Water Heating technology it has been difficult to integrate other technologies into market.

The Electricity Supply Act enacted in 1907 under which BL&P Co. was formed and which gives it rights to generate and transmit electricity and the Public Utilities Act of 1951 which established the Public Utilities Board and then the Fair Trading Commission, are still to date the only pieces of legislation that govern the power sector, thus making it impossible for IPPs to potentially market themselves to the utility company. In 2010 the Fair Trading Commission approved a Renewable Energy Rider pilot project, which is similar to a net metering project. The program limits sizes to 5kW for domestic and 50kW for other tariff brackets. All kWh supplied to the grid are credited for 1.8 times the Fuel Clause Adjustment or 31.5 cents/kWh, whichever is greater (BL&P Co., 2011). While it is difficult to judge the program's success after only a few months, it seems that the capital costs of PV systems and the lack of financing options is a major barrier. Oil price increases may make the program more attractive in the near future but to date there has been less interest shown than expected.

Despite this effort to support and encourage distributed generation, there has been little action derived from the 2007 National Energy Policy and while acknowledging the recent launch of the Renewable Energy Rider pilot project, the Commission has done little thus far to prod the utility into new generation capacity considerations or into exploring a generation marketplace. It would seem that while the necessary components are present, there needs to be a more structured build path for Barbados in the near and long term future. Strides are indeed being made, but a more concrete structure and outlined plan of action would help to ensure that energy is channelled into the most useful avenues of development.

2.3. Wind Development in Jamaica

The Jamaica Public Service Company Limited (JPS) is the sole distributor of electricity in Jamaica, inheriting an electricity sector that dates back to 1892, when electricity first began to be generated on the island. Jamaica was one of the first countries in the world to develop electricity infrastructure, and initially the service was provided through the Jamaica Electric Light Company. Within the coming decades several towns had their own private electric companies but through a process of consolidation during the early twentieth century, Jamaica Public Service Company Limited (JPS) emerged as the parent company in 1923 and was granted an all-island franchise in 1966, making it the sole public supplier of electricity on the island (JPS, 2010).

JPS has changed ownership a number of times during its history. Starting as a private company owned by foreign shareholders, it was acquired by the Government in 1970 but in 2001 majority shareholder ownership was sold to US based energy service provider Mirant Corporation who still owns these shares after their changing hands over the years. The privatized JPS operates under the All Island Electricity License 2001, which expires in 2021 (Ministry of Energy and Mining, 2006) and a regulated utility with rates subject to the Office of Utility Regulation (JPS, 2010). In keeping with the provisions of the license, power generation was liberalized in 2004 and several independent power producers now supply electricity to the national grid.

To meet peak daily demand of 600 MW JPS has a total installed generating capacity of approximately 820MW provided through a number of steam and combustion gas turbines plants as well as eight hydro plants spread across the island's major rivers. This generating capacity also includes roughly 197 MW from Independent Power Producers (IPPs) (Ministry of Energy and Mining, 2009) including Jamaica Energy Partners (JEP), Jamaica Private Power Company (JPPC), Jamalco and Wigton Wind Farm so that IPPs currently produce about 25% of the bulk power (JPS, 2010) and JPS no longer has monopoly on bulk electricity generation. Its exclusive franchise is limited to transmission, distribution and retail supply. Jamaica finds itself having a lower price of electricity compared to other regional economies with $0.26USD/kWh in part due to this diversification. With almost half the generation capacity over 30 years old and transmission losses being estimated at 23%, the cost is nevertheless concerning and places a significant pressure on the countries manufacturing industry.

The constant need for increased generation capacity and reduced cost has recently prompted the Petroleum Corporation of Jamaica (PCJ) to explore alternative energy solutions for the island. The PCJ was established in 1979 as a statutory corporation in response to the 1973 oil crisis, tasked with negotiating contracts with international oil suppliers, exploring the potential for oil development on island and operating the oil refinery and retailing company. In 1995 the PCJ was mandated to develop indigenous renewable energy resources in accordance with the Jamaican Energy Sector Policy drafted that year. In keeping with this mandate and following rigorous feasibility study across the island, the PCJ established a wholly owned subsidiary, Wigton Wind farm Limited (Wigton) incorporated in 2000 (Fisher, 2004).

The Dutch Development and Environment Related Export Transactions Program (ORET/MILIEV) awarded a subsidy to the Wigton Wind Farm project at a rate of 35% of the value of the supply of wind turbines and ancillaries from Holland (Fisher, 2004). The currently approved structure for electricity purchase agreements allows Wigton to sell electricity to JPS at the avoided cost of fuel, as determined by the Office of Utilities Regulation, in addition to a 15% premium. The cost effective nature of this technology will be discussed in the subsequent section. In order to secure funding for the wind farm despite a lack of international investor interest, an application to Clean Development Mechanism (CDM) was made in 2006 (CDM, 2006). Wigton is the first commercial wind farm, and the second project of any sort in the Caribbean, to qualify for carbon credits under the CDM of the Kyoto Protocol.

Jamaica has thus in a short space of time become one of the fastest growing renewable energy hubs in the region due in large part to the historical structure of the Jamaican Energy Sector where IPPs are able to both generate and sell electricity on the national grid system. The heavily industrialized Jamaican economy may have played a role in this development as many industrial plants are able to cost effectively produce their own power under this regime and while JPS Co has a monopoly on transmission and distribution, it does not actually represent a monopoly in generation, acting rather as a single buyer. Given this structure, it was the Petroleum Company of Jamaica, ironically, and not JPS Co that in 1995 began wind resource assessments which led to the development of the successful and continually expanding Wigton Wind Farm.

The government also recently finalized both a National Energy Policy and a National Renewable Energy Policy, demonstrating intent, and it should even be noted that a previous period of Energy Policy planning took place in 1995. Furthermore, over the past decades a number of wind resource assessments have been done across the island and sites in addition to Wigton have been identified as having a good resource for power production. While the government's observable interest in indigenous resources is expanding, it is important for the government to continue to seek expressions of interest from local and foreign investors (Loy & Manilo, Renewable Energy Potential in Jamaica, 2005).

To lower the threshold for investment it would seem that financial incentive or security must be availed. This can be achieved through a number of avenues such as developing standardized protocol for contractual arrangements, timelines and rates with JPSCo, working with financial institutions. Furthermore, in order to create an enabling environment for investment in utility scale to commercial and residential projects, there should be greater access to transmission and distribution grid through interconnection standards. This effort has already begun through the pilot Net Billing program initiated this year and more efforts such as this need to be developed in order to provide sufficient support for the industry. In order to take advantage of the power sector structure and to attend to the ambitions of the National Energy Policy, there needs to be initiatives to attract interest and to market the Jamaican energy space as an attractive investment landscape whether for local or foreign investors.

2.4. Wind Development in the Netherland Antilles

Despite being sister islands of the Netherland Antilles, Aruba and Curacao have separate governments and utility companies. Electricity production and desalination on the island of Curacao began in the early twentieth century through a single private company. Over subsequent decades similar companies emerged and eventually all water production, electricity generation, transmission and distribution companies were integrated into a single company now known as Aqualectra. Eventually, its shares were divested, being bought in part by the state, so that Aqualectra is jointly owned by the government and the international Marubeni Corporation though since its initial establishment Aqualectra has not been regulated by the government. Electricity production in Aruba began in the 1920s with a small company whose generating capacity was expropriated by the government to be handed over to the Dutch owned corporation OGEM. Later known as N.V. Elmar, this corporation had sole control over the generation and distribution of electricity on island. Years later the government made a major generation infrastructure investment, buying a diesel power station with three times N.V. Elmar's operating capacity, and based on this development, the government established a state owned Water and Power Company, known as WEB N.V.

Within a few years, the government established a new agreement with N.V. Elmar, unbundling electricity operations such that N.V. Elmar would be responsible for distribution, transmission and maintenance while WEB N.V. would be the sole generator. The OGEM consortium eventually dissolved due to financial difficulty and since the 1990s N.V. Elmar has been a stable company whose shares are owned by Utilities Aruba N.V., a government owned holding company, so that both generation and transmission capacities are now under state ownership.

Thus Curacao has had a utilities history with relatively little government involvement, outside of the purchasing of shares in an established company, while in Aruba the government has been more forceful in designating authority over assets and functions. Interestingly however, neither of these local governments has taken to regulation and today there is no legislation overseeing the operation of these utility companies. Rather, rate setting formulas from the 1980s are used to ensure the economic protection of the customer base. Both islands meet their demand through diesel generation but a significant portion of demand is also now met through wind energy (N.V. Elmar, 2004).

Despite a privatized and largely unregulated monopoly within its electricity sector, Curacao was in fact one of the first islands of the Caribbean region to experiment with the integration of renewable energy. During the 1980s Aqualectra conducted wind resource assessments and established a 3 MW wind farm in Tera Cora. Based on the wind farm's initial production success by 2000 another 9 MW wind farm was commissioned by the utility in Playa Kanoa. This wind farm was initially developed by a Dutch Company but rights to its ownership have recently been bought by new comer renewable energy development company NuCapital. Though founded in 2007, NuCapital has been part of subsidiary operations for over a decade, focusing on wind development in the Caribbean and Latin America, also owning and operating wind farms in Aruba, Brazil and Chile. Government support for the Aqualectra and now NuCapital projects has come in the form of rights to land for development and waivers on import taxes for all materials imported from Europe for the construction of these wind farms. There is no official energy policy in Curacao but a policy is currently being developed through the Ministry of Economics and the Environment.

Wind energy took longer to develop in Aruba, with the first wind farm beginning production in Vader Piet in late 2010. The push for this project came not from the utility but from independent project developers. Overtime the utility was persuaded to enter into a PPA agreement and provide grid access to the project with NuCapital again being the project developer. Given that the constant trade winds received by this part of the island are consistent, highly regular and almost always in the same direction, the wind farm has one of the highest capacity factors in the world. Now a 30 MW wind farm with outstanding success, NuCapital intends to expand the project through installing another 30MW in the near future. Neither the local government of Curacao nor Aruba has an Energy Portfolio or has begun drafting an Energy Policy. Rather the impetus behind these wind farm projects thus far has been private project developers. The utility companies are not subject to any regulatory body and thus there is no incentive to standardize the bidding and PPA process. Neither is there an incentive to standardize grid access and integration procedures. Furthermore the experience has shown that intra-political personalities have been a factor in holding projects back in the past. An impartial policy or regulatory body would allow for these considerations to carry less weight.

Thus wind energy has developed in an organic way in the Netherland Antilles and successfully according to the production levels reported by project owners. Clearly in this case because of the power of the wind regime in these islands there is a significant amount of investor interest. This has meant that the utility company itself has been able to benefit but energy policy or a framework would be helpful to harness, direct and stream line the interactions between state, utility and project developers, conserving on time and energy.

3. COST BENEFIT ANALYSIS

From the above case studies we are able to understand the landscape of energy production within the region. In Grenada less than 1% of generation capacity comes from photovoltaics. Diesel generation is the only other type of electricity production. In Barbados all generation is based on fuel oils as well but there is a mix of steam, gas and diesel turbines and it is estimated that SWH contributes to at least 18 MW of avoided diesel generation. Jamaica clearly has the greatest diversity of generation with wind providing 4% of the total installed capacity amongst hydroelectricity and various diesel fired engine types.

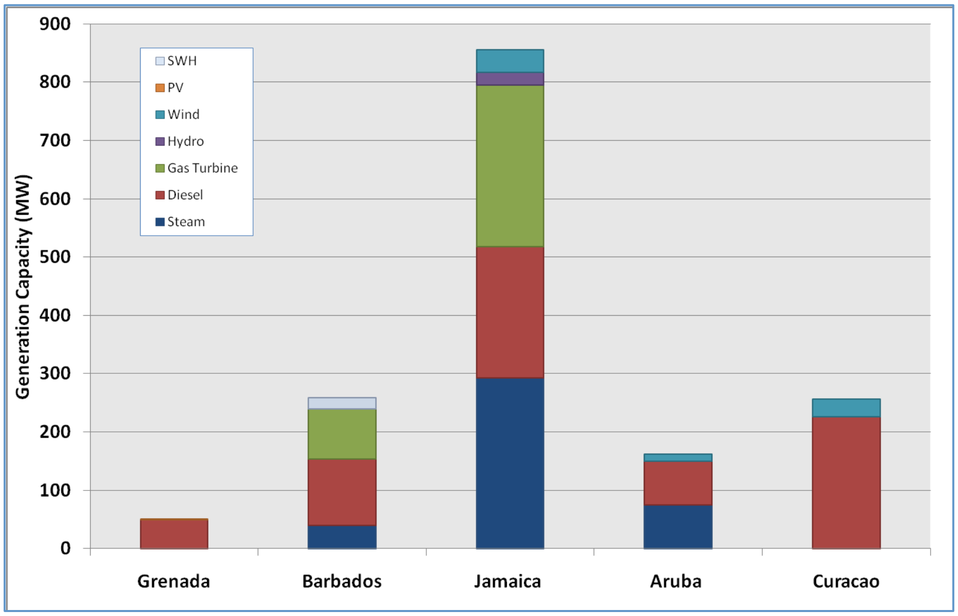

Figure 4 Generation Capacity

To compare the cost effective nature of investments outlined above, we have performed a simple Levelized Cost of Electricity (LCOE) calculation for the technologies introduced. We also calculate estimates of wholesale generation costs and report on current utility rates[i].

	Renewable Energy Technology Costs				Generation Rates					
Country	**Technology**	**Installation Cost($/W)**	**O&M Cost ($/KW/yr)**	**LCOE @ r = 7% ($/kWh)**	**Cost of Fuel ($/kWh)**	**Avoided Cost of Electricity ($/kWh)**	**Fuel Surcharge ($/kWh)**	**Domestic Retail Rate ($/kWh)**	**Net Metering Payment ($/kWh)**	**IPP Contract Rate ($/kWh)**
Jamaica	Wind	2.50	210	0.078	0.219	0.225	0.233	0.265	0.225	0.101
Aruba	Wind	2.40	36	0.013	0.329	0.336	0.160	0.260		0.092
Curacao	Wind	2.40	53	0.028	0.352	0.358	0.211	0.355		0.092
Grenada	Photovoltaics	6.17	0.010	0.283	0.146	0.154	0.213	0.341	0.341	
Barbados	SWH			0.051	0.228	0.235	0.227	0.294	0.227	

Figure 5 LCOE of Renewable Energy Technologies Compared to other Electricity Cost Estimates

The LCOE of wind generation in Jamaica is based on data provided by Wigton Wind farms on investment and operations costs[ii]. When compared to the Domestic and Net Billing rates in Jamaica, the Wind LCOE seems quite favourable. A clearer picture comes from comparison to avoided costs of current electricity generation. According to the Office of Utilities Regulation (OUR) in Jamaica the Long Run Incremental Cost (LRIC) of generation represents the incremental cost of provided electrical power over a 20 year period discounted to present value by the opportunity cost of capital (12%) attributable to new plants to be added over the planning horizon divided by the expected capacity to be supplied by these plants. This rate is currently \$0.10 USD/kWh and is used as the base for contracts for guaranteed capacity. Where capacity cannot be guaranteed, pricing is based on the short term avoided cost which is the cost of fuel to the system, which varies from month to month. This rate is roughly \$0.088 USD/kWh. Wigton Wind Farm for instance receives a 15% premium over this avoided cost at \$0.10 USD/kWh.

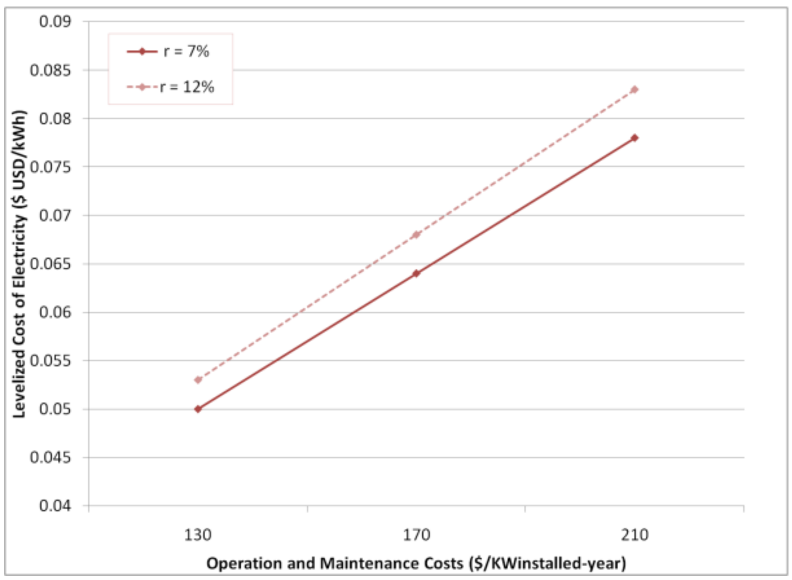

Figure 6 Sensitivity of Wind to O&M Costs

The LCOE of wind energy in Jamaica is lower than each of these different estimates of cost and is well within the range of costs experienced in other wind developments across the world (Cory & Schwabe, 2009) (Bolinger, 2010), so that it would appear to be an economical alternative. This cost effectiveness would increase with lower OM costs as seen in the sensitivity analysis in Figure 4 above. However when compared to countries such as Germany, Switzerland and Australia where purchase agreements allow for the sale of wind power above even \$ 0.20 USD/KWh (Myers, 2008), Wigton's selling price translates into a very low rate of return and may be partially responsible for the dearth of international investor interest that Wigton has been able to attract, hence still being wholly owned by the PCJ.

Given the wind regime, capacity factors of the wind farm projects in the Netherland Antilles are over 40%. Combined with having spent relatively little in the first years of production on OM thus far, the LCOE of wind energy in Aruba and Curacao both fall to less than \$0.03/kWh[iii]. This is lower than the avoided cost of electricity and the IPP 'take or pay' contract price allowing NuCapital to make a significant return on investment. This rate may be an underestimate given future OM cost increases as suggested by the difference in OM costs between the older farms in Curacao and the new farm in Aruba. Nevertheless Antillean wind developers are able to provide a significant amount of electricity production at low cost, attracting investment to the resource.

We then turn to the LCOE based on data made available from GRENSOL[iv]. While the current LCOE at an installed cost of over \$6.00/$_{\text{Winstalled}}$ is lower than the domestic rates charged and net metering rates offered in Grenada and Barbados (where systems are also starting to be sold), providing profitability for system owners, the cost of photovoltaics is still much higher than the fuel and short run avoided cost of current electricity production. Again, this may be in part due to the shipping costs that are incurred from importing small orders for panels. As seen in Figure 5 below, the LCOE of photovoltaics with an install cost reduced to \$3.00 USD/$W_{\text{installed}}$ would much better aligned with the avoided cost estimates, showing the potential for greater penetration to create a cost competitive arena at the wholesale level.

With Solar Water Heating (SWH), we derive the Levelized Cost of Electricity Displacement[v]. This calculation gives a Levelized Cost of Electricity Displacement of \$0.05 USD/kWh and confirms Solar Dynamics Ltd.'s assertion that the payback period on SWHs can be on the order of 2 years. The cost effective nature of SWH with or without subsidies is clear when compared to the avoided costs of electricity in Barbados, and even when compared to the \$0.088 USD/kWh non-firm capacity energy rates offered in Jamaica. This highlights the potential benefits that could come to the Barbados government or utility from helping families and businesses to finance the upfront payment for such systems, which is a current barrier given that electric water heaters are at least half the price of SWHs. This also speaks to the potential that SWH technology could have in other islands, where it is also likely to be cost competitive. Note that the cost competitive nature of these technologies may vary when compared to Time of Use (TOU) rates.

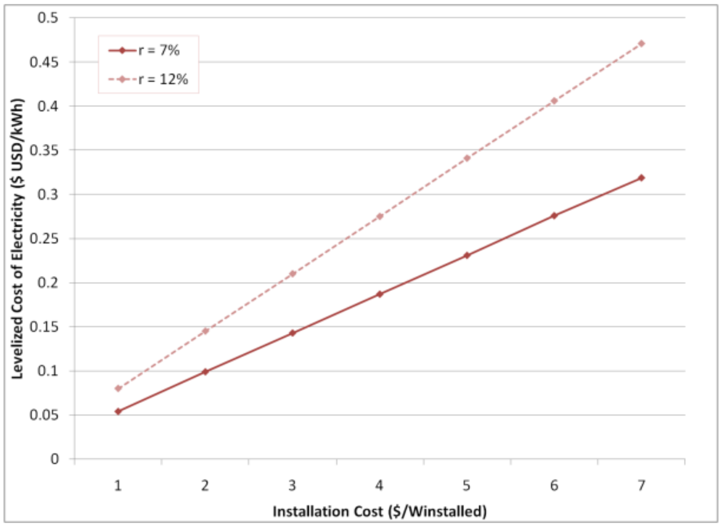

Figure 7 Sensitivity of PV to Installation Cost

While analyzing these costs of generation, it should be noted that neither the LCOE nor the avoided cost calculations reflect other indirect benefits RETs may have such as job creation and stimulation of the local economy. Here we estimate the benefits that the RETs have had thus far on the job and carbon emissions abatement fronts. Data for job estimates came directly from the number of people employed by these companies in different stages of the operation process and reflect only direct jobs created, not indirect or induced jobs. Tables below show that the wind energy project in Jamaica is able to provide 0.17 person-years/GWh providing roughly 20 full time jobs per year and it also contributes 120,000 tonnes of CO2 savings during the same period.

The spread of photovoltaics in Grenada has lead to 16.19 person-years/GWh (although this number is likely to decrease in the near future as the current team become saturated with system installations) and a total annual savings of 160 tonnes CO2. Most impressive are the indirect impacts of energy efficiency technology in Barbados where the high penetration of SWH has led to a savings of 185 GWh/year and a total savings of 200,000 tonnes CO2/year. While Wigton is the first Caribbean RET project to capitalize on these impacts through registering with the CDM there is clearly potential for other RET to pursue a similar route and potentially add to the slim revenue stream now available to such projects.

Country	Technology	Project Size (MW)	Annual Generation (GWh/yr)	Current Generation CO2 Intensity (kg CO2/kWh)	Total Annual CO2 Savings ('000 MT/yr)
Jamaica	Wind	38.70	115	0.944	120
N. Antilles	Wind	39.00	132	0.944	125
Grenada	Photovoltaics	0.12	0.237	0.66	0.16
Barbados	SWH		185.5	1.106	200

Figure 8 Green House Gas Emissions Savings

As can be seen from these case studies there are a number of successful wind, solar and solar thermal projects that have been deployed in the region within recent times. There are other notable wind projects that have been developed in islands such as Guadeloupe and a photovoltaic market in islands such as St. Lucia and St. Vincent is also beginning to emerge. Geothermal energy as a base load substitute for fossil fuels is also proving successful in Dominica, St. Lucia and Guadeloupe. However the government, regulator and utility support given to such efforts varies from island to island.

Energy Technology	Source of Numbers			Employment Components			
	Project	Project size	Equipment Lifetime (years)	CIM (jobs/MWinstalled)	O&M (jobs/MWactual)	Cap Factor	AVG (person-years/GWh)
Wind	Wigton Wind Farm	20.7 MW	25	3.88	0.59	0.34	0.17
Wind	Nu Capital, Curacao	12MW	25	1.50	1.43	0.35	
Wind	NuCapital, Aruba	30MW	25	1.50	0.85	0.47	
Solar PV	Grensol Ltd	65KW	25	0.00	30.77	0.22	16.19
SWH	Solar Dynamics Ltd	140,000 MWh saved	20	0.59		0.22	0.31

Figure 9 Estimates of Direct Employment Benefits

Furthermore, there is also a discussion around electrical interconnection of various islands in the region so that the benefits of low cost power can be strategically shared. A study by Nextant shows that there could be savings from the future development of renewables through a regional transmission grid despite the associated infrastructure capital cost (Nextant , 2010). Though it could radically change the competitive position of renewables in the region, there would be a number of political barriers to this development and it is the type of regional policy scenario which would benefit from a deep appreciation of the different market and regulation dynamics at play amongst the islands.

Despite the regional grid assessment and a number of local energy programs and draft energy policies that have evolved as described herein, there is not a collective outlook towards renewable energy integration that has yet led to any major shift or development in the philosophy of power sector regulation and operation. We now pull from the above case studies to discuss what some of the reasons behind this may be.

4. CONCLUSIONS

In this analysis we have explored the history of energy policy and the cost effective nature of RETs in the Caribbean. Even though such a small region, there are significant differences between islands in the scale of industry, the type of utility ownership, the level of regulation and legislation as well as the degree of government involvement in the sector. Each of these issues presents a separate set of considerations that should be addressed in creating an enabling environment for renewables, and different levels of power sector sophistication might make centralized policy planning difficult otherwise.

To elaborate, it seems that some islands, particularly the smaller eastern islands, sit to the right of these scales or continuums and need focus to be placed on developing a greater sense of government involvement in power sector operation so as to provide greater and timelier impetus for assessing the local generation mix. Other islands, such as Barbados, already have a regulatory structure in place and need to harness that already established capacity to create more binding policies and to harness local RET market potential. Utilities sometimes need to be provided with the security of government support to explore the riskier realm of renewables and creating a supportive legislative and policy backbone is a crucial step for energizing the local market. Islands like Jamaica that have developed more sophisticated legislation might focus on creating an enabling market environment to feed the growing local appetite for renewables. Such an island, as it appears, would benefit from putting incentives in place to attract investment beyond state financing to the local resources.

History has shown that socio-technical transitions take time and involve systemic changes. Because infrastructure favours currently dominant fuels, renewable energy deployment will be most effective if their environment becomes more conducive to change. An enabling environment for renewable energy involves policy that addresses a number of domains with different configurations of interaction depending on country context (Mitchell, et al., 2011). In general, enabling policy will involve non-governmental stakeholders in formulation and implementation, will support the burden of financial and investment risk, will place focus on infrastructure and network development, will encourage technology transfer and will be designed to be complementary to other non-energy related policy (transportation, agriculture, water management). We have shown here how focus on different policy domains in various island types might lead to the design of such an enabling policy environment.

These nuances in country to country needs and contexts may be part of the reason that inter-island policy is so difficult to develop and should be well understood for a regional direction to emerge and for policy initiatives and implementation mechanisms to then be derived from that. As said there are already institutions that are concerned with the regional approach to renewable energy and a cognizance of the degrees of and the types of incentives that are most useful for different power sector landscapes is crucial to the success of such agencies. This is a consideration that warrants greater attention and more thorough analysis than presented herein but hopefully we have provided some insight for conceptualization.

	GRENADA	BARBADOS	JAMAICA	ARUBA	CURACAO
Monopoly Utility	Grenada Electric Services Ltd (GRENLEC)	Barbados Light and Power Company (BL&P)	Jamaica Public Services Company (JPS Co)	W.E.B. ARUBA N.V.	Aqualectra
Utility Ownership	50% foreign, 25% state, 25% local investor	37% foreign, 23% state, 35% local investor	80% foreign, 20% state	100% state holding company	25% foreign, 75% state
Utility Exclusive Rights	Generation, Transmission, Distribution	Generation, Transmission, Distribution	Transmission, Distribution	Generation	Generation, Transmission, Distribution
Regulatory Agency	None	Fair Trading Commission	Office of Utility Regulation	None	None
Energy Legislation	1994 Electricity Supply Act	1907 Electricity Supply Act 1951 Public Utilities Act 1974 Fiscal Incentives Act	1958 Electricity Development Act 1995 Office of Utilities Regulation Act 2001 All Island Electricity License	None	None
Government Energy Policy	None	2007 Barbados National Energy Policy	2009 Jamaica National Energy Policy	None	None
RPS Goal	None	20% by 2020	20% by 2030	None	None
Net Metering Policy	max 10kW, retail rate, cap 1% installed capacity	max 50kW, fuel adjustment rate cap 1600 kW	max 100 kW, avoided cost cap 3% installed capacity	None	None
Financial Incentives	5% Duty Concession for PV (since 2005)	Consumption Tax on EWH (1974), Inc Tax Deduction for SWH (1980)	None	None	None
RE Pilot Projects to Date	Small Scale Solar	Bagasse, WTF, Wind, Small Scale Solar, SWH, LFG	Bagasse, Hydro, Wind	Large Scale Wind	Large Scale Wind

Figure 10 Summary of Energy Sector Policy

A further point to note is that all of these islands are in the very early stages of power sector reform and renewable energy integration, so it is difficult to judge the successes of the growing RET industry. Instead, the aim is to improve the frameworks that are in place to support the successes of the industry. As our cost analysis has shown, there are many scenarios in which certain RETs already provide significant social benefit and are cost competitive with the short run avoided costs of current generation mixes despite isolation and relatively small markets. This would indicate the potential for small scale resource development and profitability that can be precipitated by local innovation, local investment and local market interest, all of which can be encouraged through more directed and enabling policy.

A paradigm shift in energy resources is clearly impending and regardless of the policy framework that develops over the future, CARICOM, CARILEC, international investors and local regulatory agencies will be key players in the decisions that are to be made. The long term target may be a physical regional transmission grid or a regional energy information network where islands exchange knowledge, experience and expertise. Regardless, a sensitization to the differences in power sector dynamics outlined herein and a working knowledge of the success that can come from small scale energy technologies will better position decision makers to make enforceable and actionable policy. It would thus seem most useful to explore a number of different regional physical and institutional regimes through feasibility, cost benefit and barrier assessments to determine what best serve as potential solutions for the Caribbean. In this way enabling regional policy mechanisms can be guided by national energy plans allowing the islands to pursue their individual and collective energy security and sustainability goals within their collective context.

[i] The utility domestic rates are taken from CARILEC Technical Reports (CARILEC, 2010).

[ii] The current wind farm was built at an average capital cost of $2-3 million USD/MW installed and the 18MW project, which was recently commissioned in March 2011, cost US$49 million. Wigton operation costs include financing and sales, labour, electricity, repair and maintenance operations and depreciation and insurance expenses. These operating costs were estimated at US$4.258 million for 2008 (E. Barrett - General Manager, Wigton, 2010).

[iii] Based on installation costs of $2.4million USD/MW for both Vader Piet and Playa Canoa. Annual production output and associated OM costs for both projects were provided by NuCapital. Fuel costs based on Curoil (local gas and oil distribution company) diesel prices for both Aruba and Curacao and assuming a Heavy Fuel Oil engine heat rate of 13.6E3 kJ/kWh.

[iv] The cost of a system includes a lifetime guarantee, including maintenance and inverter replacement costs. There are thus very few additional costs that an owner would have to pay for the system. We assume a marginal degradation rate of 0.005%. The LCOE of photovoltaics is estimated at roughly $0.28 USD/kWh (Barbose, Darghouth, & Wiser, 2010). This is much higher than the average US LCOE of around $0.16 USD/kWh, however there are a few things to note. Firstly, according to GRENSOL the installation price decreases the larger the system purchased so that $6.17/W$_{installed}$ is a conservative estimate of the installation costs for their systems. Furthermore, the US LCOE includes an Investment Tax Credit (ITC) of 30%. Without this tax credit, the cost of PV would be much higher in the states.

[v] Approximately 0.11kWh are needed to heat a gallon of water given the ambient temperature in the tropics and the theoretical heat capacity of water. Assuming electric water heaters are about 90% efficient, assuming that an average household uses approximately 10,000 gallons of hot water a year and given that the electrical fuel efficiency of the BL&P Co. generator fleet is roughly 30%, the amount of electricity that a standard 65gallon SWH can displace per year is 3700 kWh.

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