Challenges and Opportunities for the Energy Sector in the Eastern Caribbean

Achieving an Unrealized Potential

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Acronyms

AOSIS (CAAP)	China Climate Change Adaptation Pilot Program
APUA	Antigua Public Utilities Authority
CARILEC	Caribbean Electric Utilities Services Corporation
CDB	Caribbean Development Bank
CEEAP	Caribbean Energy Awareness and Education Programme
CFL	Compact fluorescent light
CHENACT	Caribbean Hotel Energy Efficiency Action
CREDP	Caribbean Renewable Energy Development Programme
CSEP	Caribbean Sustainable Energy Program
DOMLEC	Dominica Electricity Services Limited
EC$	Eastern Caribbean Dollar
ECERA	Eastern Caribbean Energy Regulatory Authority
ECELP	The Eastern Caribbean Energy Labeling Project
ECLAC	Economic Commission for Latin America and the Caribbean
EDF	European Development Fund
EE	Energy efficiency
EIA	U.S. Energy Information Administration
ESA	Electricity Supply Act
ESCOs	Energy service companies
GEF	Global Environment Facility
GHI	Global Horizontal Irradiance
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GRENLEC	Grenada Electricity Services Ltd.
GrenSol	Grenada Solar Power Limited
GSEII	Global Sustainable Energy Islands Initiative
GSWMA	Grenada Solid Waste Management Authority
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GWh	Gigawatt hour
IDB	Inter-American Development Bank
IPP	Independent power producer
IRC	Independent Regulatory Commission (Dominica)
IRENA	International Renewable Energy Agency
kWh	Kilowatt hour
LCCC	Low Carbon Communities in the Caribbean
LCOE	Levelized cost of energy
LRMC	Long run marginal costs of generation
LUCELEC	Saint Lucia Electricity Services
MW	Megawatt
MWh	Megawatt hours
NEVLEC	Nevis Electricity Company Limited
NPV	Net present value
O&M	Operations and maintenance
OAS	Organization of American States
OECS	Organization of Eastern Caribbean States
OPIC	Overseas Private Investment Corporation
OTEC	Ocean Thermal Energy Conversion
PPA	Power purchase agreement
PPCR	Pilot Program for Climate Resilience
RE	Renewable energy
RSF	Risk-sharing facility
SEAP	Sustainable Energy Action Plan
SEEC	Sustainable Energy for the Eastern Caribbean
SKELEC	Saint Kitts Electricity Company
Solar PV	Solar photovoltaic
SWH	Solar water heaters
UK DFID	United Kingdom Department for International Development
US$	United States Dollar
VINLEC	Saint Vincent Electricity Services Limited

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Keywords:

Sustainable energy; eastern Caribbean; renewable energy; energy efficiency; electricity; geothermal; solar; wind; hydro; waste-to-energy

JEL Codes:

Q42, Q41, Q55

Executive Summary

This paper focuses on *how the Eastern Caribbean can achieve its unrealized sustainable energy potential*, where:

- 'Eastern Caribbean' means Antigua and Barbuda, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines, and
- 'Sustainable energy' means economically viable renewable energy (RE) and energy efficiency (EE) projects that displace fossil fuel–based electricity.

Sustainable energy matters in the Eastern Caribbean because it represents an untapped potential (summarized in the sustainable energy supply curve in Figure ES.2 and the barrels of oil displaced by technology in Figure ES.1) to reduce dependence on expensive imported oil for electricity generation, and therefore reduce energy costs. The estimates suggest that sustainable energy could save about 30,244 gigawatt hours (GWh) in a 20-year period (2015–2034). This is equivalent to fuel savings with a net present value (NPV) of about US$578 million[1] and a discount rate of 12 percent over the period. Estimates also suggest that implementing sustainable energies could lead to about 2.7 million barrels of oil displaced per year. Among the technologies, geothermal has the largest potential for displacement of oil barrels (close to 70 percent of the total), while having one of the lowest levelized costs of energy (LCOE) and the highest potential in terms of megawatts (MW) installed.

Reducing the import of fossil fuels would have a dramatic impact on the region's GDP. For example, the NPV of US$578 million in fuel savings is equivalent to 11 percent of the Eastern Caribbean's 2014 GDP, thus reducing total expenditure on fuel and keeping more money in the region.

Implementing sustainable energy technologies would also benefit the region's governments, many of whom have a high debt-to-GDP ratio. Reducing government expenditure on electricity (for example, street lighting and in government facilities) would free up fiscal space for governments to pay down debt or provide other needed services. For street lighting and government customers alone, the savings would be US$14 million in the six countries.[2]

Key sustainable energy potential in the region includes geothermal, solar water heating, EE, waste-to-energy, wind, solar photovoltaic (solar PV), and hydropower. In spite of several steps in the right direction, this potential remains largely unrealized due to the following barriers:

- *Financial barriers*—limited funding for good projects, limited private sector interest in financing projects, low commercial bank interest in financing good projects, or limited availability of appropriate terms for project financing
- *Legal and regulatory barriers*—continued dependence on outdated frameworks that favor traditional fossil fuel over sustainable energy technology
- *Information barriers*—limited information about sustainable energy options, causing energy consumers and governments to continue with the status quo
- *Market barriers*—limited human capital, sustainable energy equipment hard to come by, difficulty in telling good quality from poor quality equipment

The barriers to RE development in the Eastern Caribbean are not insurmountable. Key measures that can build on existing strengths are the following:

- *Financial measures*—concessional loans, loan guarantees, risk-sharing facilities, performance-based contracts for EE retrofits, concessional grants, and grants
- *Legal and regulatory measures*—technical assistance for utility regulation (obligation for utilities to purchase from third parties, standard offer contracts for distributed renewables, cost recovery tariff mechanisms), clear licensing processes for independent power producers (IPPs), and improved legislation and regulation for access to land and resources
- *Information measures*—RE resource assessments, outreach efforts for increasing the public's knowledge of sustainable energy, and region-wide efficiency labeling standards for products
- *Market measures*—training or hiring staff for government entities and utilities, establishing consumer finance facilities, and revising building codes

[1] EC$1,560 million at an exchange rate of US$1.00 = EC$2.70.

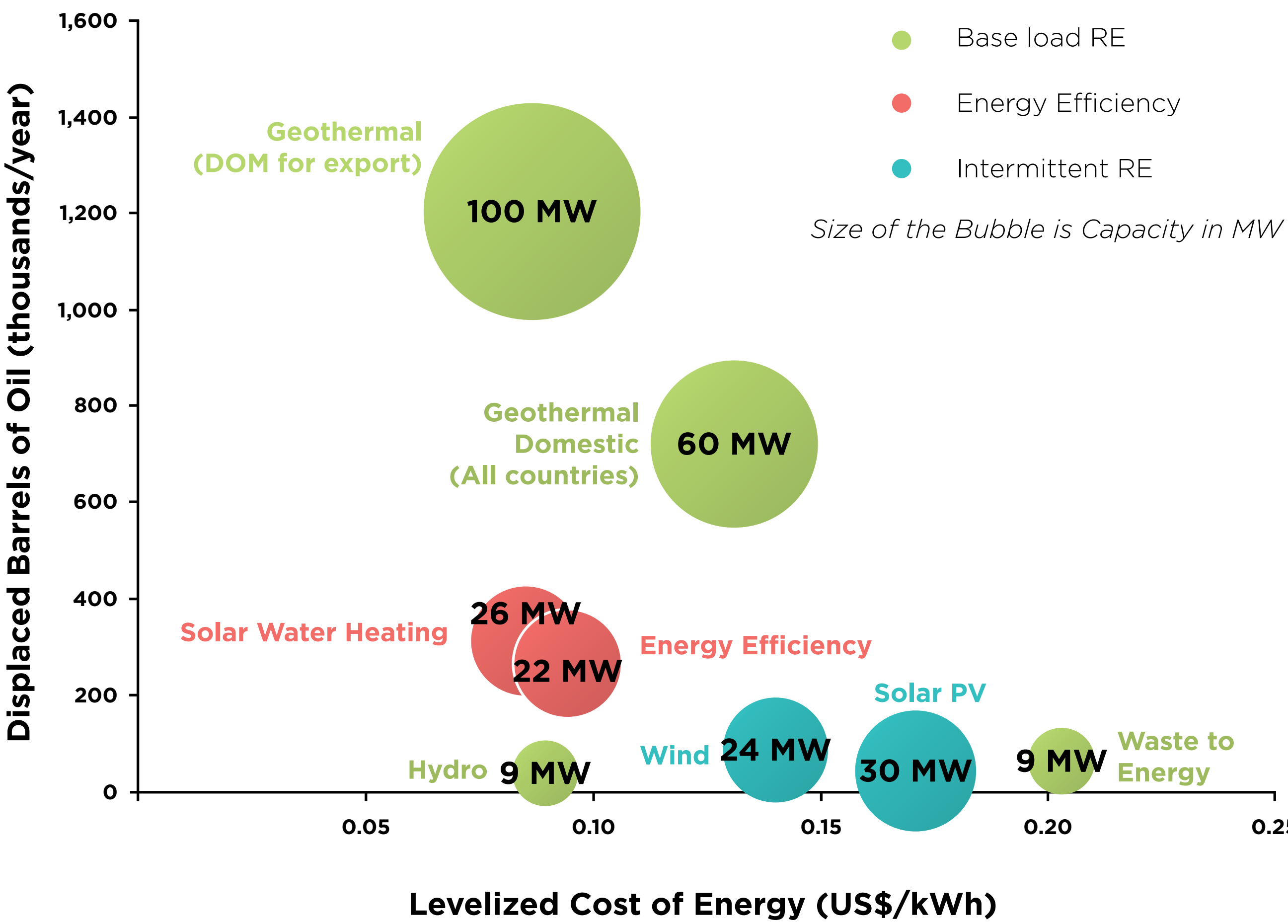
[2] Calculated as the percentage of street lighting and government customers in 2034 times the NPV of savings in each country. The sum of savings in each country yields this number.

Donors can play an important role in the implementation of these measures and help the region realize its sustainable energy potential. A technical and financial facility, funded by donors, to support sustainable energy in the region would be justified because:

- Eastern Caribbean countries face similar problems; many solutions developed for one country could be effective in the other countries as well.
- There are many donors interested in the region's energy situation; therefore, a technical and financial facility to support sustainable energy could create synergies among donors and facilitate coordination, which could make current programs more effective.
- The technical and financial facility could lend support to the development of geothermal power in the Eastern Caribbean. Funding from the Inter-American Development Bank (IDB) and other international donors, using innovative financial instruments, could facilitate the development and deployment of Public-Private Partnerships for geothermal power in five islands in the Eastern Caribbean: Dominica, Grenada, Nevis, Saint Lucia, and Saint Vincent and the Grenadines.
- The facility would make sustainable energy projects more attractive for private sector and commercial lenders. The lack of economies of scale and unclear regulation for private participation discourages the private sector from financing projects in the region. The facility could help overcome this barrier by financing earlier, riskier stages of sustainable energy projects. It could also support countries in preparing or modifying necessary regulations and laws such that rules for private participation become more clear. If the private sector plays a more relevant role in financing sustainable energy investments, the countries could avoid taking on more public debt and, as a result, improve national accounts.

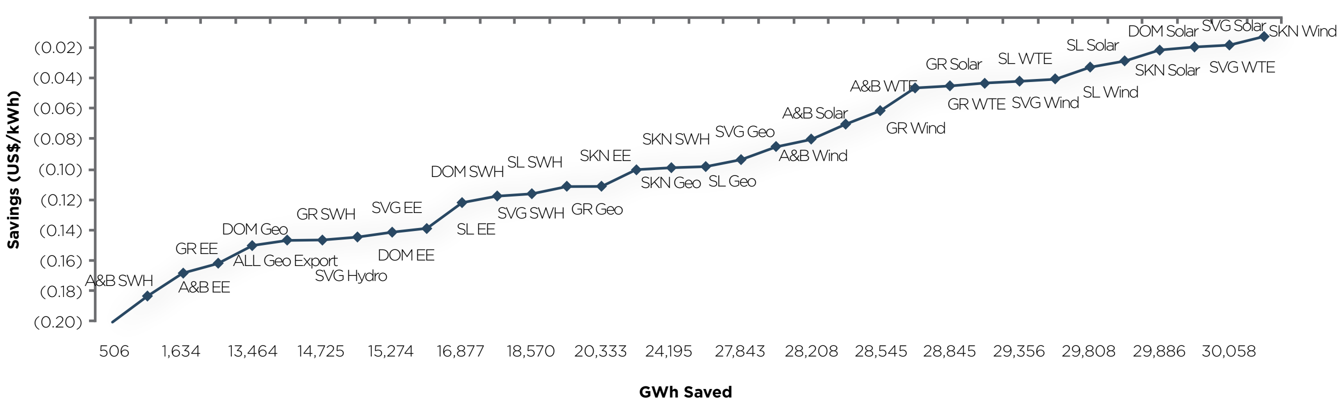
Figure ES.1 shows the barrels of oil that each sustainable technology would displace per year versus their LCOE in the Eastern Caribbean countries considered in this report. The sizes of the bubbles are the potential installed capacity of each technology in MW. **Figure ES.2** aggregates the sustainable energy supply curve for the years 2015–2034.

FIGURE ES.1 Barrels of Oil Displaced by Sustainable Technologies in the Eastern Caribbean



Source: Author's own calculations.

Figure ES.2 Unrealized Sustainable Energy Supply Curve for the Eastern Caribbean (2015–2034)



Source: Author's own calculations.

Note: Figure 2.2 shows an estimate of unrealized sustainable energy potential, and therefore does not include existing RE capacity in the OECS. The additional cost of including energy storage for utility PV is US$0.02 per kWh. The following notations are used in the figure: Antigua and Barbuda (A&B), Dominica (DOM), Grenada (GR), Saint Kitts and Nevis (SKN), Saint Lucia (SL), Saint Vincent and the Grenadines (SVG), all Eastern Caribbean countries with geothermal energy potential (ALL Geo).

1 Introduction

This paper provides an analysis of the electricity sector in the Eastern Caribbean, and recommendations on what to do to realize untapped potential for renewable energy (RE) and energy efficiency (EE) in the region.

This paper presents an overarching analysis that is enriched by eight more specific and in-depth studies. Those studies are presented in chapters as follows: six Energy Dossiers, one for each of the countries of study, which discuss the challenges and opportunities for the energy sector; and a "Strategy for Developing Geothermal Potential through Public-Private Partnerships in the Eastern Caribbean."

This introduction: (i) describes the research question that guides this paper, (ii) explains why RE and EE matter in the region, and (iii) presents the content of the remaining sections.

1.1 Research Question: How to Achieve an Unrealized Potential

This paper answers the following question:

How can the Eastern Caribbean achieve its unrealized sustainable energy potential?

In this paper, 'Eastern Caribbean' means the following six countries: Antigua and Barbuda, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines.

Also, in this paper 'sustainable energy' means EE and RE projects that (i) displace oil-based electricity, therefore reducing the need for imported fossil fuels (which are the largest source for electricity generation in the region); and (ii) are economically viable (meaning they reduce energy costs to a country as a whole by costing less than fossil fuel–generated electricity).

Answering the research question involves:

- Identifying *which technologies* are best suited;
- Assessing if the *countries are ready* to incorporate these sustainable technologies and, if not, identifying *what is missing*;
- Assessing *how much uptake* of these technologies may be reasonably assumed over the long term;
- Estimating *fuel savings (in energy and monetary terms)* that could be produced; and
- Recommending *which measures* could help Eastern Caribbean countries achieve their sustainable energy potential.

1.2 Why Sustainable Energy Matters for the Eastern Caribbean

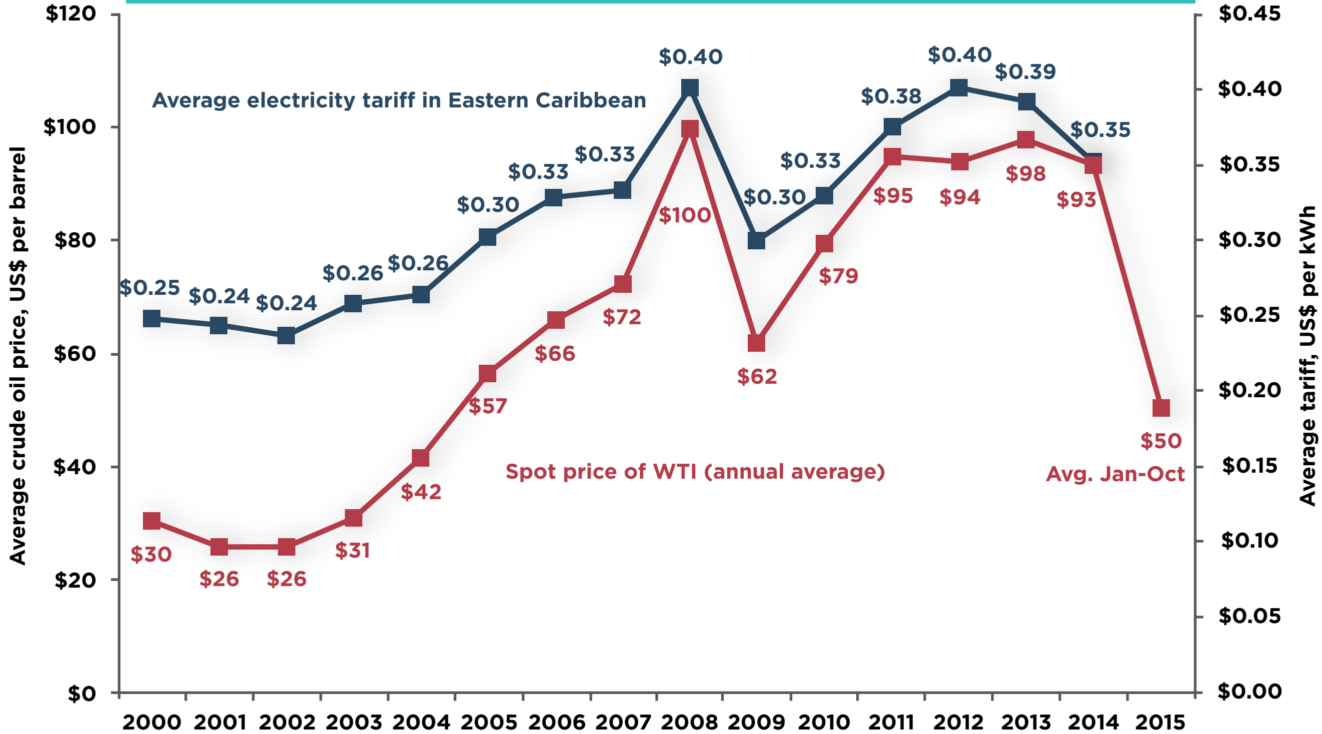
Sustainable energy matters in the Eastern Caribbean because it represents an untapped potential to reduce dependence on expensive imported oil for electricity generation, and therefore reduce energy costs.

Households, businesses, and public entities in the Eastern Caribbean pay some of the highest electricity tariffs in the world. The average tariff in the Eastern Caribbean was US$0.37 per kWh in 2014.[3] Apart from some hydropower (36 percent of gross generation in Dominica in 2013 and 16 percent of gross generation in Saint Vincent and the Grenadines in 2013; see Energy Dossiers of Saint Vincent and the Grenadines and Dominica), electric utilities in the Eastern Caribbean use diesel generators. Utilities have relatively small customer bases, which do not allow for larger and more cost-effective power generation plants that use other fuels. There are no fossil fuel sources available domestically in any of the six countries. Diesel and heavy fuel oil is all imported. Cost of diesel for power generation is directly passed on to customers via special tariff components that vary directly with the cost of fuel. This leads to tariffs that are not only high, but that also vary unpredictably with international oil prices.

Figure 1.1 shows that average tariffs correlate strongly with crude oil prices. When oil prices are low, tariffs are also relatively low. For example, average tariffs ranged between US$0.25 per kWh and US$0.26 per kWh from 2000 to 2004, when the average price of crude was between US$30 and US$42 per barrel. Similarly, consistently high oil prices from 2008 to 2013 led to average tariffs of up to US$0.40 per kWh. With the significant drop in the oil price in 2015, the average tariff may also experience a reduction.

[3] CARILEC (2014).

FIGURE 1.1 Average Tariffs (US$ per kWh) and Crude Oil Prices (US$ per barrel)



Source: The utilities in each country and the Caribbean Electric Utilities Services Corporation (CARILEC) for the average tariff; the U.S. Energy Information Administration (EIA) for the Oklahoma West Texas Intermediate (WTI) crude price, available here: EIA, "Spot Prices for Crude Oil and Petroleum Products," accessed March 15, 2015, http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm.

Note: Average tariff for Antigua and Barbuda, Anguilla, Dominica, Grenada, Saint Lucia, and Saint Vincent and the Grenadines. Figures for each year are not available for all utilities. There is no available public information on 2015 tariffs.

High electricity prices affect all types of consumers:

- Households face high electricity bills, and many low-income households are increasingly unable to pay them.
- Businesses' operating costs grow more and faster than revenues, slowing economic growth; this affects large energy consumers like hotels (and, therefore, the region's main industry, tourism).
- Governments face fiscal constraints—all six Eastern Caribbean states had gross debt-to-GDP ratios of over 74 percent in 2013.[4] The Eastern Caribbean states are expected to continue having high gross debt-to-GDP ratios in 2015.[5] In fact, in 2014 and 2015 some countries had gross debt-to-GDP of approximately 100 percent.[6] Some of these countries subsidize electricity tariffs for targeted consumers—Antigua and Barbuda, Saint Kitts and Nevis, and Saint Vincent and the Grenadines.

As a result of the recent drop in crude oil prices, the cost of fuel to utilities in the Eastern Caribbean has dropped. The price of crude oil decreased from a high of US$107.95 per barrel in June 2014 to a low of US$53.45 per barrel in December 2014.[7] This decrease is an example of the volatility inherent in the global price of oil. Table 1.1 presents the cost of fuel per kWh in 2015 (or 2014 when 2015 data is not available), as well as the all-in cost of diesel generation, for each country in this study.

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[4] CARILEC (2014).
[5] International Monetary Fund, "World Economic Outlook Database 2014," accessed July 29, 2015,
[6] CARILEC (2014). Antigua and Barbuda had a debt-to-GDP ratio of 98.7 percent in 2015 and Grenada had a debt-to-GDP ratio of 105.5 in 2014.
[7] EIA, "Spot Prices for Crude Oil and Petroleum Products," accessed March 15, 2015,

TABLE 1.1 Avoided Cost Benchmarks Assumed in This Study

Avoided Cost Benchmark	All-in cost of generation	All-in cost of generation adjusted for system losses	Cost of fuel	Cost of fuel adjusted for system losses
	Firm, unity scale	Firm, distributed scale	Non-firm, utility scale	Non firm, distributed scale
US$ per kWh				
Antigua and Barbuda	0.26	0.33	0.22	0.27
Dominica	0.23	0.25	0.18	0.20
Grenada	0.25	0.27	0.21	0.22
Saint Kitts and Nevis	0.20	0.23	0.15	0.18
Saint Lucia	0.22	0.24	0.18	0.19
Saint Vincent and the Grenadines	0.23	0.25	0.18	0.20

Source: Cost of fuel in Dominica, Grenada, Saint Kitts and Nevis, and Saint Lucia is based on information reported by CARILEC and the electricity utilities in those countries. Cost of fuel for Antigua and Barbuda and for Saint Vincent and the Grenadines was calculated using information reported by CARILEC and the historic information reported by the electricity utilities. Specific sources for all costs are the following: CARILEC, *Tariff Survey among Member Electric Utilities*, 2014; DOMLEC, Annual Report 2013 and 2014 Financial Statements; GRENLEC, Annual Report 2013 and 2014 Financial Statements; LUCELEC, 2013 Annual Report; VINLEC, 2013 Annual Report and 2014 Financial Statements; Barbados Light and Power Company Ltd. (2014).

Note: All-in cost of diesel generation consists of the cost of fuel, fixed and variable operations and maintenance cost, and unit capital cost. All-in cost of generation is calculated by adding these three costs. These costs, other than the cost of fuel, are based on the average costs of two 13 MW diesel generators used in Barbados, as presented in Barbados Light and Power Company Ltd. (2014), which amounts to about US$0.04 per kWh.

1.3 Contents of this paper

This paper shows that there is an untapped potential for sustainable energy in the Eastern Caribbean, analyzes the barriers that have prevented its development, and recommends measures for overcoming those barriers:

- All of the countries included in this paper have available sustainable energy resources that could offset fossil fuel generation and save money. This unrealized potential is presented in Figure 2.2: (i) the cumulative potential of individual technologies to reduce electricity generation with fossil fuel in the long term (over a 20-year period, 2015–2034), and (ii) how much money those technologies save compared to fossil fuel generation.

- The potential presented in Figure 2.2 begs the question: why is that potential unrealized? This paper will explore the answer by analyzing four barriers that prevent the development of the region's sustainable energy potential: (i) information barriers restrict people's knowledge of the sustainable energy options available; (ii) legal and regulatory barriers perpetuate the status quo in the energy sector and slow the adoption of new technologies; (iii) market barriers restrict either the demand for, or the supply of, sustainable energy technologies; and (iv) financial barriers prevent viable projects from getting financing. These barriers are explained in Section 3.

- Targeted interventions can overcome the barriers to sustainable energy development. A few of these interventions are being set up or planned, while many others remain to be done. Section 4 concludes this paper by recommending interventions and presenting a brief overview of the entities that are working on these interventions, suggesting what is being done and where there is need for additional work.

Appendix A explains the methodology used in constructing the sustainable energy supply curve.

Appendix B presents the barriers to sustainable energy in the Eastern Caribbean, as well as the interventions and intervening entities that are addressing them.

Appendix C presents the sustainable energy supply curves for each of these countries and assesses the commercial viability of RE and EE technologies.

Appendix D summarizes key indicators for electric utilities of the Eastern Caribbean.

Appendix E shows sources used for the report and the country briefs, organized by country. Sources that do not correspond to information for one specific country are included separately in Sections E.7 and E.8. In addition, as mentioned above there are seven studies that complement this paper:

- Energy Dossiers for each country (Antigua and Barbuda, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines).
- "Strategy for Developing Geothermal Potential through Public-Private Partnerships in the Eastern Caribbean".

2 The Eastern Caribbean's Unrealized Sustainable Energy Potential

The Eastern Caribbean, though poor in fossil fuel resources, does have a wealth of RE resources. The region could also benefit from using electricity more efficiently. This section presents the estimated barrels of oil that could be displaced by tapping into the region's sustainable energy potential (Figure 2.2). It also shows a sustainable energy supply curve (Figure 2.1) that summarizes the region's sustainable energy potential, and assesses such potential by technology. Finally, this section presents the region's existing strengths upon which it could build to realize the potential shown by Figures 2.1 and 2.2.

2.1 Assessing the Eastern Caribbean's Sustainable Energy Potential

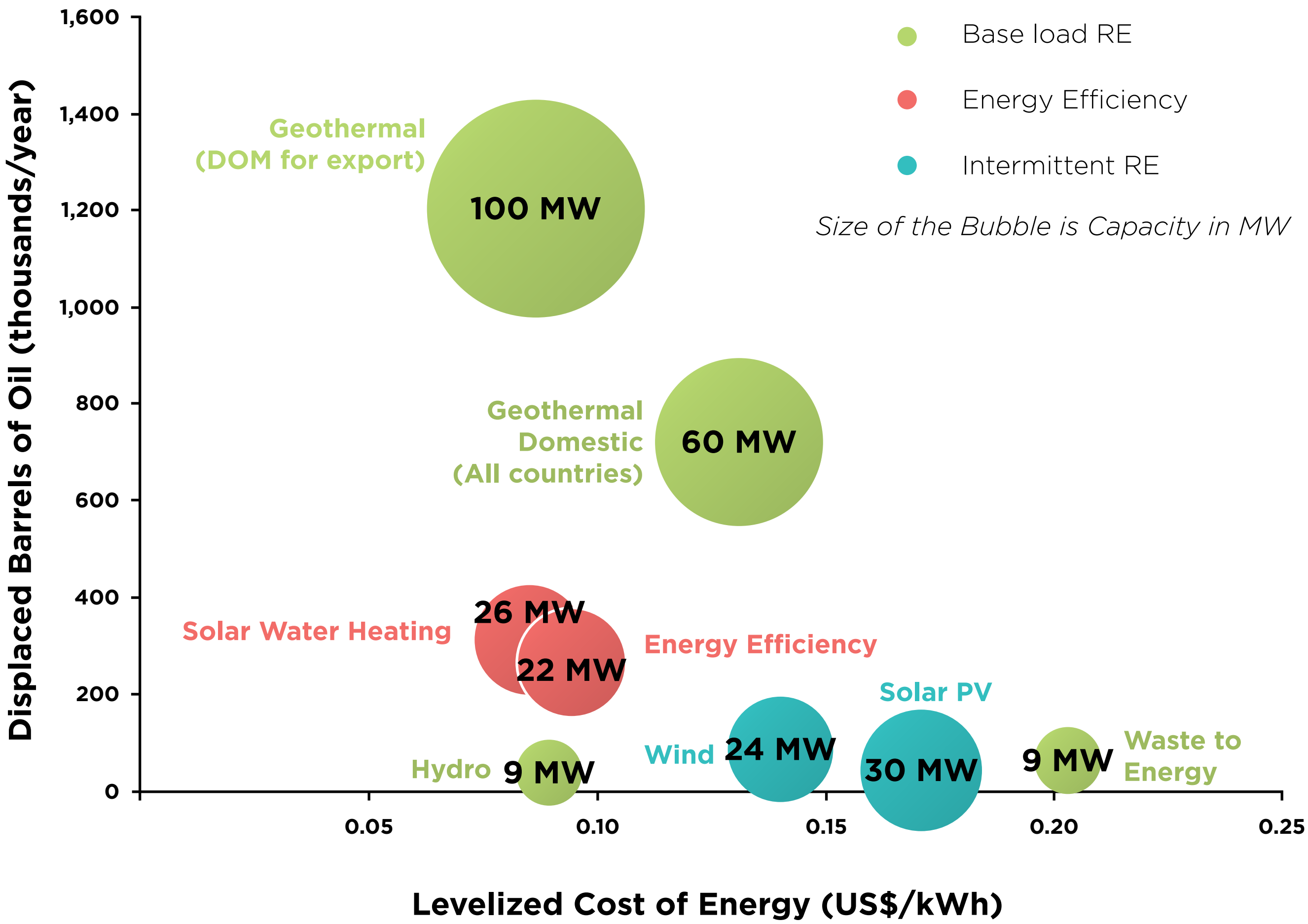
Figure 2.1 shows the estimated barrels of oil that each sustainable technology could displace per year, versus their LCOE. The sizes of the bubbles represent the potential installed capacity of each technology in MW. Implementing sustainable technologies could lead to about 2.7 million barrels of oil displaced per year. This estimate is based on the expected generation from sustainable technologies—which would displace diesel or heavy fuel oil generation—multiplied by the estimated use of barrels of oil per kWh generated.[8]

Among the technologies, geothermal has the largest potential for displacement of oil barrels (2 million barrels, which is close to 70 percent of the total estimated displacement), while having one of the lowest LCOE (around US$0.11/kWh) and the highest potential in terms of MW installed (120 MW). Geothermal energy is the largest renewable resource available in the Eastern Caribbean countries (except for Antigua and Barbuda), even with the potential for exporting power to neighboring countries.

As Figure 2.1 also shows, EE has the second highest potential in terms of barrels of oil displaced (close to 600,000 barrels of oil per year), for a potential installed capacity of 48 MW and a LCOE similar to that of geothermal energy. Finally, intermittent power resources are also largely available in the region (54 MW) and could lead to significant barrels of oil displaced (130,000 barrels of oil per year)—though less than the savings from other technologies.

[4] Assuming a heat rate of 10,200kj/kWh and an energy content of 6,311,532 kj/barrel.

FIGURE 2.1 Barrels of Oil Displaced by Sustainable Technologies in the Eastern Caribbean



Source: Author's own calculations.

Figure 2.2 below presents the potential energy savings for the Eastern Caribbean for the period 2015–2034. The horizontal axis of Figure 2.2 shows that 30,244 GWh could be saved in the region over the period 2015–2034 using economically and commercially viable sustainable energy technologies. This represents the cumulative sustainable generation (for renewables) or savings (for EE) of these technologies over the period.

The vertical axis shows the monetary savings of each technology compared to fossil fuel generation in US$. Intermittent renewable technologies, like wind and solar, are benchmarked against the variable cost of conventional generation; firm renewable technologies, such as waste-to-energy and geothermal energy, and EE technologies are benchmarked against the all-in long run marginal cost of conventional generation.

Model for generating a sustainable energy supply curve

Figure 2.2 is the result of a model that involves a two-step process:

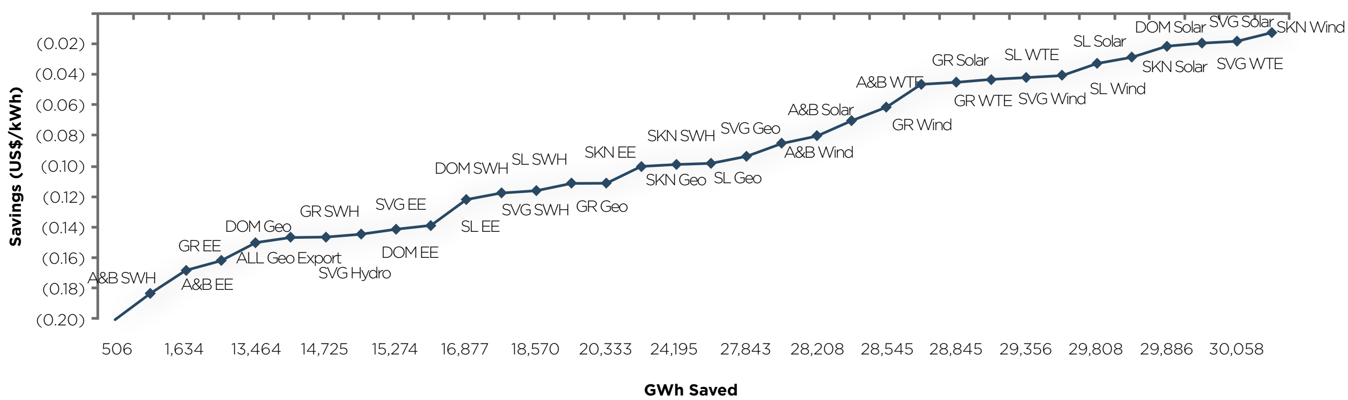
1. **Assessing the cost of sustainable energy technologies in the six countries** to determine what technologies are viable and how much money they can save per kWh, compared to the appropriate conventional generation benchmarks described above. Long run marginal costs of generation (LRMCs) are calculated over a 20-year period, including capital and operations and maintenance (O&M) costs, based on technology-specific capacity factors, and using a 10 percent discount rate for utility generation and a 5 percent discount rate for distributed generation and EE (this is based on assumed support from donor agencies for EE and distributed generation).

2. **Estimating the potential cumulative electricity generation or electricity savings from each sustainable energy technology between 2015 and 2034** to identify how much electricity can be generated from viable RE generation sources (this electricity would displace energy generated from conventional energy generation technologies); and how

much electricity can be saved from EE technologies and solar water heaters (this saved electricity eliminates the need for electricity that would otherwise need to be generated from conventional sources). Since sustainable energy sources replace conventional energy sources, supply is never greater than the electricity needs. Total supply, taking into account generation from conventional plus sustainable energy sources, is set to meet demand.

The model considers estimated penetration of unrealized sustainable energy potential. This means that Figure 2.2 does not show any projects that have already been developed and are operating—in particular: 1 MW of solar PV in Saint Kitts, 2.2 MW of wind capacity on Nevis, 6.6 MW of hydro on Dominica, and 5.7 MW of hydro on Saint Vincent—and distributed renewable generation already implemented (see Box 2.1). For a complete explanation of the methodology used to derive Figure 2.2, see Appendix A.

Figure 2.2 Unrealized Sustainable Energy Supply Curve for the Eastern Caribbean (2015–2034)



Source: Author's own calculations.

Note: Figure 2.2 shows an estimate of unrealized sustainable energy potential, and therefore does not include existing RE capacity in the OECS. The additional cost of including energy storage for utility PV is US$0.02 per kWh. The following notations are used in the figure: Antigua and Barbuda (A&B), Dominica (DOM), Grenada (GR), Saint Kitts and Nevis (SKN), Saint Lucia (SL), Saint Vincent and the Grenadines (SVG).

All of the technologies included in Figure 2.2 are commercially and economically viable. As noted above, sustainable energy technology is defined as economically viable if it can generate electricity at a lower cost than diesel-fueled generation, and can save money for the country as a whole over the long term. A technology is defined as commercially viable if it generates profits or savings for a company or an individual.

There have been various utility scale RE sites targeted for development in the region. However, as of July 2015, of this unrealized sustainable energy potential shown on Figure 2.1, only two projects have recently progressed (or passed) the physical works stage:

- Geothermal development in Dominica: a production well with a potential of 11.4 MW was drilled in March 2014
- A 1.3 MW solar farm was inaugurated in Saint Kitts in September 2013

Using the data and assumptions for Figure 2.1, it is estimated that close to US$578 million could be saved by exploiting the existing EE and RE potential. **Table 2.1** summarizes the total potential savings per technology in energy (GWh) and monetary terms. Furthermore, this generation could have the capacity or the potential to replace the equivalent of 30,244 GWh of power generation based on fossil fuels.

Table 2.1 Savings Represented by Figure 2.1

Technology	GWh Saved	US$ saved (in millions)
Geothermal	10,490	258
Solar Water Heating	3,884	150
Energy Efficiency	3,301	127
Solar PV	547	5
Wind	1,069	15
Waste-to-energy	784	10
Hydro	488	12
Total	30,244	578

Note: All monetary figures are NPV over a 20-year period, using a discount rate of 12 percent. The GWh saved does not include the electricity (generated from the 100 MW plant) that would be exported from Dominica to Martinique and Guadeloupe in a second phase of the geothermal project in Dominica.

2.2 Key Sustainable Energy Technologies for the Region

This section presents the key technologies that can be developed to achieve the Eastern Caribbean's sustainable energy potential. They are: geothermal, solar water heating, EE, wind, waste-to-energy, solar PV, and hydro. The technologies are presented in aggregate order of potential, from highest to lowest. In this paper, a technology's potential refers to the money it saves compared to the fossil fuel generation that it replaces (US$ per kWh), multiplied by the total amount of fossil fuel generation it avoids over the period 2015–2034.

Table 2.2 summarizes the resource availability in each country by technology. The remaining sections will further discuss the economic and commercial viability of sustainable energy technologies in each country.

Table 2.2 Resource Availability in the Eastern Caribbean

Technology	Antigua and Barbuda	Dominica	Grenada	Saint Kitts and Nevis	Saint Lucia	Saint Vincent and the Grenadines
Geothermal		✓	✓	✓	✓	✓
Solar (for PV, water Heating)	✓	✓	✓	✓	✓	✓
Energy efficiency	✓	✓	✓	✓	✓	✓
Waste-to-energy	✓		✓	✓	✓	✓
Wind	✓	✓	✓	✓	✓	✓
Hydro		✓				✓

2.2.1 Geothermal

The only geothermal power plant operating in the Caribbean at this time is a 15 MW plant in Guadeloupe. In the Eastern Caribbean, Dominica's resource is the more developed and presents a significant opportunity for the region, especially if interconnection with Guadeloupe and Martinique is pursued. Dominica has drilled a production well that has the capacity to produce 11.4 MW, which would allow Dominica to construct a plant to meet its base load demand.[9] Interconnection would allow even greater exploitation of Dominica's geothermal resource (potentially up to a total of 100 MW+ additional capacity).[10]

Both Saint Lucia and Nevis have drilled slim-hole wells, but have not drilled exploratory wells.[11] Saint Lucia has not drilled a commercially viable slim-hole.[12] It is carrying out 3G studies and slim-hole drilling with the support of the World Bank and the Government of New Zealand.[13] In contrast, Nevis drilled a successful slim-hole well and signed a concession agreement with a developer in September 2014.[14]

Saint Vincent and the Grenadines and Grenada are in the early stages of exploring and have not drilled slim-hole wells. However, Saint Vincent expects to complete a geothermal plant by 2018. Saint Vincent partnered with Emera and Reykjavik Geothermal to carry out surface exploration, which was completed in July 2015.[15] The results of the surface exploration studies suggest the existence of 300 MW of potential, and project developers will advance directly to exploratory drilling without drilling slim-hole wells. The government received a US$15 million loan from the Abu Dhabi Fund for Development to begin the development of a geothermal plant. Grenada began surface exploration in December 2014 with the support of the Government of New Zealand.[16] The results of 3G studies became available in July 2015, and the government met with donors to discuss a plan going forward.

Geothermal energy has the potential to generate a cumulative 20,170 GWh in the Eastern Caribbean (including energy exported to Guadeloupe and Martinique) by 2034. Of that, 10,490 GWh would be consumed by Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines, with the remaining amount exported. Figure 2.2 assumes that all five countries with geothermal potential will develop power plants of the sizes shown in Table 2.3 below. More detailed information and analysis on the development of geothermal resources in the Eastern Caribbean are in the chapter "Strategy for Developing Geothermal Potential through Public-Private Partnerships in the Eastern Caribbean".

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[9] Dominica Makes Huge Step in Geothermal Energy Production," Dominica News Online, June 17, 2014, accessed July 29, 2015.
[10] The government has indicated that the first phase of the project may reach a capacity of up to 20 MW. See Government of Dominica (2014).
[11] West Japan Engineering Consultants, Inc., "Study on Current Status of Geothermal Development in the Eastern Caribbean Islands," March 2014; Paul Brophy and Bastien Poux, "Status of Geothermal Development in the Islands of the Caribbean," GRC Annual Meeting 2013, Las Vegas, Nevada, USA, September 29–October 2, 2013.
[12] Ministry of Sustainable Development, Energy, Science and Technology, "Geothermal Exploration in Saint Lucia Progresses," September 18, 2014, accessed July 29, 2015, "Saint Lucia and New Zealand Sign Geothermal Energy Contract," Caribbean 360, September 2, 2014, accessed July 29, 2015.
[13] World Bank, "General Procurement Notice: Geothermal Development in Saint Lucia," Project ID: P149959, August 22, 2014, accessed December 8, 2015. http://www.worldbank.org/projects/procurement/noticeoverview?id=OP00029019; "St. Lucia, New Zealand Sign Agreement on Geothermal Energy," Caribbean Journal, September 3, 2014, accessed July 30, 2015, http://caribjournal.com/2014/09/03/st-lucia-new-zealand-sign-agreement-on-geothermal-energy/#; Merinda-Lee Hassall, "New Zealand Aid Programme Geothermal Energy," June 5, 2015.
[14] "Nevis Island Administration (NIA) and Nevis Renewable Energy International, Inc. (NREI) Sign Geothermal Concession Agreement," Nevis Pages, September 3, 2014, accessed July 29, 2015.
[15] "St. Vincent & the Grenadines Outline Progress on Geothermal Work," ThinkGeoEnergy, July 16, 2015, accessed August 4, 2015.
[16] "New Zealand and Australian Scientists to Conduct Geothermal Study in Grenada," Caribbean 360, February 17, 2015, accessed July 29, 2015.

Table 2.3 Geothermal Potential

Country and project	Plant Size (MW)	Est. Year of Operation	Phase of Development	Status
Dominica Phase I (domestic consumption)	10	2017	Development (production/ reinjection)	• Most developed resource in the region; under commercial development (test wells and production wells drilled). A two-phase approach is planned. The government identified a potential developer for the project, but has not signed project agreements for Phase I. • Commercial aspects with off-taker (EDF in Guadeloupe and Martinique) needed for expanding beyond 10 MW (up to 100 MW additional).
Dominica Phase II (domestic consumption)	10	2020		
Dominica Phase II (export)	50	2020		
	50	2024		
Grenada	10	2019	Pre-investment (studies)	• In July 2015, completed 3G studies with support from the Government of New Zealand. Results were made publicly available in July 2015, when the government met with donors and local stakeholders to discuss a plan going forward. • Draft legislation to govern resource exploitation developed in 2012, but not yet passed into law and further revisions may be necessary to deploy RE and EE. • GRENLEC carried out some initial studies with the government and planned to build a geothermal plant by 2015. However, it stopped work due to uncertainty caused by the change in government and the proposed changes to the Electricity Supply Act (ESA).
Saint Kitts and Nevis Phase I (Supply for Nevis)	10	2018 (end of the year)	Exploration (full scale drillings) (not begun)	• Slim-holes drilled in Nevis with a previous project developer. In September 2014, the Nevis Administration signed a concession agreement with Nevis International for 20 years. In November 2015 Nevis International, the Nevis Administration, and Nevis Electricity Company Limited (NEVLEC) signed a purchase power agreement for 25 years. • The Nevis Administration is currently reviewing project documents, after which exploratory drilling is expected to begin.
Dominica Phase II (domestic consumption)	25	2023		
Saint Lucia	30	2019	Pre-investment (studies)	• Two deep exploratory boreholes were drilled, but neither was suitable for commercial production. The wells provided a high-enthalpy resource, but were unusable due to permeability, corrosiveness, and gases. • At the end of 2014, the government received a US$2.8 million grant from the World Bank and the Government of New Zealand that is being used to fund 3G studies and slim-hole drilling. • The government has an agreement in place with ORMAT Technologies Inc. ('ORMAT') to carry out surface exploration and exploratory drilling. If the resource is confirmed, the government will need to develop a new project agreement to carry out production drilling and build the power plant. • LUCELEC is open to participate in that new project agreement.
Saint Vincent and the Grenadines	10-15	2018	Exploration (drilling phase) (not begun)	• The government is working with a consortium of Emera and Reykjavik Geothermal to develop its geothermal resources. • The partners completed Saint Vincent's pre-investment studies in July 2015 and the drilling phase is expected to begin in early 2016. • The parties have reached preliminary agreements (a technical and economic business plan) that will serve as the foundation of the project agreements. • The government has secured a loan from Ahu Dhabi Fund for this project. The specific use of the funds is still to be determined.

Note: Plant size estimates are based on resource quality and electricity market size. For sources consulted, see Appendix E.7.

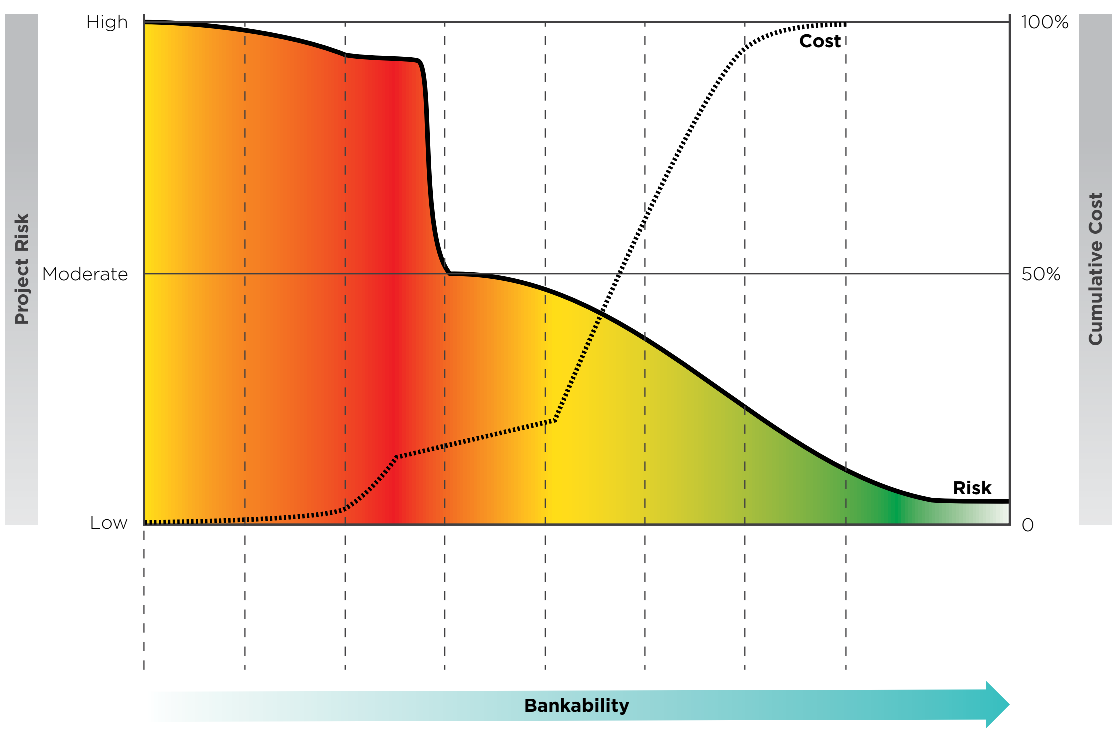
Geothermal savings over conventional generation are significant in each of the countries. The expected savings in each country is:

- Dominica US$0.13 per kWh for Phase I and US$0.015 per kWh for Phase II
- Grenada US$0.10 per kWh
- Nevis US$0.06 per kWh
- Saint Kitts US$0.011 per kWh
- Saint Lucia US$0.09 per kWh
- Saint Vincent and the Grenadines US$0.09 per kWh

The NPV of savings from geothermal over conventional generation is US$258 million using a 12 percent discount rate.[17]

Most of the planned projects for geothermal power plants are in the early stages of development. The figure below shows the cost and risk related to each of the phases of geothermal development.

Figure 2.3 Phases of Geothermal Development



Source: Gehringer and Loksha (2012).

Note: F/S stands for feasibility study.

In the Caribbean, most geothermal projects are in the exploration, test drilling, or project review and planning step. See "Strategy for Developing Geothermal Potential through Public-Private Partnerships in the Eastern Caribbean."

[17] This excludes the savings from electricity that is generated in Dominica and then exported to Guadeloupe and Martinique.

2.2.2 Solar water heating

Although solar water heaters are already being used in the Eastern Caribbean, their adoption rate is low. For example, around 10 percent of electricity customers are estimated to have solar water heaters in Grenada (see Energy Dossier: Grenada). The example of Barbados, which has a 40 percent technology penetration rate, suggests that uptake of this technology could be much higher in the Eastern Caribbean.

Solar water heating (including both residential and commercial applications) has the potential to generate savings of 3,884 GWh in the Eastern Caribbean, thanks to the abundant solar energy resource in the region. These savings assume gradual adoption of the technology, reaching 30 percent penetration among residential electricity customers, and 15 percent penetration among commercial electricity customers by 2034.

Solar water heating is a mature technology, and is viable in all six Organization of Eastern Caribbean States (OECS) countries considered in this study. Commercial solar water heaters save between US$0.11 per kWh and US$0.20 per kWh compared to conventional generation. For residential systems, savings are between US$0.08 per kWh and US$0.17. The NPV of savings from commercial and residential solar water heating over the period is US$150 million, using a 12 percent discount rate.

BOX 2.1 Solar Water Heaters in the Region

The Eastern Caribbean countries covered in this report have had a relatively low adoption rate of solar water heaters compared to the experience of their neighbor, Barbados (which has upwards of 40 percent penetration). This indicates that there is a significant opportunity for expansion.

Solar water heaters are available on all of the islands in the Eastern Caribbean (the company Solar Dynamics, a solar water heater manufacturer, has retail partners on all of the islands covered in this report and a manufacturing facility in Saint Lucia). Some governments have attempted to increase adoption of solar water heaters by offering tax breaks.

Grenada

Grenada's import records indicate that 4,500 units were imported to the country between 2000 and 2008 and an estimated 10 percent of electricity consumers use a solar water heater. The Grenada Public Service Co-op Credit Union also has a loan program to specifically finance solar water heaters.

Saint Kitts and Nevis

The draft energy policy of Saint Kitts and Nevis (Government of Saint Kitts and Nevis, 2011) calls for investigating the possibility of requiring the use of solar water heaters for "all major users of hot water." Solar water heaters have been tax exempt in Saint Kitts and Nevis since June 2012. The penetration rate of solar water heater use is not known.

Saint Lucia

Solar Dynamics, the Barbados-based solar water heater manufacturer, has manufacturing facilities on Saint Lucia. The purchase of solar water heaters is also tax deductible in Saint Lucia.

Sources: IRENA (2015); Grenada Public Service Co-op Credit Union (2015); "St. Kitts and Nevis to Waive Taxes on Green Energy Equipment" (2012).

Note: See Appendices C–H.

2.2.3 Energy efficiency

Some EE technologies are already used in the Eastern Caribbean, but their penetration rate among electricity consumers is generally low due to various barriers described in detail in Section 3 (for example, low awareness of and access to financing, limited markets for installation and equipment of technologies, and uncertainty in cost recovery for utility demand-side management programs). The analysis underlying Figure 2.2 assumes that adoption of EE technologies will grow gradually to reach 45 percent of electricity customers by 2034 (a conservative assumption).

The key EE technologies for the Eastern Caribbean can be divided into five groups:

- **Lighting**—This includes both indoor and outdoor lighting with efficient lamps such as T5, T8, and LED lighting (which has reached a cost inflection point and is now economically viable). Depending on the technology, efficient lighting can save up to 50 percent compared to conventional counterparts. Efficient lighting technologies make up about 1.8 percent of total estimated EE savings for the period from 2015 to 2034.
- **Air-conditioning**—This category includes both residential and large-scale efficient air-conditioning technologies (including for hotels), which consume between 33 and 38 percent less energy than their conventional counterparts. Efficient air-conditioners account for 7.1 percent of total estimated EE savings for the period from 2015 to 2034.
- **Refrigeration**—Both residential and commercial refrigeration offer significant opportunities for electricity savings, reducing consumption between 15 to 40 percent depending on the technology. Refrigeration technologies contribute 3.0 percent of total estimated EE savings for the period from 2015 to 2034.
- **Mechanical**—Premium efficiency motors, variable frequency drives, and efficient chillers all can save money in commercial and industrial settings; savings vary depending on the technology, from 5 percent up to 40 percent. These technologies are responsible for 87.0 percent of total estimated EE savings over the 20-year period.
- **Other efficient appliances**—LCD computer monitors and power monitors can help reduce electricity consumption; monitors do this directly by consuming less electricity than their conventional counterparts, while power monitors allow electricity users to see how much power they are using and save by reducing their consumption. Other efficient appliances make up 1.1 percent of total estimated EE savings in the period from 2015 to 2034.

A 45 percent rate of adoption of EE technology reduces electricity demand by 3,301 GWh over the period 2015 to 2034. Based on data for a range of different technologies, the savings per kWh compared to the conventional benchmark is between US$0.10 and US$0.17 per kWh. The NPV using a 12 percent discount rate of total savings from EE over the period is US$127 million.

2.2.4 Solar PV

Currently, solar PV systems installed in the Eastern Caribbean consist of distributed systems amounting to about 1.4 MW[18] and of utility-scale solar PV facilities of about 2.4 MW. An additional 1.5 MW of solar PV is planned in Saint Kitts and Nevis.[19]

Solar PV represents a portion of the unrealized potential for the region, and is an increasingly attractive option to save diesel fuel thanks to a continued decrease in capital costs of this technology, and increasingly interesting options for energy storage.

Solar PV is also a valuable technology for the region because the hours of the day when solar PV panels generate often coincide with peak load. In addition, solar PV's load curve is predictable, allowing utilities to plan dispatch more efficiently. In comparison to wind, solar PV is also generally easier to permit and develop.

The Eastern Caribbean has a very good solar resource. It is estimated that solar PV could generate 547 GWh and save US$5 million by 2034.

We calculate the rate of savings from solar PV compared to diesel generation with the following assumptions:

- **Utility scale** with capital cost of US$2,250 per kW installed,[20] O&M cost of US$17 per kW per year, and a discount rate of 10 percent.[21] This yields a LRMC of US$0.18 per kWh, which consists of US$0.17 per kWh unit capital cost and an additional US$0.01 per kWh for the O&M cost.
- **Commercial scale distributed** with capital cost of US$2,750 per kW installed,[22] O&M cost of US$18 per kW per year, and a discount rate of 5 percent (assuming concessional loans from donors).[23] The LRMC based on these costs is US$0.15 per kWh. Specifically, the unit capital cost is US$0.14 per kWh and the O&M cost is US$0.01 per kWh.
- **Residential scale distributed** with capital cost of US$3,250 per kW installed,[24] O&M cost of US$28 per kW per year, and discount rate of 5 percent (assuming concessional loans from donors), and no storage backup.[25] These costs yield a LRMC of US$0.18 per kWh. The unit capital cost is US$0.17 per kWh and the O&M cost is US$0.02.[26]

All solar technologies considered in this study prove to be economically viable in four of the six OECS countries considered. Utility scale solar PV is not economically viable in Saint Kitts and Nevis or in Saint Lucia. Residential scale solar PV is not economically viable in Saint Kitts and Nevis.

Utility scale solar PV saves between US$0.01 and US$0.04 per kWh. Distributed generation solar PV at commercial scale saves between US$0.07 per kWh and US$0.11 per kWh. Finally, distributed generation solar PV at residential scale saves between US$0.01 per kWh and US$0.12 per kWh. The cumulative savings generated from implementing solar PV technologies are US$5 million.

2.2.5 Wind

The first wind farm to operate in the Eastern Caribbean is a 2.2 MW facility on Nevis. It has been operating since 2010. There are other wind developments under consideration in the region, for example, a 2 MW facility on Carriacou Island in Grenada and a 5.4 MW facility in Saint Kitts. The Carriacou plant has the potential to meet approximately 8 percent of the estimated wind potential shown in **Figure 2.2**.[27]

Wind energy has good potential in the region, but may face practical problems in implementation. Wind is estimated to generate 1,069 GWh of electricity in OECS countries, and save US$15 million by 2034 (NPV, using a 12 percent discount rate). The Eastern Caribbean has a good quality wind resource due to the trade winds blowing

[18] This excludes the savings from electricity that is generated in Dominica and then exported to Guadeloupe and Martinique.
[19] "Two New Solar Farms Planned for St Kitts-Nevis," Renewable Energy Caribbean, November 26, 2014, accessed March 20, 2015.
[20] National Renewable Energy Laboratory (2014).
[21] Lazard (2014). The LRMC was calculated using the average levelized costs of a 10 MW facility, with assumed capacity of 18 percent.
[22] National Renewable Energy Laboratory (2014).
[23] Lazard (2014). The LRMC was calculated using the average levelized costs of a 1 MW facility, with assumed capacity of 18 percent.
[24] National Renewable Energy Laboratory (2014).
[25] Lazard (2014). The LRMC was calculated using the average levelized costs of a 5 kW facility, with assumed capacity of 18 percent.
[26] The sum of unit capital cost and O&M cost may not seem to equal the LRMC due to rounding.
[27] Calculated as 2000 kW × 8760 hours in a year × 20 years × 0.28 capacity factor divided by 1,000,000 (GWh conversion) = 98 GWh out of 1,643 GWh projected yields 6 percent.

from the northeast. The wind quality is best in the southern islands: Dominica, Grenada, Saint Lucia, and Saint Vincent and the Grenadines. The northern islands (Antigua and Barbuda and Saint Kitts and Nevis) also have commercially exploitable wind resources, despite milder winds. Actual development may be limited by low social acceptance and difficulties in securing the required land (although distributed generation turbines could solve, at least in part, this problem at a higher cost), as well as complex and lengthy permitting and planning processes.

Wind energy is estimated to save between US$0.01 and US$0.08 per kWh compared to conventional generation.

The potential for intermittent technologies could be higher if further energy storage technologies were implemented. The analysis contained in the Inter-American Development Bank paper "Potential for Energy Storage in Combination with Renewable Energy in Latin America and the Caribbean"[28] suggests that battery storage is already viable in small island countries of the Caribbean, and can increase the penetration of intermittent RE like wind.

2.2.6 Waste-to-energy

There are no waste-to-energy facilities operating in the Eastern Caribbean, but governments in the region are interested in developing this resource. The Cabinet of Saint Lucia approved development of a waste-to-energy facility in 2011, though no physical development has begun. The government, with the assistance of the Carbon War Room, published a Request for Qualifications for the development of the facility by the end of 2014.

The Government of Grenada has also explored developing biomass resources. In 2011, the Grenada Solid Waste Management Authority (GSWMA) commissioned a study to assess the potential of a waste-to-energy project. The study identified a waste-to-energy project that would cost US$48 million to develop.[29] The GSWMA issued a request for expressions of interest in 2011. The Government of Grenada wanted to have an operating waste-to-energy facility by the end of 2015.[30] However, it is not evident that the GSWMA awarded the contract for this project, nor that any progress in developing biomass resources has been made since then.

Studies on Saint Vincent in 2009 suggested a combination of municipal waste and crop residues could power a biogas plant of 3–4 MW. The study assessed the potential of different biomass residues and the availability of plants dedicated to electricity generation from biogas.[31]

Waste-to-energy technologies are estimated to generate a cumulative 784 GWh by 2034. The NPV of savings from waste-to-energy is US$9.6 million using a 12 percent discount rate. The waste-to-energy technologies included in the analysis are landfill gas to energy and anaerobic digestion. Both are mature base load technologies that can be tailored to the size of available waste streams in the Eastern Caribbean countries.

In the analysis presented in Figure 2.2, it is assumed that Antigua and Barbuda, Grenada, and Saint Vincent and the Grenadines install 2 MW anaerobic digesters in 2020 (Antigua and Barbuda and Grenada) and in 2030 (Saint Vincent and the Grenadines). Antigua and Barbuda would save US$0.06 per kWh and Grenada would save US$0.04 per kWh, while Saint Vincent and the Grenadines would save US$0.02 per kWh. Finally, assuming Saint Lucia installs the 3 MW waste-to-energy plant that is planned to come online in 2016, this would generate savings of US$0.04 per kWh. The impact of waste-to-energy is limited by the relatively small size of waste streams available, which keep plant sizes under 3 MW.

2.2.7 Hydro

Saint Vincent currently has 5.7 MW of installed hydro capacity. Studies of the island's remaining hydro potential were conducted, but no concrete steps to construct a plant have been taken. Dominica has 6.6 MW of installed hydro capacity. Like Saint Vincent, preliminary studies indicate the presence of an untapped resource, but there is no physical development yet. The other island states in the Eastern Caribbean do not have hydropower potential.

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[28] Inter-American Development Bank, "Potential for Energy Storage in Combination with Renewable Energy in Latin America and the Caribbean," Technical Note no. IDB-TC-626, February 2014.

[29] Government of Grenada, The National Energy Policy of Grenada: A Low Carbon Development Strategy for Grenada, Carriacou and Petite Martinique, 2011.

[30] GSWMA (2011).

[31] Government of Saint Vincent and the Grenadines (2010).

Expansion of hydropower is projected to generate 488 GWh and save US$12 million in the region by 2034 (NPV, using a 12 percent discount rate). In Saint Vincent and the Grenadines, 9 MW of hydro capacity would come online in 2025. Hydropower has the potential to save US$0.14 per kWh compared to conventional generation. However, the downside of hydropower is that it is a seasonal source of generation.

Despite being a mature, low-cost technology, hydro makes a relatively small contribution to savings shown in Figure 2.2 since only two countries have available resources.

2.3 Current Efforts to Support Sustainable Energy

Countries in the region have taken concrete steps that will help them realize their sustainable energy potential (see Box 2.2 for distributed renewable generation, and Appendices C through H for more details):

- In **Antigua and Barbuda**, the government approved a national energy policy in 2011,[32] outlining its objectives and proposed legal, regulatory, and institutional reforms, with a focus to increase energy conservation and RE development. The government developed and published a Sustainable Energy Action Plan (SEAP) in March 2013 to set out a path for implementing the reforms proposed in the draft policy. Furthermore, the utility has developed a framework for the first grid-connected distributed generation systems. In addition, the government has approved a Sustainable Island Resource Fund (SIRF), which in part intends to finance RE development. For more information, see Energy Dossier: Antigua and Barbuda.
- In **Dominica**, the government has developed a draft national energy policy and draft SEAP, as well as a Low Carbon Climate Resilient Strategy. It also has experience in implementing EE on its own premises. A geothermal bill and draft environmental regulations for RE have been prepared. As of March 2015, the bill has been reviewed by the Attorney General, the legal experts in the Ministry of Legal Affairs, and international experts. The government expects it to go to Parliament soon.[33] The government is pursuing geothermal development for the domestic and export markets. The activity of the Independent Regulatory Commission (IRC) corresponds to best practices for promoting least-cost renewable generation. The electric utility has sound experience operating hydro plants, and has set an objective of generating 40 percent of the island's energy from renewable sources by 2017. The government is also working to develop a geothermal power plant. It has drilled a production well and is in the process of confirming the interest of a project developer and signing the project agreements. For more information, see Energy Dossier: Dominica.
- In **Grenada**, the government published a national energy policy and a SEAP in 2011, calling for the implementation of institutional, legal, regulatory, and fiscal measures to increase the use of RE and EE technologies, enhance energy conservation, and exploit local hydrocarbon resources. The government has experience in implementing EE on its premises, and launched a public sector energy conservation program in 2010. The government and the electric utility have set objectives for future renewable generation, and have taken concrete steps towards developing solar PV (0.54 MW installed capacity) and wind options (a 2 MW installed capacity planned to come online in 2016). The utility also began to develop a geothermal bill and draft regulations for geothermal development. However, these efforts were halted in 2013 and the final drafts of these documents have not been finalized. A Grenada vision for 2030, approved in 2012, calls for a 100 percent RE target for both the electricity and transport sectors. However, the government has not advanced in creating the laws and regulations for developing RE and EE. The electric utility has implemented two subsequent arrangements for distributed renewable generation. For more information, see Energy Dossier: Grenada.
- In **Saint Kitts and Nevis**, the first wind farm in the Eastern Caribbean is operating under a power purchase agreement (PPA) with the electric utility in Nevis. Saint Kitts Electricity Company (SKELEC) signed a 20-year PPA in 2011 with project developer North Star to develop another wind farm on Saint Kitts. Saint

[32] Government of Antigua and Barbuda, Sustainable Energy Action Plan, March 2013, accessed July 29, 2015, http://www.oas.org/en/sedi/dsd/Energy/Doc/EAP_AntiguaBarbuda_web.pdf. Confirms the approval of the National Energy Policy; however, the policy is not publicly available.
[33] "Geothermal Bill to Go before Parliament Soon" (2015).

Kitts also hosts a 1.3 MW solar farm, the first in the Eastern Caribbean of this scale. Nevis hosts one of the best documented geothermal resources in the Eastern Caribbean, and the Nevis Island Administration is committed to using renewable resources for 100 percent of its electricity generation and for exporting it to Saint Kitts (via an undersea interconnection) and potentially to other neighbors as well. In September 2014, the Nevis Administration signed a 20-year concession agreement with Nevis International to develop a geothermal project. The draft PPA and lease for exploiting the exploration areas are under review, and exploratory drilling is expected to begin soon after that. In 2014, with support from the European Union, the Government of Saint Kitts updated the Electricity Supply Act (ESA) and the Energy Policy. SKELEC and the Ministry of Energy are currently developing the legislation for a feed-in tariff for distributed generation. Further, EE audits were carried out in 2012 as part of the Caribbean Sustainable Energy Program. For more information, see Energy Dossier: Saint Kitts and Nevis.

- In **Saint Lucia**, the government has proposed reforms under the national energy policy, which the Cabinet approved in 2010, to lower the country's dependence on imported fossil fuels, including a RE portfolio standard, regulatory reform (including least cost in generation with private sector participation), encouragement of distributed renewable generation, and EE mandates. Saint Lucia agreed to participate in the Eastern Caribbean Energy Regulatory Authority (ECERA),[34] which would be established as an advisory agency by the end of 2015. ECERA will provide advisory support to the national regulators. The government, with support from the World Bank, is also working to reform the legal and regulatory framework of the energy sector to promote IPPs of RE. It drafted the Electricity Services Supply Bill and accompanying regulations that would replace the ESA and allow for the independent power producers to participate in the electricity sector to expand RE.[35] The Energy Supply Bill is expected to be completed and passed by Parliament in 2016.[36] The government has also announced it will pilot legislation through Parliament for the establishment of the National Utilities Regulatory Commission (NURC), a multi-sector regulator for the energy and water sectors. The government is also carrying out surface exploration with grant funding from the World Bank. The electric utility has extensive experience with smart meters to manage demand. EE lighting initiatives have taken place, and there are voluntary EE labeling standards for lighting too. For more information, see Energy Dossier: Saint Lucia.
- In **Saint Vincent and the Grenadines**, the electric utility already generates some electricity using small hydroelectric plants. The government is working with several private companies to develop a geothermal power plant and completed surface exploration in July 2015. The project will proceed directly to exploratory drilling, skipping slim-hole drilling. The government has released a national energy policy and an Energy Action Plan calling for various measures for developing RE in the country (reaching a goal of 60 percent of generation by 2020). The government has also provided incentives for EE technologies, and the Action Plan calls for further ones. Energy audits have been performed for 70 government buildings, and have informed action plans for reducing energy consumption in the buildings. The government drafted the Geothermal Resources Exploration and Development Bill and in 2014 the Prime Minister expected that it should be approved during the next two sittings of Parliament.[37] For more information, see Energy Dossier: Saint Vincent and the Grenadines.

[34] At the 44th OECS Authority Meeting in 2007, the heads of state of the OECS countries agreed to adopt a regional approach to carry out the necessary regulatory reforms. They decided to establish a regional energy regulator as a way to improve efficiency in electricity service delivery in Member States. At the 49th OECS Authority Meeting in 2009, Grenada and Saint Lucia expressed formal interest in establishing ECERA and accepted the World Bank's support to do so. However, the two other countries that could have joined the initiative did not do so, and there has been limited progress in establishing the ECERA as a regional regulator. In February 2015, Saint Lucia and Grenada agreed that ECERA would be established by the end of 2015 as an advisory agency to national regulators instead of a regional regulatory agency. Grenada has moved ahead in drafting the legislation necessary to establish the Public Utilities Regulatory Commission, which would act as its national regulator.

[35] Compton (2015).

[36] Compton (2016).

[37] "St. Vincent Geothermal Power Plant Could Be Operational by 2018" (2014).

BOX 2.2 Distributed Renewable Generation in the Region

Antigua and Barbuda. The Antigua Public Utilities Authority (APUA) has developed a new interconnection policy for customer-owned RE systems with a rated capacity up to 50 kW. Several customers have registered to participate once the interconnection process is operational. APUA connected the first distributed systems to the grid in 2012. APUA will allow for a maximum penetration of distributed RE equivalent to 15 percent of annual peak demand. The utility will also accept the implementation of a limited number of larger (up to 225 kW) pilot projects.

Dominica. DOMLEC has published a policy for interconnection of customer-owned generation. Between December 2010 and March 2012, three distributed RE installations came online: a 22 5kW wind turbine at Rosalie Bay Resort, a 9 kW solar array at a private residence in Castle Comfort, and a 50 kW solar array at a commercial property in Canefield. In March of 2012, Rosalie Bay Resort applied for the permission to interconnect another 32 kW to the grid. Rosalie Bay Resort later installed a distributed generator with 257 kW (DOMLEC, 2013).

Grenada. In February of 2007, Grenada Electricity Services Ltd. (GRENLEC) launched the pilot phase of its Interconnection Programme. Under the pilot phase, GRENLEC capped the installed capacity it would allow at 300 kW. Customers had the option to establish a net metering or net billing arrangements with GRENLEC. By 2011, the capacity allowed under the pilot phase had been fulfilled with 54 distributed generators.

As a result, in 2011 GRENLEC launched Phase II of the Interconnection Programme and increased the allowable capacity by another 500 kW, for a total of 800 kW. GRENLEC only offers net billing arrangements in Phase II. GRENLEC offers Interconnected Customers the option to purchase electricity at a fixed price per kWh for a 10-year period, or at a variable price that is adjusted annually to reflect GRENLEC's avoided cost of fuel. Through June 2014, GRENLEC had approved nine distributed generation facilities (with total installed capacity of 66.3 kW) to connect to the grid under Phase II.

Note: See Appendices C–H.

3 Barriers to Sustainable Energy Development in the Region

As suggested by Figure 2.2, there is significant potential for countries of the Eastern Caribbean to save money on electricity by using a variety of sustainable energy technologies. Why, in spite of significant sustainable energy potential and concrete steps taken in the right direction, is this potential still unrealized? This section identifies the barriers that continue to prevent the development of sustainable energy projects in the region.

Table 3.1 summarizes the barriers examined in this section, which are organized in four categories:

- **Information barriers**—limited information about sustainable energy options causing energy consumers and governments to continue with the status quo
- **Legal and regulatory barriers**—continued dependence on outdated frameworks that favor traditional fossil fuels over sustainable energy technology
- **Market barriers**—limited human capital, hard to come by sustainable energy equipment, difficulty in telling good-quality from poor-quality equipment
- **Financial barriers**—limited funding for good projects, low interest in financing good projects, or limited availability of appropriate terms for project financing

Table 3.1 below discusses these barriers further.

Table 3.1 Barriers to Sustainable Energy Development in the Eastern Caribbean

Barriers		Affected Countries		
Category	Description	Utility RE	Distributed RE	Distributed RE
Information	Limited information on wind resources	A&B, DOM, GR, SL, SVG	A&B, DOM, GR, SL, SVG	
	Limited information on waste quantities and quality	A&B, SKN, SVG		All countries
	Limited public awareness of costs and benefits of sustainable energy technologies	All countries	A&B, SL, Saint Kitts, SVG	All countries
Legal and Regulatory	No obligation or incentive for utilities to purchase from large and small independent power producers (third parties' inability to sell)	A&B, GR, SL	A&B, SL, Saint Kitts, SVG	
	Licensing regime for third parties is nonexistent, unclear, or too onerous for large and small independent power producers (third parties' inability to sell)	A&B, GR, SL	A&B, SL, SKN	
	Uncertainty of cost recovery through tariffs of efficiently incurred sustainable energy investments	A&B, GR, Saint Kitts, SL	A&B, GR, Saint Kitts, SL	A&B, GR, Saint Kitts, SL
	Unclear rights to use geothermal resources	GR, SL, Saint Kitts, SVG		
	Unclear land rights to access sites for project development	A&B, GR, Saint Kitts, SL, SVG		
Market	Information asymmetry between suppliers and customers of energy services and equipment		All countries	All countries
	Relatively limited RE and EE equipment available, relatively high costs		All countries	All countries
	Limited capability to originate and conclude loans	All countries	All countries	All countries
	Lack of technical and professional capacity and capability to assess and install RE and EE projects	All countries	All countries	All countries
	Lack of experience of utility staff in operating and maintaining RE plant	All countries		
	Limited capabilities in planning and implementing sustainable energy policies	All countries	All countries	All countries
	Limited capacity and capabilities in carrying out electrical inspections for RE systems	All countries	All countries	
Financial	Limited access to capital on appropriate terms (high interest rates, high guarantee requirements, short loan durations, no grace periods)	All countries	All countries	All countries
	Fiscal constraints	All countries	All countries	All countries
	Limited creditworthiness of off takers (utilities) for renewable generation projects	A&B, SKN	A&B, SKN	A&B, SKN
	Lack of incentives to invest due to mismatch between investment decisions and operating decisions ("agency problem")	SL, GR	All countries	All countries
	Limited private sector interested in investing in sustainable energy projects	All countries	All countries	All countries

Note: Antigua and Barbuda (A&B), Dominica (DOM), Grenada (GR), Saint Kitts and Nevis (SKN), Saint Lucia (SL), Saint Vincent and the Grenadines (SVG).

A more complete table presenting the barriers and interventions to overcome those barriers, as well as the organizations executing those interventions, is found in Appendix B.

3.1 Information Barriers

To make informed choices about sustainable energy, governments and individuals need information on the costs and benefits of options available to them. Consumers need information about the products they buy. Utilities and governments need information on the sustainable energy resources available to them. The Eastern Caribbean may be unable to achieve its sustainable energy potential until options are properly understood by those who would benefit from them.

3.1.1 Lack of information on renewable energy resources

There is clear potential for RE in the Eastern Caribbean. However, few renewable resources are well documented in a commercially exploitable way. This is particularly the case for wind and geothermal resources. This creates a barrier to development especially considering that in some other markets there is government-supplied data available to developers on specific sites, which makes those sites more attractive targets for investment. Better information on the geothermal resources on Saint Lucia would hasten the development of its resource. Wind maps and site-specific assessments in all countries in the Eastern Caribbean would help facilitate investment in wind generation.

3.1.2 Lack of public awareness of sustainable energy costs and benefits

Households and businesses in the Eastern Caribbean lack the information to make informed decisions about using EE and distributed generation technologies. There may be limited information about what sustainable energy options are available, and what energy saving practices one can benefit from. There may also be limited information about the actual technical, economic, and financial benefits of sustainable energy options. As a result, households and businesses are unlikely to risk investing in sustainable energy technologies they are unfamiliar with.

3.2 Legal and Regulatory Barriers

Legal and regulatory frameworks for the power sector in most Caribbean countries favor fossil fuel–based power generation and are not designed to promote RE. In the past only fossil fuel–based energy was a technically viable option, so regulation was formulated specifically for that type of generation. These regulations create a powerful incentive for utilities to continue operating as they have in the past, rather than incorporate sustainable energy technologies.

3.2.1 No obligation for utilities to purchase from third parties

There are viable distributed generation and utility scale projects in the Eastern Caribbean that utilities may be unable or unwilling to do, particularly when they involve unknown or complex technologies that are very different from the utilities' business. Third parties cannot take advantage of those opportunities unless the utility is required to purchase the electricity generated by a project. In Antigua and Barbuda, Grenada, and Saint Lucia there is no requirement that utilities purchase from utility scale IPPs at a value lower than their own avoided cost. In Antigua and Barbuda, Saint Lucia, Saint Kitts, and Saint Vincent and the Grenadines there is no requirement for the utility to purchase power from distributed generation at or below avoided cost.

3.2.2 Inadequate licensing regime for third-party power producers

The licensing regime for third-party power producers in Grenada and Saint Lucia does not allow utility scale generation by IPPs. In Antigua and Barbuda there is a precedent for IPPs selling to the utility, but the licensing process is not fully clear or efficient. IPPs could potentially develop, build, operate, maintain, and finance sustainable energy projects (see Section 3.3.4), but this is not possible unless regulations permitting third-party generation are introduced.

Licensing inadequacies also hamper the development of distributed scale RE in Saint Kitts and Nevis and Saint Lucia. In Saint Kitts and Nevis, consumers are unable to realize the full potential of distributed generation because the utility does not purchase the excess electricity they generate. In Saint Lucia, interconnection is negotiated with the utility on an ad hoc basis, and there is no standard offer contract (or policy, like in Dominica and Grenada) in place. This makes it harder for customers to connect their system and slows development of distributed systems. Although further reductions in costs are expected for solar PV to reach its full potential in the region, currently the difference in generation costs is relatively low, so all the electricity that solar PV systems produce must be consumed for them to be economically viable. This is only likely to be the case if the owner can sell excess power back to the utility.

3.2.3 Uncertain utility cost recovery mechanisms

For a utility to be financially viable, it must be able to recover the costs of service through tariffs. Because of the dominance of fossil fuel–based generation in the Eastern Caribbean, these cost recovery mechanisms are designed for fossil fuel (primarily diesel) generation. Utilities recover the cost of capital investments through a base rate, and then pass the cost of fuel directly to the consumer via a fuel surcharge. There is no equivalent mechanism appropriate for recovering costs for RE technologies, which are all capital cost and no fuel cost. Utilities could request a rate case to adjust tariffs to reflect a new cost recovery mechanism, but rate cases are rare and may be a disincentive to invest in renewables since recovering the cost of diesel generation is, in comparison, very easy and certain.

3.2.4 Unclear geothermal rights

Geothermal energy was not considered a resource for electricity generation in the Eastern Caribbean in the past when most laws and regulations in force today were drafted. In most countries it is unclear how a geothermal resource is defined, who owns it, and who can access it for electricity generation purposes. Concessions for developing geothermal resources have been granted on a case-by-case basis, without clear rights being in place. Nevis, Saint Lucia, and Saint Vincent and the Grenadines have all granted one-off exploration or development rights to private companies. Grenada and Dominica developed a draft legal and regulatory framework, but in both countries legislation and regulations had not been approved by Parliament as of July 2015.

3.2.5 Unclear land rights for potential renewable energy project sites

This barrier refers to inadequate or unclear processes and rules for accessing land to develop utility scale RE projects. RE projects require site-specific resources, so access to particular locations is more critical than for fossil fuel projects (which can be located almost anywhere). Any generating facility also needs to include access roads, and transmission lines for transporting electricity to the distribution network. In practice, this supporting infrastructure crosses other people's land. Unclear or incomplete land rights frameworks create a great barrier to resource development, and can prevent otherwise viable RE projects from being developed.

3.3 Market Barriers

Absent market barriers, the products and skills necessary to complete a sustainable energy project would be available at a competitive price and a known quality. However, human capital is often not at its full potential, sustainable energy products are relatively hard to come by, and evaluating the products available is difficult for the consumer. These barriers reduce demand for sustainable energy technologies, or reduce the supply of those technologies.

3.3.1 Information asymmetry in energy service and equipment markets

It is difficult for consumers in the Eastern Caribbean to evaluate EE and distributed generation products and services, due to information asymmetry between consumers and those who supply products and services. Consumers may be unable to tell good equipment from poor-quality equipment. Similarly, they may not know which energy service providers have the necessary skills and experience to be trustworthy. This information asymmetry acts as a market barrier to further uptake of sustainable energy technologies.

3.3.2 Limited sustainable energy equipment available at relatively high costs

The current market for RE and EE technology in the Eastern Caribbean is small. There are some retailers selling EE technologies, but fewer providing distributed generation products and services. For example, only Grenada has a dedicated distributed solar PV installation company. Because there are few companies providing RE and EE products and services, prices are relatively high in these markets, dampening demand.

3.3.3 Likely limited capability to originate and conclude loans

Financial institutions in the Eastern Caribbean, as in many other emerging markets, have relatively limited experience in lending to RE or EE projects that are not at utility scale. Most financial operators are unfamiliar with distributed scale technologies and their economics, as well as the possible loan structures for these transactions. Even if there are financial resources available, they may be of little use unless there is adequate capability to originate and conclude loans. This type of problem has been experienced in nearby Barbados, where a Smart Energy Fund (see Box 3.1), established and capitalized to provide consumer financing for sustainable energy projects, has taken several years to master the lending learning curve. While the financial sector in the Caribbean has advanced expertise it could build on, it is prudent to expect that delays similar to those encountered elsewhere in the region may also happen in the six countries considered, and act to prevent them.

BOX 3.1 Barbados Smart Energy Fund

The Government of Barbados has established a Smart Fund to provide financial and technical support to RE and EE projects in Barbados. To capitalize the Smart Fund, the government has obtained a loan of US$10 million from the IDB.

The objectives of the Smart Fund are to increase:

• The use of viable RE and EE technologies in Barbados, in order to decrease energy costs of the population.

• The country's energy security by reducing its dependency on imported fossil fuels; and

• Local and global environmental sustainability by reducing emissions of polluting substances, particulate matter, and carbon dioxide (CO2) and other greenhouse gases.

This objective is consistent with that of the government's Sustainable Energy Framework for Barbados (SEFB), the comprehensive policy framework within which the Smart Fund is implemented.

The Smart Fund is comprised of six facilities. These six facilities are organized under two components, based on the entity that executes them:

• Enterprise Growth Fund Limited (EGFL) executes Component One, which includes five facilities: four facilities that issue grants (Technical Assistance Facility, Pilot Consumer Finance Facility, EE Lighting Distribution Facility, and A/C Rebate Trade-In Facility), and one that issues loans (EE Retrofit and RE Finance Facility).

• The Energy and Telecommunications Division of the Office of the Prime Minister of Barbados directly executes Component Two, which consists of a Discretionary Grant Facility, providing money for supporting the operation of the other five facilities, implementing awareness and education on RE and EE, and monitoring and collecting data on the Smart Fund's activities.

3.3.4 Limited capacity and capability to assess and install utility scale projects

Implementing a RE project requires different capabilities than the fossil fuel generation projects the region's utilities are used to implementing. The skills to assess renewable resources, navigate the regulatory requirements, and procure services for RE projects are relatively rare in the region. Even if a utility decides to contract with an IPP, that utility will still need some level of RE expertise in-house to evaluate the progress of the project and make sure that the contract between the two parties is fair and reasonable.

3.3.5 Limited utility experience operating and maintaining renewable energy plants

Because the Eastern Caribbean utilities do not currently operate or maintain RE plants (except for hydro), they may sometimes not have the full technical and professional skills needed to do so successfully. Training and staff development will be necessary to build RE operations and maintenance skills within the utilities. This may be especially important in Saint Lucia and Grenada, where IPPs cannot be licensed, unless the vertically integrated electricity utilities directly grant a sub-license to the IPP. In countries where IPPs are permitted, the utility's technical ability to operate and maintain RE plants is less critical since the IPP can be contracted to build, own, operate, and maintain RE assets.

3.3.6 Limited government capabilities to implement sustainable energy programs

The limited staff and resources of Eastern Caribbean governments make it difficult for them to implement sustainable energy programs. This is demonstrated by the fact that the six OECS countries considered in this study have each drafted a national energy policy but have yet to adopt it or begin implementing it.

Implementing sustainable energy programs also requires inspectors with the technical skills to perform electrical inspections on distributed generation systems. As more such systems come online, electrical inspectors could face a growing backlog of projects if they do not increase their capacity and capability to perform inspections.

3.4 Financial Barriers

Absent financial barriers, money goes to good projects on appropriate terms. This is not the case for sustainable energy projects in the Eastern Caribbean. Financial barriers in the region could be: limited funding for good projects, low interest in financing viable projects, or limited availability of appropriate terms for project financing.

3.4.1 Limited access to capital on appropriate terms

Distributed scale RE and EE projects require an upfront capital investment. Many households in the Eastern Caribbean have limited access to credit, so expensive equipment is unaffordable for them, even if the equipment would pay for itself over time. For example, a residential hot water heater costs around US$1,600, approximately 20 percent of Grenada's GDP per capita, which was US$7,891 in 2013 (World Bank, 2015b). This could be because the interest rate is too high, the loan duration is too short, or the guarantees required are excessive or difficult to secure.

Limited access to credit is exacerbated by the fact that the technologies are new and unfamiliar, so many banks are unwilling to lend against them. Additionally, few equipment suppliers have developed hire purchase schemes (a method of buying something by making installment payments over time) or other consumer finance arrangements for these technologies.

3.4.2 Fiscal constraints

The debt burden of several Eastern Caribbean governments makes it hard for them to borrow, even if there are distributed generation or EE projects that may save them money in the long run, for example energy retrofits of government buildings. The gross debt-to-GDP ratios of the six countries (for which the IMF provides data) are presented below.

Table 3.2 Gross Debt-to-GDP Ratios in the Eastern Caribbean

Country	2013 %	2014 %	2015 %
Antigua and Barbuda	92.2	100.8*	98.7
Dominica	75.0	75.8*	76.3
Grenada	115.0	105.5	115.7
Saint Kitts and Nevis	104.9	91.2*	80.0
Saint Lucia	79.8	83.7*	87.0
Saint Vincent and the Grenadines	76.4	85.0*	84.9

Source: International Monetary Fund (2014).
Note: Figures with * are estimates.

Government debt also makes it difficult for government-owned utilities to secure funding. Antigua and Barbuda, Saint Kitts and Nevis, and Saint Vincent and the Grenadines all have government-owned utilities that could find their ability to borrow constrained.

Reducing government expenditure through increased adoption of sustainable energy technology could free up fiscal space for governments in the region. For example, in 2011 approximately 2.5 percent of Grenada's recurrent expenditure budget was spent on electricity, equivalent to US$592,600 per month (Burke, 2012). The 2012 Budget Statement sets the goal of reducing the government's energy consumption by 20 percent, which would represent freeing up 0.5 percent of the recurrent expenditure budget for the country. More aggressive implementation of EE technology could save the government even more money on its electricity bill. The other countries in the Eastern Caribbean could also benefit from increased fiscal space from reduced electricity consumption.

3.4.3 Limited creditworthiness of utilities

Utilities must be creditworthy in order to secure financing for their own projects, or to be a reliable buyer of power generated by third parties (distributed generation or utility scale). Third-party power producers need a creditworthy utility to sell to in order to secure financing for their sustainable energy projects. Some of the utilities in the Eastern Caribbean, in spite of being well managed, are not creditworthy enough to secure their own financing or to reliably purchase power from third parties; APUA and SKELEC are reported to be especially financially weak (see Energy Dossiers of Antigua and Barbuda and Saint Kitts and Nevis).

3.4.4 Misalignment between investment decisions and operating decisions

Investments in viable EE and distributed generation technologies can be prevented when agents who are responsible for making the investment decisions are not the people who would benefit from the savings from that investment. This mismatch between capital and operating expenditure decisions is known as an "agency problem," and leads to inefficient choices for the purchase of technologies, such as, for instance, selecting equipment that is cheaper, but that consumes more electricity (and therefore costs more) over its lifetime. For example, people who develop buildings or rent out properties may have an incentive to keep capital costs down, and disregard the possibility of installing technologies that reduce electricity bills.

3.4.5 Limited private sector interested in investing in sustainable energy projects

The lack of economies of scale and inexistent or unclear regulation for private participation in the sector discourages the private sector from investing in sustainable energy projects in the countries of study. This barrier is therefore directly related to the legal and regulatory barriers discussed in Section 3.3. Multilaterals can play a role in overcoming this barrier in two ways. First, they could finance earlier, riskier stages of sustainable energy projects. That way, the private sector would be more attracted to invest in later stages. Second, they could support countries in preparing or modifying necessary regulations and laws such that rules for private participation become more clear. Advice could also be provided to governments in drafting contracts with private partners, which incorporate the lack of an appropriate or complete legal framework. If the private sector plays a more relevant role in financing sustainable energy projects, the countries could avoid taking on more public debt and, as a result, improve national accounts.

4 Conclusion: Opportunities to Realize the Eastern Caribbean's Sustainable Energy Potential

The barriers to RE development in the Eastern Caribbean are not insuperable; a few are already starting to be overcome. The sustainable energy technologies with greater potential in each country are summarized in **Table 4.1** (Appendix C shows the full analysis of all options). This section also shows how the barriers to support the development of those technologies can be overcome, as well as to what extent (and by whom) those barriers are currently being addressed.

Table 4.1 Renewable Energy Technologies with Greater Potential

Technology	Antigua and Barbuda	Maturity (0–2)	Availability of resource (0–2)	Viable?	Estimated Potential
Antigua and Barbuda	Solar PV	1	2	Yes	***
	Wind	2	1	Yes	**
	Waste-to-energy	2	Unknown	Maybe	*
Dominica	Geothermal	2	2	Yes	****
	Solar PV	1	2	Yes	**
Grenada	Geothermal	2	Unknown	Maybe	***
	Solar PV	2	2	Yes	**
	Wind	2	1	Yes	*
	Waste-to-energy	2	1	Yes	*
Saint Kitts and Nevis	Geothermal	2	2	Yes	***
	Wind	2	1	Yes	*
	Solar PV	1	2	Yes	*
Saint Lucia	Geothermal	2	Unknown	Maybe	***
	Solar PV	1	2	Yes	***
	Wind	2	2	Yes	**
	Waste-to-energy	2	1	Yes	*
Saint Vincent and the Grenadines	Geothermal	2	1	Yes	***
	Hydro	2	2	Yes	***
	Solar PV	1	2	Yes	**
	Wind	2	2	Yes	*

Note: **** >50 MW; *** 10–50 MW; ** 5–10 MW, * 1–5 MW.

Appendix B shows the barriers to RE development, organized by category, as well as interventions to overcome those barriers in a table format. Interventions can be of two types: technical assistance and/or investments. Appendix B also includes information on the entities and programs already conducting interventions and the nature of those interventions.

Figure 4.1 presents the order in which measures to overcome the barriers to sustainable energy in the Eastern Caribbean should be implemented.

FIGURE 4.1 Measures to Increase Uptake of Sustainable Energy Technologies

Information Measures	Make consumers, government, and businesses aware of sustainable energy opportunities available to them.
Legal and Regulatory Measures	Create a legal and regulatory framework that allows the use and integration of sustainable energy.
Market Measures	Develop the market for sustainable energy products and services so that they are available for purchase.
Financial Measures	Provide or facilitate financing for sustainable energy projects.

Source: Author's own elaboration

4.1 Information Measures

Both developers and consumers in the Eastern Caribbean are unable to take full advantage of the sustainable energy opportunities available due to limited information. Developers often lack information about the RE resources available to the country (wind, geothermal, waste, etc.), and consumers are often unfamiliar about distributed generation and EE technologies. The following measures can remove or reduce information barriers to sustainable energy development:

- **Funding renewable energy resource assessments.** Though the presence of RE resources is well known, it can be difficult to evaluate if that resource is sufficient for commercial scale exploitation. The strong solar resource in the Eastern Caribbean is fairly well documented, but waste, wind, and geothermal resources are generally not well documented and could benefit from additional study. Funding scientific resource assessments removes one level of risk for the potential developer, be it the local utility or an IPP, by providing that information.

- **Providing technical assistance to outreach efforts for increasing the public's knowledge of sustainable energy.** Educational materials, best practices from other regions, and training can support governments in making their citizens aware of the benefits of using sustainable energy technologies.
- **Funding or providing technical assistance to create region-wide efficiency labeling standards for products.** An Eastern Caribbean–wide labeling standard would allow consumers to more easily compare and purchase equipment. It would also provide information specific to the region. The current Energy Star information on many products may not be totally accurate when devices operate in the Caribbean region, since it is developed for the North American market.

4.2 Legal and Regulatory Measures

Changes in laws and regulations are a lengthy and complex matter in any country, but in the Eastern Caribbean this may be even more the case because of the fact that frameworks are designed with powerful incentives for maintaining the status quo, which was created (appropriately, at the time) to allow recovering costs on conventional generation. Legal and regulatory measures would enable both independent power producers and small power producers. On the other hand, governments in the region generally have a strong commitment to reducing energy costs. Similarly, power utilities have a strong incentive to find new and clearly regulated ways to be profitable within the emerging technological context, a context in which customers may find it increasingly worthwhile to self-generate if changes are not made. Legal and regulatory measures to spur sustainable energy development include:

- **Providing technical assistance for utility regulation.** Shaping a country's electricity regulatory framework can incentivize utilities to diversify their generation base and pursue sustainable energy options. Some key changes to the regulatory environment that spur the use of sustainable energy technologies are:

  –Introduce an obligation for utilities to purchase from third parties (IPPs or distributed generation systems) when they generate at a price that is lower than the utility's own generation cost;

  –Introduce standard offer contracts for distributed renewable generation; and

  –Introduce cost recovery mechanisms for RE technology (similar to those for recovery of diesel fuel, but for capital costs instead), so that utilities choose between conventional generation and renewable generation on price only.

- **Providing technical assistance to create clear licensing processes for IPPs.** IPP licensing in the Eastern Caribbean, when it does happen, is often done on an ad hoc basis. Clear processes make it easier and faster for IPPs to develop projects and also reduce the risk of poor governance in the distribution of IPP licenses.
- **Providing technical assistance to draft clear legislation and regulation for land and resource access.** Given Eastern Caribbean governments' staffing constraints and relatively limited experience in sustainable energy, providing support in developing legislation for land and resource access could build on existing strengths and help remove a key bottleneck from RE project development.

4.3 Market Measures

Technical assistance can help develop the market for sustainable energy technologies in the Eastern Caribbean. The following measures address skills shortages, market size constraints, and agency problems. Some measures to overcome market barriers include:

- **Training or hiring staff** for financial institutions in the region to enable them to lend to sustainable energy projects. Providing technical assistance to local financial institutions will help build expertise in lending for sustainable energy technologies and ultimately increase their adoption.
- **Building utility capacity and capability** to develop sustainable energy projects and to procure operations and maintenance services for RE power plants. Utilities in the region need skills development and training in sustainable energy to economically build, operate, and maintain RE plants.
- **Providing technical assistance to governments** in implementing sustainable energy programs. In addition to technical assistance in drafting legislation and regulations for sustainable energy (see Section 4.2), government ministries could benefit from training in sustainable energy technologies.
- **Training electrical inspection departments** on sustainable energy. In order to bring distributed generation systems online safely, government entities will need to scale up their capacity and capability to conduct

interconnection inspections. This may require hiring more staff, as well as training existing staff to certify distributed RE connections efficiently and safely.

- **Funding consumer finance facilities** to increase demand for sustainable energy equipment and grow the market for such technologies. This measure is connected to some of the Information Measures described previously. In the context of market barriers, providing consumer financing increases demand for sustainable energy technologies and builds the market, ideally generating economies of scale.
- **Providing technical assistance to revise Eastern Caribbean building codes and mandate the use of energy efficient technologies.** EE building codes will increase demand for efficiency products, developing the market for sustainable energy technologies. It also reduces the agency problems between those who pay the capital costs for buildings and those who pay for their operations and maintenance.

4.4 Financial Measures

The financial barriers to sustainable energy development in the Eastern Caribbean can be overcome through technical assistance and investment. Financial measures would benefit small power producers (for example, businesses that want to install solar panels on their roof). The investment measures attempt to compensate for limited local capital (or the actual possibility to use it). Financial instruments that could catalyze lending to economically viable sustainable energy projects include:

- **Providing concessional loans for sustainable energy projects.** These loans could be to local financial institutions, governments, or utilities depending on the needs in individual countries. Concessional loans would have lower interest rates, longer terms, or grace periods to increase the financial attractiveness of sustainable energy projects.
- **Providing loan guarantees for sustainable energy projects.** Since local financial institutions do not have adequate experience lending to sustainable energy projects, outside institutions that understand the technologies can provide loan guarantees that enable local institutions to lend. This also helps familiarize local lenders with sustainable energy technologies and their financing structures so they can lend without guarantees in the future.
- **Creating a risk-sharing facility to invest in sustainable energy.** A risk-sharing facility creates a lower barrier to entry for investors interested in investing in sustainable energy. As private investors in the facility become more familiar with loans for sustainable energy, they could develop a portfolio containing structured information that eventually allows them to lend to these projects without special support.
- **Providing technical assistance structuring contracts with energy service companies.** Because there are few or no energy service companies currently operating in Eastern Caribbean countries, governments and businesses could benefit from training on how to structure energy service contracts.
- **Providing grants and contingent grants for sustainable energy projects and initiatives.** Strategically placed grants may be necessary to catalyze project development when there is no possibility of private financing. Grants can fund technical assistance, demonstration projects, public awareness, and other areas that help reduce the barriers described in Section 3. Contingent grants can fund earlier, riskier stages of projects.

Appendix A: Constructing the Sustainable Energy Supply Curve

This appendix summarizes the methodology for developing the Sustainable Energy Supply Curve presented in Section 2. Figure 2.2 presents the estimated cumulative amount of RE generation and EE savings that can be achieved across Antigua and Barbuda, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines over a 20-year period (from 2015 to 2034). Figure 2.1 also shows the difference between each technology's cost of generating or saving one unit of electricity, and the cost of one unit of electricity generated with conventional (fossil fuel–based) technology.

To produce Figure 2.2 we:

1. **Assess the cost of sustainable energy technologies in the six countries** to determine what technologies are viable and how much money they can save per kWh. This involves, for RE technologies, comparing their LRMC in US$ per kWh with appropriate conventional energy generation avoided costs benchmarks for each country. For utility scale intermittent RE technologies, such as wind and solar, the appropriate benchmark is the avoided cost of fuel. In regards to intermittent RE distributed generators, the benchmark used is the avoided cost of fuel grossed-up to include the estimated electricity losses in each country. For firm RE technologies, such as geothermal, hydro, and waste-to-energy, the appropriate benchmark is the avoided all-in cost of generation with diesel-fueled plants. For EE technologies, we compare their savings costs per kWh of electricity conserved with the appropriate conventional energy generation avoided costs benchmark—which is also the avoided all-in cost of generation with diesel-fueled plants. As a result of this approach, each country will have its own avoided cost benchmark for firm and intermittent RE.
2. **Estimate the potential cumulative electricity generation or electricity savings from each sustainable energy technology between 2015 and 2034** by assessing how much electricity can be generated from viable RE generation sources, and how much electricity can be saved from EE technologies (this saved electricity eliminates the need for electricity that would otherwise need to be generated from conventional sources). The electricity generated with firm RE technologies would displace energy generated from conventional energy generation technologies, while electricity generated with intermittent RE technologies would offset the variable cost of fuel used when generating with conventional energy technologies. Total electricity supply, of conventional plus sustainable sources, is set to meet demand.

The following sections summarize the methodology and assumptions used for completing each of these steps.

A.1 Assessing the Cost of Sustainable Energy Technologies

This section explains how sustainable energy technologies are benchmarked to conventional technologies to generate the "savings/cost per kWh" used in Figure 2.1. It also presents the data used to calculate LRMC for both EE and RE technologies.

A.1.1 Renewable energy technologies

Table A.1 presents the estimated costs of RE technologies that are feasible in the region, including solar PV, solar water heaters, wind energy, waste-based energy, geothermal power, and hydropower. Distributed generation and EE assume a discount rate of 5 percent (assuming concessional financing) and utility scale generation assumes a discount rate of 10 percent (assuming commercial financing). The table also presents different scales of the same technology. For example, there are three types of solar PV installations that vary in scale depending on their use (utility, commercial, or residential).

Table A.1: Cost Assumptions (US$) for Renewable Energy Technologies

Technology	System Size (kW)	Unit Capital Cost (US/kW)	O&M Costs (US$ per kW per yr)	Capacity Factor (%)	Total Annual Output (MWh per yr)	Life time (years)	LRMC (US$ per kWh)
Solar PV: Polycrystalline, fixed (commercial scale)	1000	$2,750	$18	18%	1,577	20	0.15
Solar PV: Thin film, fixed, small (residential scale)	5	$3,250	$28	18%	8	20	0.18
Solar PV (utility scale with l lead acid battery storage	10,000	$2,250	$17	18%	15,768	20	0.18
Solar water heater: 20kW flat plate, commercial	20	$1,100	$24	19%	33	20	0.07
Solar water heater: 2kW flat plate, small	2	$1,600	$20	17%	3	20	0.10
Wind (850 kW Class 1 turbines)	3,400	$2,500	$50	28%	8	20	0.14
Anaerobic digestion/ biogas (2 MW)	2,000	$7,780	$450	75%	6,750	20	0.21
Landfill gas to energy (3 MW) Carbon Room	3,000	$3,275	$450	75%	6,750	20	0.11
Waste to energy (3 MW internal combustion)	3,000	$8,500	$55	65%	5,691	20	0.18
Geothermal: Dominica Phase 1 (10 MW)	10,000	$5,200	$149	85%	74,460	25	0.10
Geothermal: Dominica Phase 2 (100 MW)	110,000	$4,827	$75	85%	819,060	25	0.08
Geothermal: Grenada (10 MW)	10,000	$8,600	$149	85%	74,460	25	0.15
Geothermal: Saint Kitts (25 MW)	25,000	$4,800	$149	85%	186,150	25	0.09
Geothermal: Nevis (10 MW)	10,000	$8,000	$149	85%	74,460	25	0.14
Geothermal: Saint Lucia (20 MW)	20,000	$7,600	$149	85%	148,920	25	0.13
Geothermal: Saint Vincent (10 MW)	10,000	$8,000	$149	85%	74,460	25	0.14
Commercial hydro (5,700 kW)	5,700	$2,000	$250	62%	30,928	20	0.09

Table A.2 below presents the avoided cost benchmarks used to calculate the savings that could be achieved in the six OECS countries.

TABLE A.2 Avoided Cost Benchmarks

Avoided Cost Benchmark	All-in cost of generation	All-in cost of generation adjusted for system losses	Cost of fuel	Cost of fuel adjusted for system losses
	Firm, unity scale	Firm, distributed scale	Non-firm, utility scale	Non firm, distributed scale
US$ per kWh				
Antigua and Barbuda	0.26	0.33	0.22	0.27
Dominica	0.23	0.25	0.18	0.20
Grenada	0.25	0.27	0.21	0.22
Saint Kitts and Nevis	0.20	0.23	0.15	0.18
Saint Lucia	0.22	0.24	0.18	0.19
Saint Vincent and the Grenadines	0.23	0.25	0.18	0.20

Figure 2.2 shows the difference between the LRMC and the appropriate avoided cost benchmark for each technology. Appropriate avoided costs benchmarks are different for different kinds of RE technologies:

- For **firm technologies**, we use the LRMC of the cheapest available generation option available to the grid. This is because firm options do not require backup capacity and can, therefore, offset the operating and maintenance, fuel, and capital costs that the utility would incur building new capacity.
- For **non-firm technologies**, we consider the offset operations and maintenance costs and fuel costs of conventional generation. This is because non-firm technologies require backup capacity for when their primary source of energy (for example, the sun) is not available.
- For **distributed generation technologies** we include an additional "grossing up" equal to transmission and distribution losses in each country. This is because they deliver their electricity at the load; thus, they are not subject to (and in fact avoid) transmission and distribution losses.

For the purposes of estimating the potential savings generated from the integration of RE and EE technologies in the Eastern Caribbean, the cost of fuel for utilities in the Eastern Caribbean was calculated based on information reported by CARILEC and the electricity utilities in those countries. Then, the fixed and variable operations and maintenance cost, and the unit capital cost, were added to the cost of fuel to calculate the all-in cost of diesel generation.

[38] These costs, other than the cost of fuel, are based on the average costs of two 13 MW diesel generators used in Barbados, as presented in Barbados Light and Power Company Ltd. (2014), which amounts to about US$0.04 per kWh.

Table A.3 Key Features of Energy Efficiency Technologies (in US$)

Energy Efficiency Measure	Applicable sectors*	Installed capacity	Lifetime	Yearly energy savings**	Annualized capital cost	Capital cost recovery factor	O&M costs***	Savings cost
		(kW)	(Years)	(kWh/year)	(US$)	(US$/kWh)	(US$/kWh)	(US$/kWh)
T8 Fluorescent Lamps w/ Occupancy Sensor	C, I, P	0.048	19	116.0	12.51	0.108	-	0.11
T5 High-Output Fluorescent Lamps	I, P	0.352	16	318.0	50.75	0.160	-	0.16
LED Street Lighting	P	0.059	12	258.4	56.41	0.218	0.04	0.26
LCD Computer Monitors	R, C, I, P	0.040	15	160.0	28.90	0.181	-	0.18
Efficient Window A/C Systems	R	1.000	15	730.0	48.17	0.066	-	0.07
Efficient Split A/C Systems	R, C, I, P	1.846	15	2,308.0	192.68	0.083	-	0.08
Efficient Residential Refrigerators	R	0.105	12	481.8	112.83	0.234	-	0.23
Efficient Retail Refrigerators (Condensing Unit)	C	0.525	15	812.0	192.68	0.237	-	0.24
Premium Efficiency Motors	I, P	9.846	20	2,191.2	120.36	0.055	-	0.05
Variable Frequency Drives	I, P	7.178	10	11,687.2	906.53	0.078	0.01	0.07
Efficient Chillers	I, P	14.064	20	23,439.8	3,209.70	0.137	-	0.14
Power Monitors	R	NA	20	315.6	8.02	0.025	-	0.03
Weighted Average		**0.96**	**9.71**	**1106.6**	**125.31**	**0.09**	**0.001**	**0.09**

Source: Castalia (2010) and subsequent updates under the same assignment.

Note: * R=Residential, C=Commercial, I=Industrial, P=Public; ** Compared to baseline; *** O&M costs considered only if different (more or less) than under baseline. Savings cost does not include cost of disposal. A/C, lighting, and other technologies require sustainable disposal in order to prevent adverse environmental impacts; amortized capital cost assumes a 5 percent discount rate.

A.2 Estimating the Potential Cumulative Electricity Generation and Savings

Figure 2.2 makes assumptions about the installation and operation of RE and EE technologies in the Eastern Caribbean; for example, the years in which plants come online or the size of those plants. This section explains those assumptions and includes the data used to construct the EE estimations for the six countries.

A.2.1 Renewable energy potential

Figure 2.2 includes potential RE projects that could come online between 2015 and 2034. Projects that are in the physical development phase as of February 2015 are included in Figure 2.1, but operating projects are not included since they do not represent a potential unrealized energy source. Current RE excluded from Figure 2.1 includes: 2.2 MW of wind on Nevis, 5.7 MW of hydro on Saint Vincent, 6.6 MW of hydro on Dominica, and less than 1 MW of distributed generation throughout the Eastern Caribbean (wind and solar PV). Similarly, Figure 2.2 does not include existing solar water heaters or EE technologies.

The utility scale technologies in Figure 2.2 come online according to the following schedule and plant sizes:

- Utility solar PV comes online in:
  - 2020 and 2024 in Antigua and Barbuda
  - 2020 in Dominica
  - 2018 and 2020 in Grenada
  - 2016 and 2030 in Saint Kitts and Nevis
  - 2015, 2020, and 2030 in Saint Lucia
  - 2020 and 2025 in Saint Vincent and the Grenadines
- Wind comes online in:
  - 2020 in Antigua and Barbuda
  - 2016 in Grenada, Saint Kitts and Nevis, Saint Vincent and the Grenadines, and Saint Lucia
- Geothermal comes online in 2017 in Dominica (10 MW) with a 50 MW expansion in 2020 and another 50 MW expansion in 2024 (the electricity from this expansion is assumed to be exported to Martinique and Guadeloupe via an underwater interconnection); geothermal comes online in the remaining countries as follows:
  - Saint Kitts and Nevis—the power plant to serve Nevis (10 MW) 2018; the power plant to service Saint Kitts (25 MW) 2023
  - Saint Vincent and the Grenadines (10 MW) 2018
  - Grenada (10 MW) 2019
  - Saint Lucia (20 MW) 2019
- Waste-to-energy comes online in:
  - 2020 in Antigua and Barbuda (2 MW anaerobic digester) and Grenada (2 MW anaerobic digester)
  - 2016 in Saint Lucia (3 MW waste-to-energy plant)
  - 2030 in Saint Vincent and the Grenadines (2 MW anaerobic digester)
- Hydro comes online in Saint Vincent and the Grenadines in 2025 (9 MW).

For geothermal, waste, and hydro, the plant size is based on estimations of the size of the resource and the size of the market.

Intermittent generation capacity (wind and solar PV) is limited to 40 percent of peak demand in each country. This relatively high penetration of intermittent generation depends on the use of lead acid storage with utility scale PV, which the Inter-American Development Bank paper “Potential for Energy Storage in Combination with Renewable Energy in Latin America and the Caribbean” (2014) explores. The 40 percent includes: 10 percent of utility scale wind (as above), 16 percent of utility scale solar PV (as above), 8 percent of commercial distributed solar PV, and 6 percent of distributed residential solar PV. As utility scale wind and solar PV plants come online, they are equal to their respective shares of intermittent generation (as noted above). Distributed solar PV grows linearly over the period, reaching its full potential (14 percent of peak demand) in 2034.

Figure 2.1 assumes 30 percent of residential electricity customers and 15 percent of commercial electricity customers install solar hot water heaters by the end of the period. Penetration grows linearly to reach this potential by the end of the period.

Table A.4 shows total generation or savings by each technology type (in GWh) per country for the period.

TABLE A.4: Cumulative Generation (or Savings) by Technology and by Country (2015-2034, GWh)

	Solar PV (Utility and DG)	Solar Water Heaters (Commercial and Residential)	Wind (Utility Scale Wind)	Waste to Energy	Geothermal*	Hydro	Energy Efficiency
Country	GWh	GWh	GWh	GWh	GWh	GWh	GWh
Antigua and Barbuda	181	506	184	197	N/A	N/A	690
Dominica	59	550	N/A	N/A	2,150	N/A	215
Grenada	102	772	140	197	1,191	N/A	438
Saint Kitts and Nevis	79	1,042	373	325	2,383	N/A	1,053
Saint Lucia	19	362	186	N/A	3,500	N/A	571
Saint Vincent and the Grenadines	106	651	186	66	1,266	488	334
Total	547	3,884	1,069	784	10,490	488	3,301

Note: Annual generation is calculated according to the following formula: Installed capacity x capacity factor x 8,760 [hours in year] = Total electricity generated. DG stands for distributed generation.
* Only includes geothermal generated and sold in the domestic market; does not include energy exported to Guadeloupe and Martinique.

A.2.2 Energy efficiency potential

To estimate the potential impact of using EE technologies, we:

1. **Calculate the maximum potential percentage of electricity savings per sector that is possible if all electricity consumers use energy efficient technology**. We do this by estimating: (i) the percentage of electricity usage that each category of technology represents in each sector;[39] (ii) the percentage of electricity that can be saved in each sector using EE equipment over the baseline usage by category; and (iii) the total percentage of electricity that a customer in each sector can save by using EE technology. Table A.5 shows how we calculate the potential reductions in electricity consumption for customers in each sector.
2. **Project the impact that energy efficient technology will have on each sector by applying the projected market penetration of energy efficient technology in each sector to the potential savings per sector**. We use a conservative projection of 50 percent market penetration for all EE technologies for the year 2034, and assume that the uptake of EE technologies grows gradually between 2015 and 2034.
3. **Apply the impact in percentage of electricity usage saved to sales figures from each country to calculate the MWh saved using energy efficient technology**. We use historical data to make projections of electricity sales for each country,[40] and then apply the expected reductions in electricity consumption to

[39] We do not consider application in a sector when it would be negligible (for example, commercial companies could in some cases benefit from premium efficiency motors, but these would only represent a small portion of overall energy use in the sector, compared to the industrial sector where energy from motors is a significant portion of energy use).

[40] "Rebound effects" of EE have always been experienced historically, as regular technological progress allows the consumption of more energy more efficiently. Therefore, we do not adjust growth rates based on any additional rebound effect. Doing so would run the risk of double counting any such effect, and therefore overestimating the EE potential that is calculated based on projected consumption.

projected energy sales in each country in order to calculate the savings per sector in each country by customer category. We then sum the savings of all customer categories in all countries to determine the total savings from adopting EE equipment in the six countries. Table A.6 presents the estimated savings by country and sector.

Table A.5: Calculating the Maximum Possible Percentage of Electricity Savings

Technology Category	Energy Efficient Technology	Avg. Consumption within Sector	Avg. Savings Potential from EE Equipment	Savings Per Customer
		(a)	(b)	(a*b)
Residential				
Refrigeration	Efficient residential refriferators	45.3%	15%	6.8%
Lighting	Efficient lighting	20.6%	75%	15.5%
Air-conditioning	Efficient window A/C systems	6.8%	33%	2.3%
Other		27.3%	10%	2.7%
Sector Total		100.0%		27.3%
Commercial/Public				
Refrigeration	Efficient retail refrigerators	12.6%	15%	1.9%
Lighting	T8 fluorescent lights and other lighting	29.3%	38%	11.1%
Air-conditioning	Efficient window and split A/C system	49.8%	37%	18.4%
Other		8.3%	10%	0.8%
Sector Total		100.0%		32.2%
Industrial				
Motors	Premium efficiency motors	41.2%	32%	13.2%
Refrigeration	Efficient chillers	19.1%	40%	7.7%
Lighting	T5 and T8 fluorescent lights	5.8%	18%	1.1%
Air conditioning	Efficient window and split A/C system	5.6%	37%	2.1%
Other		28.3%	10%	2.8%
Sector Total		100.0%		26.8%
Street Lighting				
Street lights	LED street lighting	100.0%	50%	50.0%
Sector Total		100.0%		50.0%

TABLE A.6: Cumulative Energy Efficiency Savings by Country and Sector between 2015 and 2034

	Residential Savings	Commercial Savings	Insdustrial Savings	Street Lighting Savings	Total Savings
Country	MWb	MWb	MWb	MWb	MWb
Antigua and Barbuda	21,456	33,472	3,120	2,629	60,078
Dominica	7,906	8,884	1,512	639	18,940
Grenada	13,401	22,384	1,135	1,661	38,582
Saint Kitts and Nevis	17,769	27,720	2,584	2,178	50,250
Saint Lucia	27,633	55,919	4,241	4,905	92,697
Saint Vincent and the Grenadines	12,614	14,182	1,340	1,214	29,350
Total	10,778	162,560	13,933	13,226	290,497

Appendix B: Energy Barriers, Interventions, and Intervening Entities

Table B.1 shows the barriers to RE development (organized by category) as well as interventions to overcome those barriers.

Table B.1 Barriers to Sustainable Energy in the Eastern Caribbean, Appropriate Interventions, and Intervening Entities

Barriers		Affected Projects			Appropriate Interventions		Recent, Existing, and Upcoming Interventions			
									Intervention Type	
Category	Description	Utility RE	Distributed RE	EE	Technical Assistance	Investment	Entity/Program	Status	Technical Assistance	Investment
Financial	Limited access to capital on appropriate terms (high interest rates, high guarantee requirements, short loan durations, no grace periods)	GR, SL, SKN, SVG	All countries	All countries	Assess need for, design, and set up financial instruments	Provide concessional loans (lower interest rate, longer term, grace period compared to market), grants (normal or conditional), RSFs, and loan guarantees	EU Energy Facility	Ended in 2013		Grants and concessional loans
							AOSIS (CAAP)	Ongoing		Financing for equipment
							GEF	Ongoing		Rebates and financing
							SEEC Program (multiple donors)	In preparation	Market study on financing	Grants and loans for EE and RE pilot projects in private sector
							UK DFID	Ongoing	Market study on financing	Grants and concessional loans (exploratory drilling in SL and potentially GR and SVG)
							IRENA and Abu Dhabi Fund	Ongoing	Market study on financing	Concessional loan (SVG)
							Government of New Zealand	Ongoing	Support for surface exploration, feasibility studies, environmental impact assessments (GR, SL, DOM)	
							World Bank	Ongoing	Market study on financing	Contingent and concessional loans (SL)
							Governments of China and Taiwan	Ongoing	Market study on financing	Investment support for retrofitting streetlights (A&B, SKN, DOM)

Barriers		Affected Projects			Appropriate Interventions		Recent, Existing, and Upcoming Interventions			
							Entity/Program	Status	Intervention Type	
Category	Description	Utility RE	Distributed RE	EE	Technical Assistance	Investment			Technical Assistance	Investment
	Fiscal constraints	SL, GR	All countries	All countries	Design performance-based contracts for EE retrofits financed by ESCOs/utilities; assist with procurement	Provide concessional loans, RSFs, and loan guarantees for ESCOs/utilities	Sustainable Energy for the Eastern Caribbean (SEEC) Program (multiple donors)	In preparation	Assistance in procurement of public-building retrofits	Grants and loans for EE and RE pilot projects in public sector
							European Union	Complete	Market study on financing	Grants for carrying out EE audits for public sector (SVG)
	Limited creditworthi-ness of off-takers for renewable generation projects	A&B, SKN	A&B, SKN	A&B, SKN		Develop RSFs; provide guarantees	Sustainable Energy for the Eastern Caribbean (SEEC) Program (multiple donors)	In preparation	Assistance in procurement of public-building retrofits	Grants and loans for EE and RE pilot projects in public sector
	Lack of incentives to invest due to mismatch between investment decisions and operating decisions ("agency problem")		All countries	All countries	Design performance-based contracts for EE retrofits; develop building codes that mandate energy efficient design/equipm ent and compatibility with SWH and solar PV		OECS Secretariat	Building codes developed in 2001; codes do not include updated EE or distributed RE requirements	Creation of building codes to be adopted by all OECS mem-bers	

Barriers		Affected Projects			Appropriate Interventions		Recent, Existing, and Upcoming Interventions			
							Entity/Program	Status	Intervention Type	
Category	Description	Utility RE	Distributed RE	EE	Technical Assistance	Investment			Technical Assistance	Investment
Legal and Regulatory	No obligation or incentive for utilities to purchase from large and small independent power producers (third parties' inability to sell)	A&B, GR, SL	A&B, SL, SKN (Saint Kitts), SVG		Reform regulation to introduce obligation to purchase at or below avoided cost from credible suppliers; develop standard offer contracts for distributed generation		EDF	Ongoing	Support the creation of legal, regulatory, and policy frameworks to allow developing viable RE options	
							ECERA (World Bank)	Ongoing	Development of standard offer contract for distributed scale renewable generation	
	Licensing regime for third parties is nonexistent, unclear, or too onerous for large and small IPPs (third parties' inability to sell)	A&B, GR, SL	A&B, SL, SKN		Develop a clear licensing regime for IPPs for utility scale generation; develop standard offer contracts for distributed generation (incl. standard interconnection rules)		ECERA (World Bank)	Ongoing	The ECERA terms of reference (TORs) include development of new licensing provisions to increase third-party electricity generation	
	Uncertainty of cost recovery through tariffs of efficiently incurred sustainable energy investments	A&B, GR, SKN (Saint Kitts), SL	A&B, GR, SKN (Saint Kitts), SL	A&B, GR, SKN (Saint Kitts), SL	Reform regulation and tariff structures to ensure safe and easy cost recovery through tariffs of efficiently incurred sustainable energy investments					

Barriers		Affected Projects			Appropriate Interventions		Recent, Existing, and Upcoming Interventions			
							Entity/Program	Status	Intervention Type	
Category	Description	Utility RE	Distributed RE	EE	Technical Assistance	Investment			Technical Assistance	Investment
	Unclear rights to use geothermal and water resources	DOM GR, SL, SVG			Reform laws and regulations that establish the rights to own and/or use geothermal and water resources		CSEP (OAS)	Ended in October 2012	Support the creation of legal frameworks to allow developing viable RE options, including framewor-ks for: hydro and wind in DOM, geothermal in GR, geothermal in SVG, and geothermal in SL	
							Clinton Climate Initiative	Ongoing		
							World Bank	Ongoing		
	Unclear land rights to access sites for project development	A&B, GR, SKN (Saint Kitts), SL, SVG			Reform laws and regulations that establish the rights to access geothermal and water resources		CSEP (OAS)	Ended in October 2012	Support the creation of legal frameworks to allow developing viable RE options, including frameworks for: hydro and wind in DOM, geothermal in GR, and geothermal in SL	
Information	Limited information on wind resources	A&B, DOM GR, SL, SVG	A&B, DOM GR, SL, SVG			Fund wind resource assessments	CSEP	Ended in October 2012	Carry out wind studies	
							GIZ	Ongoing	Carry out wind studies	
	Limited information on geothermal resources	GR, SKN, SL, SVG				Funding for geothermal exploration	Geothermal Exploration Risk Mitigation Facilities (CDB, IDB, World Bank)	In preparation	Market assessment for, and design of, facility	Grants (equity) and loans for facility
							EU Energy Framework	Ongoing		Grants and concessional loans

Barriers		Affected Projects			Appropriate Interventions		Recent, Existing, and Upcoming Interventions			
							Entity/Program	Status	Intervention Type	
Category	Description	Utility RE	Distributed RE	EE	Technical Assistance	Investment			Technical Assistance	Investment
	Limited information on waste quantities and quality	A&B, SKN, SVG				Fund studies on waste quantity and composition				Grants (equity) and loans for facility
	Limited public awareness of costs and benefits of sustainable energy technologies	All countries	All countries	All countries	Design public awareness and public outreach programs	Grants for implementing public awareness and public outreach programs	SEEC Program (multiple donors)	In preparation	Design and implementation of public awareness programs	Funding for EE and RE pilot projects
							CHENACT	Ongoing (second phase)		Funding for hotel DG and EE projects
							CEEAP	Ongoing	Curriculum development and teacher training about energy	
							GEF	Ongoing	Caribbean buildings fund	Caribbean buildings fund
							Sustainable Energy Technical Assistance (CDB)	Ongoing	Public awareness and education program	
							CSEP (OAS)	Ended October 2012	Design and implementation of public awareness programs	
Market	Information asymmetry between suppliers and customers of energy services and equipment		All countries	All countries	Support countries in creating region-wide certifications for service providers, and region-wide labeling program		ECELP	Ongoing	Introduce EE labels and standards for household appliances and lighting equipment	

Barriers		Affected Projects			Appropriate Interventions		Recent, Existing, and Upcoming Interventions			
							Entity/Program	Status	Intervention Type	
Category	Description	Utility RE	Distributed RE	EE	Technical Assistance	Investment			Technical Assistance	Investment
	Relatively limited RE and EE equipment available, relatively high costs		All countries	All countries	Revise building codes to mandate EE and SWH; design consumer finance facilities	Fund consumer finance facilities	GIZ	Ongoing	Support in preparing feasibility studies and business appraisals to develop a market for RE and EE investments in the Caribbean	
							Energy for Sustainable Development in Caribbean Buildings (GEF)	Ongoing	Energy for Sustaina-ble Development in Caribbean Buildings (GEF)	
	Limited capability to originate and conclude loans	All countries	All countries	All countries	Train and hire specialized, dedicated staff for local lenders and facilities		SEEC Program (multiple donors)	In preparation	Funding for training and hiring staff to originate and conclude loans	
	Lack of technical and professional capacity and capability to assess and install RE and EE projects	All countries	All countries	All countries	Fund training and capacity-building programs		OAS	Ongoing	Support capacity building for project finance, designing RE and EE projects, and negotiating with private sponsors (A&B)	
							ECLAC	Ongoing	Assessment of the technical and professional capacity and capability needs for implementing RE initiatives	
							SEEC Program (multiple donors)	In preparation	Institutional support for sustainable energy	

Barriers		Affected Projects			Appropriate Interventions		Recent, Existing, and Upcoming Interventions			
							Entity/Program	Status	Intervention Type	
Category	Description	Utility RE	Distributed RE	EE	Technical Assistance	Investment			Technical Assistance	Investment
							CSEP (OAS)	Ended October 2012	Training for government and utility staff	
	Lack of experience of utility staff in operating and maintaining RE plants	All countries			Help utilities procure appropriate O&M when procuring utility scale plants		OAS	Ongoing	Support capacity building for project finance, designing RE and EE projects, and negotiating with private sponsors (A&B)	
	Limited capabilities in planning and implementing sustainable energy policies	All countries	All countries	All countries	Provide capacity building and training to government staff for designing and implementing sustainable energy policies and reforms		CSEP (OAS)	Ended October 2012	Facilitate the adoption of energy policies and legislation in: A&B, DOM, GR, SKN, SL, SVG	
	Limited capacity and capability in carrying out electrical inspections for RE systems				Provide capacity building and training, and hire staff for entities responsible for electrical inspections					

Note: The following notations are used in the figure: Antigua and Barbuda (A&B), Dominica (DOM), Grenada (GR), Saint Kitts and Nevis (SKN), Saint Lucia (SL), Saint Vincent and the Grenadines (SVG), Distributed Generation (DG).

Appendix C: Energy Efficiency, Renewable Energy Resources, and Sustainable Energy Supply Curves in the Eastern Caribbean Countries

This appendix presents the sustainable energy supply curves for the six countries included in the study. It builds on the methodology for developing the sustainable energy supply curve presented in Appendix A. Specifically, it presents the estimated cumulative amount of RE generation and EE savings that can be achieved across Antigua and Barbuda, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines over a 20-year period. In addition, it assesses the commercial viability of RE technologies in each of the countries.

C.1 Antigua and Barbuda

Antigua and Barbuda's emissions per capita are higher than in other OECS countries considered in this study. The country could reduce these emissions, and lower power costs, by adopting economically viable EE and RE technologies. Promising technologies include wind, solar PV, solar water heaters, and landfill gas to energy (unlike other OECS countries, Antigua and Barbuda does not have geothermal potential). Each of these technologies is considered in the following sections.

C.1.1 Energy efficiency potential

Increasing EE is part of the government's strategy presented in its action plan for reducing Antigua and Barbuda's dependence on imported fossil fuels. However, information on the rate of adoption of EE technologies in Antigua and Barbuda is scarce. APUA monitors the efficiency and energy conservation of government ministries, but it is unclear whether that information is being used to improve efficiency. Antigua and Barbuda has adopted OECS model building codes, but it has been reported that the codes are scarcely enforced.[41]

C.1.2 Renewable energy resources

As of 2014, RE generation is limited to a few solar photovoltaic systems. The strongest candidates for viable RE options in Antigua and Barbuda are solar PV, and, potentially, wind and landfill gas to energy (depending on the quantity of the resource). In the policy and action plan, the government calls for an assessment of these resources, and suggests setting an objective for utility scale solar PV to supply 15 percent of electricity by 2025.

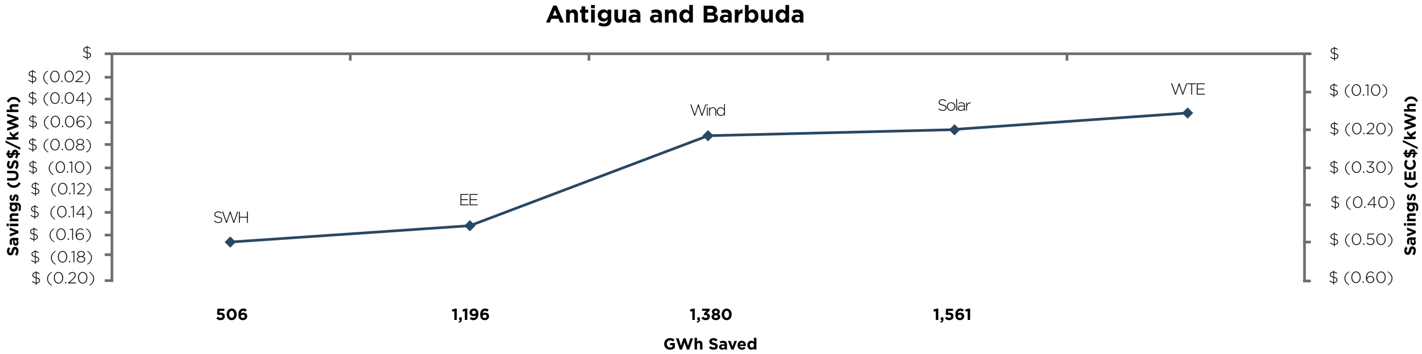
The action plan indicates that:

> *Antigua & Barbuda is endowed with renewable energy resources, mostly wind and solar, and these renewable resources have not been exploited yet. Studies indicate 400 MW and 27 MW potential for wind and solar respectively. Nevertheless, additional studies need to be carried out to evaluate the useful extent of this technology as well as other resources such as biogas and waste to energy (WTE).*

Figure 4.2 shows the potential for replacement of fossil fuel generation by sustainable energy in Antigua and Barbuda between 2015 and 2034.

[41] OAS/NREL (2011).

Figure 4.2: Sustainable Energy Supply Curve for Antigua and Barbuda



Note: This curve is generated using the same model as Figure 2.1.

Availability and commercial viability of renewable energy resources

Table C.1 assesses the maturity of RE technologies, as well as the availability of their resource in Antigua and Barbuda. Technologies with a combined maturity and availability score of three or greater are potentially commercially viable in Antigua and Barbuda.

Table C.1: Renewable Energy Options in Antigua and Barbuda

RE Technology	Maturity (0–2)	Availability of resource (0–2)	Comments	Viable?
Solar Water Heaters	2	2	Mature technology with proven success in the region. Excellent solar potential.	Yes
Wind	2	1	Mature technology. The Caribbean Renewable Energy Development Programme (CREDP) has begun monitoring the wind resource at three sites on Antigua and one on Barbuda. Initial data are positive, with wind speeds typically peaking at the same time as electricity demand. The deciding factor for the viability of wind technology is the all-in cost of the project.	Yes
Waste to Energy	2	Unknown	Several mature technologies available (landfill gas to energy, waste-to-energy). Government is interested, but it is unclear if waste exists in sufficient quantity.	Maybe
Solar PV	1	2	Mature technology, although further improvements expected. Global Horizontal Irradiance (GHI) of over 5.7 kWh per m2 per day. In addition, the costs of solar technologies have decreased rapidly since 2013. It is expected for these costs to continue decreasing over coming years.	Yes
Concentrated Solar Power (CSP)	1	0	In commercial operation, but significant improvements and cost reductions are expected. The solar resource in Antigua and Barbuda is not suited for CSP technology.	Yes
Seawater Air-Conditioning (SWAC)	1	Unknown	Technology based on other commercially proven ones, but further improvement expected.	No
Hydropower	2	0	Mature technology. No hydro resources.	No
Geothermal	2	0	Mature technology. No known resource in Antigua and Barbuda.	No
Biomass Cogeneration	2	Unknown	Mature technology. Biomass resources have not been studied.	Maybe
Biodiesel for Power Generation	2	0	Mature technology. No sufficient biodiesel feedstock available (or sufficient land to grow it).	No
Ocean Thermal Energy Conversion (OTEC)	0	1	Technology at an experimental/pilot stage. Antigua's resource has not been assessed, although it is said that the resource is likely appropriate (Vega, 2011).	No
Ocean Wave Energy Conversion	0	1	Technology at an experimental/pilot stage. Possible availability of good ocean kinetic energy, but not ascertained.	No

Sources: CARICOM, GIZ, Caribbean Renewable Energy Development Programme (2011), OAS/NREL (2011), Vega (2011).

C.2 Dominica

Dominica is endowed with RE resources. There is potential for reducing greenhouse gas emissions while also reducing electricity costs through the exploitation of economically viable RE technologies, as well as EE technologies. These technologies and an assessment of their commercial viability are presented in the following sections.

C.2.1 Energy efficiency

In recent years, the Government of Dominica has made several small-scale attempts to increase EE in the country. For example, in 2007 the government replaced 280,000 incandescent light bulbs with compact fluorescent light bulbs. The government is looking to build on this experience with further initiatives in EE and demand-side management.

The Draft National Energy Policy of the Commonwealth of Dominica[42] calls for several measures to encourage EE and energy conservation, such as: developing public education programs; encouraging the import and use of EE appliances; establishing standards for EE in buildings; developing a plan to retrofit public buildings and encouraging energy audits and retrofits in the private sector; requiring energy labeling; developing a plan; and publishing reports and statistics on EE in the country.

C.2.2 Renewable energy resources

Dominica has a wealth of RE resources. Its geothermal resource is considered to have the greatest commercial potential in the Lesser Antilles. The government has proposed to prioritize development of the following RE sources (in order of importance): geothermal, hydro, solar, wind, biofuels, biomass, and OTEC.[43]

The government is planning on building a 10.5 MW geothermal plant at Wotten Waven, with a possibility to develop a further 100 MW of capacity in the future.[44] Power in excess of Dominica's electricity demand could be exported to Guadeloupe and Martinique. Interconnection would allow even greater exploitation of Dominica's geothermal resource (potentially up to 100 MW additional capacity).[45] Conversations with Electricité de France about this opportunity are already underway. The government drilled three test wells at Wotten Waven in April 2012 with funding from the European Union and a French development bank. Dominica has also drilled a commercial production well with generation capacity of 11.4 MW,[46] which would allow Dominica to construct a plant to meet its base load demand.[47] With the increased interest in the Wotten Waven site, exploration efforts at Dominica's other geothermal areas (Soufrière, Morne au Diable, Boiling Lake, Champagne, and Galion) have slowed. The government is still working to set out the financing and ownership structure for geothermal developments.

Dominica is a participating country in the Caribbean community's CREDP—an initiative of the Energy Ministers of the Caribbean Community region established to change the RE market. Dominica has the objective of using sustainable and indigenous resources to make electricity generation on the island self-sufficient by 2020. It has not set any binding targets for RE production, but its sustainable energy plan describes a scenario in which Dominica becomes a net exporter of electricity from its geothermal resources.[48]

Some private parties have demonstrated interest in developing distributed generation. DOMLEC has published a policy for interconnection of customer-owned generation. Between December 2010 and March 2012, three distributed RE installations came online: a 225 kW wind turbine at Rosalie Bay Resort, a 9 kW solar array at a private residence in Castle Comfort, and a 50 kW solar array at a commercial property in Canefield. In March of 2012, Rosalie Bay Resort applied for permission to interconnect another 32 kW to the grid.

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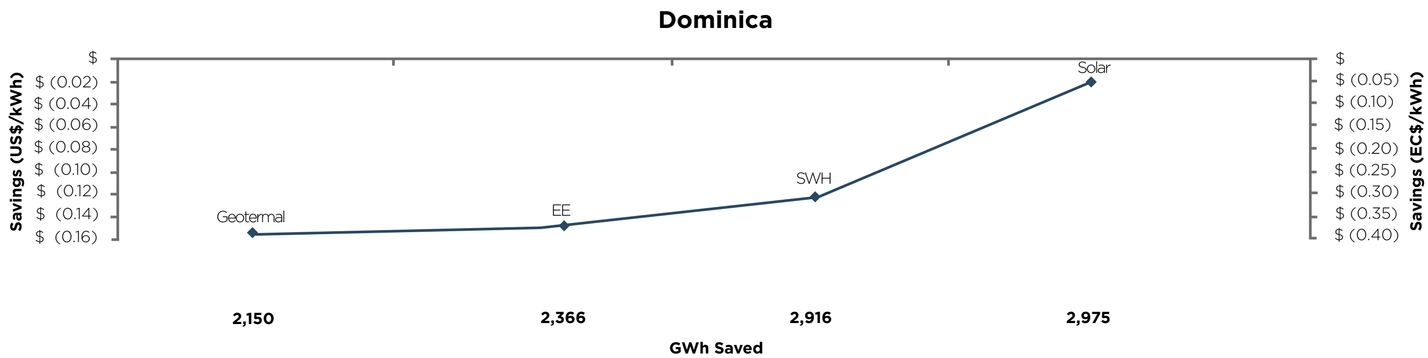
[42] Government of Dominica, *Draft National Energy Policy of the Commonwealth of Dominica*, 2011, prepared by Castalia Advisors.
[43] Ibid.
[44] The government proposes to develop an additional 120 MW in two phases: 60 MW in 2018 and 60 MW in 2020.
[45] The government has indicated that the first phase of the project may reach a capacity of up to 20 MW. See Government of Dominica (2014).
[46] Bernard Hill, Project Director & Energy Manager at Hawkins Infrastructure, e-mail message to author, November 25, 2014; Iceland Drilling Company carried out the production drilling advised by ISOR, an Icelandic geothermal consultancy.
[47] "Dominica Makes Huge Step in Geothermal Energy Production," *Dominica News Online*, June 17, 2014, accessed March 19, 2015, http://dominicanewsonline.com/news/homepage/news/economy-development/dominica-makes-huge-step-geothermal-energy-production/.
[48] National Renewable Energy Laboratory (2015b).

Figure 4.3 presents the potential for replacement of fossil fuel generation by sustainable energy in Dominica between 2015 and 2034.

Figure 4.3: Sustainable Energy Supply Curve for Dominica



Note: This curve is generated using the same model as Figure 2.1.

Availability and commercial viability of renewable energy resources

Table C.2 assesses the maturity of RE technologies, as well as the availability of resources in Dominica. Technologies with a combined maturity and availability with a score of three or greater are potentially commercially viable in Dominica. These include hydropower, geothermal, solar water heaters, solar PV, and wind power.

Table C.2: Renewable Energy Options in Dominica

RE Technology	Maturity (0–2)	Availability of resource (0–2)	Comments	Viable?
Hydropower	2	2	Mature technology already in use on the island. There is a possible 10–30 MW of untapped hydropower. There is also possibility to enhance the capacity of existing plants.	Yes
Solar Water Heaters	2	2	Mature technology with track record of success in the region. Dominica has abundant solar radiation.	Yes
Geothermal	2	2	Mature technology. Dominica hosts nine live volcanic centers and is ranked first in geothermal potential among islands of the Lesser Antilles. The government has completed drilling full-size wells at the Wotten Waven site, confirming a resource of 120 MW. The government drilled an 11 MW production well and is in the process of developing a 10 MW power plant to serve the local electricity sector.	Yes
Solar PV	1	2	Mature technology, although further improvements are expected. Dominica has abundant solar radiation. It is estimated that horizontal insolation averages roughly 5–6 kWh/m2/day. Some micro-scale PV systems are already in use by private parties. Rapidly dropping cost of solar PV means that there is potential for further development of solar PV.	Yes
Wind	2	1	Mature technology. Study by GTZ found NE coast of Dominica has best potential for wind energy. Concern about overall wind speeds; further assessments are required. Private parties have installed wind turbines.	Maybe (more studies required)

RE Technology	Maturity (0–2)	Availability of resource (0–2)	Comments	Viable?
Waste to Energy	2	0	Several mature technologies are available (landfill gas to energy, waste-to-energy). However, the waste resource available in Dominica is inadequate due to the island's small and dispersed population.	No
Concentrated Solar Power (CSP)	1	1	Technology in commercial operation, but significant improvements and cost reductions are expected. Optimal plant size may exceed needs and land availability in Dominica.	No
Seawater Air-Conditioning (SWAC)	1	1	Technology based on other commercially proven ones, but further improvements are expected.	No
Biomass Cogeneration	2	0	Mature technology. Not considered viable for Dominica due to lack of biomass.	No
Biodiesel for Power Generation	2	0	Mature technology. Not considered viable for Dominica due to lack of feedstock.	No
Ocean Thermal Energy Conversion (OTEC)	0	Unknown	Technology at an experimental/pilot stage.	No
Ocean Wave Energy Conversion	0	Unknown	Technology at an experimental/pilot stage.	No

Source: Ministry of Public Utilities, Energy, and Ports (2009), REEGLE (2012), Government of Dominica (2011a).

C.3 Grenada

Electricity generation accounts for almost half of Grenada's CO_2 emissions. An effective way of reducing Grenada's emissions would be to increase the share of RE and EE in the country's energy mix. Several of these technologies appear to be economically viable in Grenada, meaning that there are opportunities to reduce the country's greenhouse gas emission levels without increasing the cost of electricity to its citizens. Promising RE options include geothermal, wind, solar, and waste-to-energy. The commercial viability of these technologies is presented in the following section.

C.3.1 Energy efficiency

The National Energy Policy (2011) called for the development of an Energy Efficiency Act by the end of 2012 that contains provisions for various requirements, including new building planning regulations, EE standards, energy audits for government buildings, and the compilation and publication of data on energy consumption.[49] However, as of February 2015, the Energy Efficiency Act had not been passed.

In 2005, the government sponsored a program to replace incandescent light bulbs with compact fluorescent lights (CFLs). The government also launched a public sector energy conservation program in 2010. The program requires each government ministry to establish an energy management committee and develop a conservation plan to achieve 10 percent energy savings, and involves retrofitting all government complexes, hospitals, health clinics, and police stations with EE technologies (Government of Grenada, 2011b).

The commercial sector has made more progress in advancing EE measures in Grenada. All hotels use solar water heaters, and some use other EE technologies, such as EE air-conditioning and lights.[50] Hotels and the wider commercial sector have particular opportunities to gain from EE. Investing in EE measures could reduce costs for hotels and other businesses.

In October 2013, the government signed a US$5.83 million agreement with the CARICOM Development Fund, which focuses on improving EE in the tourism sector. It involves direct grant assistance for the implementation of energy plans in partnership with the Grenada Hotel and Tourism Association.[51] This agreement provides an opportunity for more robust EE programs in the commercial sector.

[49] Government of Grenada (2011a).
[50] Sustainable Energy for All, "Grenada: Rapid Assessment and Gap Analysis," 2012, http://www.se4all.org/sites/default/files/Grenada_RAGA_EN_Released.pdf.
[51] "Grenada, CARICOM Development Fund to Sign $5.8M Agreement," *Caribbean Journal*, October 25, 2013, accessed March 18, 2015, http://caribjournal.com/2013/10/25/grenada-caricom-development-fund-to-sign-5-8m-agreement/#.

C.3.2 Renewable energy resources

Grenada has the potential to use RE sources for electricity generation. RE sources that are currently used to generate electricity at the distributed generation scale are solar energy and wind energy. However, there are a variety of untapped RE resources in Grenada, Petite Martinique, and Carriacou. Solar, wind, biomass, and geothermal energy options could constitute economically viable options.

GRENLEC:

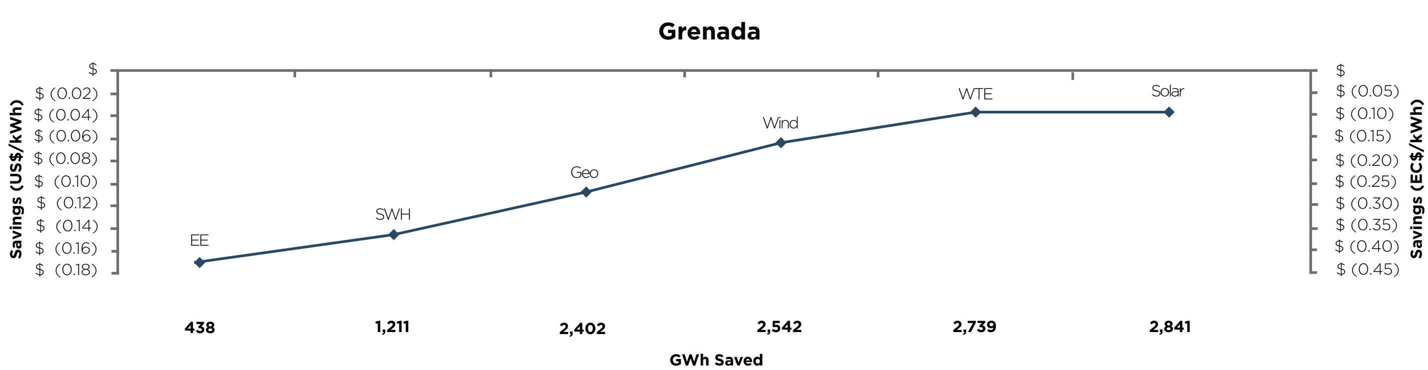
- Is developing utility scale **solar** PV. As of September 2014, GRENLEC had developed a 145 kW solar facility at Grand Anse and a 30 kW solar facility in Petit Martinique. Solar resource has mostly been developed at the distributed scale through the Interconnection Programme that GRENLEC offers. As of September 2014, the installed capacity of solar PV distributed generators was 361 kW.[52]
- Is developing a 2 MW **wind** facility on the island of Carriacou. The project was launched in 2012 and experienced some delays in 2013 and 2014. However, a call for proposals was issued in September 2014, and GRENLEC expected the project to be completed in 2016.[53]
- Was pursuing **geothermal** as an option as well. In 2012, the government worked with GRENLEC to develop a geothermal resources development bill and environmental regulations with assistance from the Organization of American States (OAS). The bill would provide a legal and regulatory framework for developing geothermal resources. However, due to the change in the government after the 2013 election and the government's plans to amend the ESA, GRENLEC stopped working on developing the geothermal resource. Geothermal resources remain unconfirmed and estimates of its size vary. Preliminary studies suggest Grenada's potential to be at least 30 MW.[54]

  The government is continuing its work on geothermal development without GRENLEC. The Government of New Zealand is assisting the government with surface exploration. This work began in December 2014 and in July 2015 the government presented the results of the study to multilateral development banks and local stakeholders, including the media, to plan the way forward.[55]

The government has explored developing biomass resources. In 2011, the GSWMA commissioned a study to assess the potential of a waste-to-energy project. The study identified a waste-to-energy project that would cost US$48 million to develop.[56] The GSWMA issued a request for expressions of interest in 2011. The Government of Grenada wanted to have an operating waste-to-energy facility by the end of 2015.[57] However, it is not evident that the GSWMA awarded the contract for this project, nor that any progress in developing biomass resources has been made since then.

Figure 4.4 presents the potential for replacement of fossil fuel generation by sustainable energy in Grenada between 2015 and 2034.

Figure 4.4: Sustainable Energy Supply Curve for Grenada



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[52] Information shared by GRENLEC with Castalia in September 2014.

[53] GRENLEC, "Carriacou Wind Energy Project Moving Ahead," September 18, 2014, accessed March 18, 2015, http://grenlec.com/Blog/TabId/126/ArtMID/657/ArticleID/21/Carriacou-Wind-Project-Reaches-Significant-Milestone.

[54] World Bank, "Got Steam? Geothermal as an Opportunity for Growth in the Caribbean," Caribbean Knowledge Series, June 2013, accessed March 6, 2014, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/06/21/000442464_20130621142703/Rendered/PDF/786080WP015.0G00Box377349B00PUBLIC0.pdf.

[55] Government of Grenada, "Results of Geothermal Study to Be Presented," July 29, 2015, accessed December 8, 2015, http://www.gov.gd/egov/news/2015/jul15/29_07_15/item_1/results-geothermal-study-presented.html.

[56] Government of Grenada (2011a).

[57] GSWMA (2011).

Availability and commercial viability of renewable energy resources

Table C.3 assesses the maturity of RE technologies, as well as the availability of their resource in Grenada. Technologies with a combined maturity and availability score of three or greater are potentially commercially viable in Grenada.

Table C.3: Renewable Energy Options in Grenada

RE Technology	Maturity (0–2)	Availability of resource (0–2)	Comments	Viable?
Solar PV	2	2	Mature technology, although further improvements expected. The solar resource is strongest in Petite Martinique and Carriacou, as well as the SW part of Grenada. Solar PV is currently commercially viable. Prices for solar panels continue to fall, so PV may also be economically viable, particularly with storage.	Yes
Solar Water Heaters	2	2	Mature technology. Excellent solar potential. Over 4,500 units were imported to Grenada between 2000 and 2008.	Yes
Wind	2	1	Mature technology. Grenada is exposed to northeasterly trade winds. A 2 MW wind farm is being developed in Carriacou. The government considers this project a pilot for further wind development on mainland Grenada. The projected completion date is 2015.	Yes
Waste to Energy	2	1	Several mature technologies are available (landfill gas to energy, waste-to-energy). Waste stream of 40,000 tons of solid waste per year. A request for expressions of interest was issued in 2011, but no progress has been made to develop the resource since.	Yes
Geothermal	2	Unknown	Mature technology. Grenada may host a medium enthalpy resource suitable for commercial exploitation. The government has developed a legal framework for geothermal development, but the draft legislation was not approved. The government was working with GRENLEC to explore Grenada's geothermal resources, but they stopped negotiations in 2013. The government is now working with the Government of New Zealand to complete surface exploration. In July 2015, results of surface exploration studies were presented to donors and local stakeholders to plan the way forward. Further exploration required to confirm the size and quality of the resource.	Maybe
Biomass Cogeneration	2	1	Mature technology. Some crop residues present from spice industry.	Maybe
Concentrated Solar Power (CSP)	1	1	In commercial operation, but significant improvements and cost reductions expected. Optimal plant size may exceed needs and land availability of Grenada.	No
Seawater Air-Conditioning (SWAC)	1	2	Technology based on other commercially proven ones, but further improvement expected. .	No
Hydropower	2	0	Mature technology. No hydropower resource available in Grenada.	No
Biodiesel for Power Generation	2	0	Mature technology. No sufficient biodiesel feedstock available (or sufficient land to grow it).	No
Ocean Thermal Energy Conversion (OTEC)	0	2	Technology at an experimental/pilot stage.	No
Ocean Wave Energy Conversion	0	2	Technology at an experimental/pilot stage. Possible availability of good ocean kinetic energy, but not ascertained.	No

Source: GRENLEC (2011), Kammen and Shirley (2011), GTZ (2010), GSWMA (2011).

C.4 Saint Kitts and Nevis

Saint Kitts and Nevis has abundant RE resources, most notably geothermal energy. Several of these technologies appear to be economically viable in Saint Kitts and Nevis, meaning that there are opportunities to reduce the country's greenhouse gas emission levels without increasing the cost of electricity to its citizens. The commercial viability of these technologies is presented in the following section.

C.4.1 Energy efficiency

The OAS conducted EE audits in Saint Kitts and Nevis over two weeks during July and August 2012 as part of the Caribbean Sustainable Energy Program (CSEP). The audits addressed issues related to high levels of energy consumption, with air-conditioning systems using the highest percentage of energy in the region. The information allowed improvements in EE performance and raised awareness about EE technologies.[58]

Additionally, the draft Energy Policy (2011) identifies improving EE as a key part of meeting the government's objectives in the energy sector. Consistent with this objective, the government and SKELEC have promoted EE efforts in electricity supply and demand. For example, SKELEC recently changed its tariff structure to encourage EE by subsidizing consumers who use less electricity.[59] SKELEC is also planning on piloting smart meters.[60]

The government is actively trying to inform residents and businesses about the importance of conservation and improving EE, in addition to engaging in efforts to improve EE in public sector buildings. In particular, the government promotes the use of EE appliances (especially air-conditioners) and lighting. In construction, the government has identified darkly colored roofs, lack of proper insulation, inefficient lighting systems and appliances, and poorly constructed windows as areas of improvement.[61]

C.4.2 Renewable energy resources

Nevis has one of the best documented geothermal resources in the Eastern Caribbean and the Nevis Island Administration is committed to using renewable resources for 100 percent of its electricity generation. Geothermal energy could provide enough base load power to supply both Saint Kitts and Nevis islands, as well as have enough left over to sell to neighboring countries. West Indies Power drilled slim-holes at various sites on Nevis in 2008 and began site preparation for an 8.5 MW power plant in 2011, but did not complete development.[62] In September 2014, the Nevis Island Administration signed a concession agreement with Nevis Renewable Energy International Inc. to begin drilling exploratory and production wells and construction and operation of a 10 MW geothermal power plant.[63]

Saint Kitts and Nevis also has commercially exploitable wind resources. Since 2010, Nevis has hosted a 2.2 MW wind farm. This makes it the first country in the OECS to operate a utility scale wind farm. Saint Kitts is also exploring wind development with the project developer North Star for a 5.4 MW wind farm. The project received a US$16.5 million commitment from the US Overseas Private Investment Corporation (OPIC) in 2011, and 25 percent of the project will be financed with private equity.[64] The government is leading discussions to reach an agreement with North Star with support from the OAS. The government has expressed the need for further support from donors in negotiating the PPA. Saint Kitts commissioned a 1 MW solar PV plant in September 2013 to supply electricity to the Robert L. Bradshaw Airport and SKELEC's grid. Saint Kitts is also assessing the viability of developing waste-to-energy, but will need support in carrying out studies on the size and potential. In addition, the Ministry of Energy is working with SKELEC to identify a feed-in tariff and drafting legislation to govern the process for self-producers to connect to the grid.

Figure 4.5 presents the potential for replacement of fossil fuel generation by sustainable energy in Saint Kitts and Nevis between 2015 and 2034.

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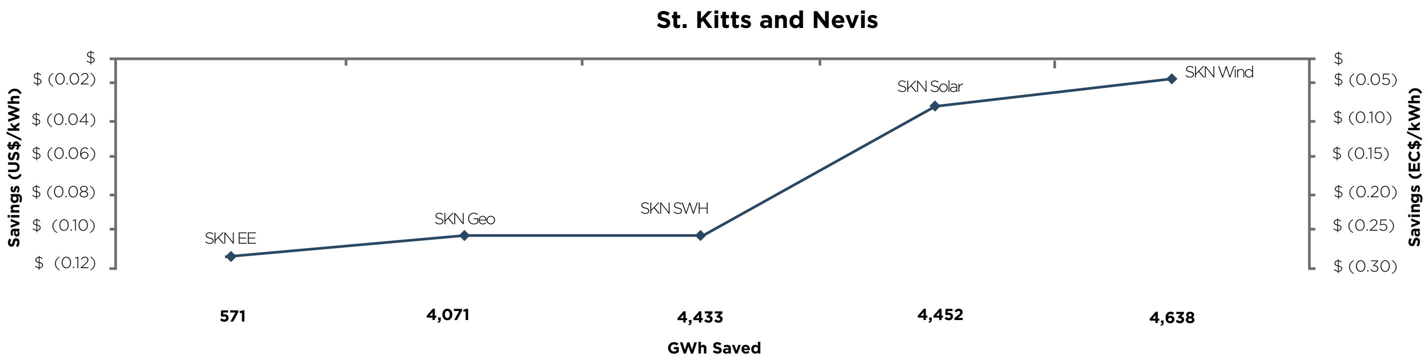
58 OAS, "Country Page: Saint Kitts and Nevis," accessed March 19, 2015, http://www.oas.org/en/about/offices_events.asp?sCode=STK.
59 "Conservation Results in Reduced Electricity Costs in Saint Kitts," Caribbean News Now, May 11, 2013, accessed March 19, 2015, http://www.caribbeannewsnow.com/topstory-Conservation-results-in-reduced-electricity-costs-in-St-Kitts-15800.html.
60 "Customers to Get a Well Needed Relief in Their Electricity Cost," ZizOnline.com, April 10, 2013, accessed March 19, 2015, http://zizonline.com/customers-to-get-a-well-needed-relief-in-their-electricity-cost/.
61 OAS, "Country Page: Saint Kitts and Nevis," accessed March 19, 2015, http://www.oas.org/en/about/offices_events.asp?sCode=STK.
62 "West Indies Power Starts First Construction Efforts at Nevis Project" (2011).
63 "Nevis Island Administration (NIA) and Nevis Renewable Energy International, Inc. (NREI) Sign Geothermal Concession Agreement," Nevis Pages, September 3, 2014, accessed July 29, 2015, http://www.nevispages.com/nevis-island-administration-nia-and-nevis-renewable-energy-international-inc-nrei-sign-geothermal-concession-agreement/.
64 Sciaudone (2011).

Figure 4.5: Sustainable Energy Supply Curve for Saint Kitts and Nevis



Note: This curve is generated using the same model as Figure 2.1. This includes the potential from Phase 2 of the geothermal plant, which will supply Saint Kitts and other islands.

Availability and commercial viability of renewable energy resources

Table C.4 assesses the maturity of RE technologies, as well as resource availability in Saint Kitts and Nevis. Technologies with a combined maturity and availability score of three or greater are potentially commercially viable in Saint Kitts and Nevis. These include wind, landfill gas to energy, solar PV, and geothermal.

Table C.4 Renewable Energy Options in Saint Kitts and Nevis

RE Technology	Maturity (0–2)	Availability of resource (0–2)	Comments	Viable?
Geothermal	2	2	Mature technology. Conservative estimates of the potential in Nevis is upwards of 30 MW—sufficient to supply the entire country's electric power. Slim-hole drilling has already taken place and a concession agreement and 25-year PPA was signed with a new developer, Nevis Renewable Energy International.	Yes
Solar Water Heaters	2	2	Mature technology. The low-lying parts of both islands have a well-documented solar resource.	Yes
Solar PV	1	2	Mature technology, although further improvements expected. The low-lying parts of both islands have a well-documented solar resource.	Yes
Wind	2	1	Mature technology and good quality resource on both islands (though it is stronger on Nevis). Nevis already operates the first wind park in the OECS (2.2 MW). A 5.4 MW wind development at Belle Vue on Saint Kitts has received US$16.5 million in OPIC funding, but development is pending.	Yes
Waste-to-Energy	2	0	Several mature technologies are available (landfill gas to energy, waste-to-energy). Waste disposal is a concern, but there may not be a sufficient waste stream.	No
Biomass Cogeneration	2	0	Mature technology; biomass available from historic sugarcane industry. GSEII found that sugarcane biomass generation could be viable, but the government is prioritizing land use for the tourism industry.	No
Concentrated Solar Power (CSP)	1	1	In commercial operation, but significant improvements and cost reductions expected. This technology may be too land intensive for extensive development on Saint Kitts or Nevis.	No
Seawater Air-Conditioning (SWAC)	1	1	Technology based on other commercially proven ones, but further improvement expected.	No

RE Technology	Maturity (0–2)	Availability of resource (0–2)	Comments	Viable?
Hydropower	2	0	Mature technology. No commercially viable resource on Saint Kitts or Nevis.	No
Biofuels for Power Generation	2	0	Mature technology. A GSEII study found that biofuel from sugarcane could be economical if a large percentage of the islands' cropland was converted to fuel crops, but at present much of the land is needed for other purposes.	No
Ocean Thermal Energy Conversion (OTEC)	0	2	Technology at an experimental/pilot stage.	No
Ocean Wave Energy Conversion	0	2	Technology at an experimental/pilot stage. Possible availability of good ocean kinetic energy, but not ascertained.	No

Source: Sciaudone (2011), Wilson (2009), GSEII (2012a).

C.5 Saint Lucia

Saint Lucia has a relatively low level of emissions per capita, but has potential to achieve even lower emissions through the use of cleaner viable electricity generation technologies, such as wind, geothermal, solar PV, and waste-to-energy, as well as improvements in EE. Several of these technologies appear to be economically viable in Saint Lucia, meaning that there are opportunities to reduce the country's greenhouse gas emission levels without increasing the cost of electricity to its citizens. The commercial viability of these technologies is presented in the following section.

C.5.1 Energy efficiency

Since 2009, Saint Lucia Electricity Services (LUCELEC) has prioritized the installation of smart meters to manage electricity demand and improve service. By the end of 2011, the utility had installed 29,000 meters, covering nearly half of its customers (LUCELEC, 2012b).

Saint Lucia received 260,000 energy efficient light bulbs from the Government of Cuba, as well as the Global Sustainable Energy Islands Initiative (GSEII) in 2004 and 2005 (GSEII, 2012). In 2006, GSEII provided a further 10,000 energy efficient bulbs (GSEII, 2014). Saint Lucia also has voluntary EE labeling standards for lighting (Saint Lucia Bureau of Standards, 2012). The very wide tolerance of the electricity supply voltage in Saint Lucia that is allowed by the ESA (240 volts +4% to –8%) may be discouraging the use of EE light bulbs. These bulbs are only cost effective if their life is in excess of about 10,000 hours, and if they are subjected to the upper limit of the allowed voltage tolerance, their life is dramatically reduced because most of these bulbs imported to the island have a nominal voltage rating of only 220 volts. Sustained use at the upper limit of almost 250 volts causes a large reduction in the life of these bulbs and will discourage their use. It is hoped that the new ESA will tighten the tolerance for supply voltage. However, the extent of EE product use is not well documented on the island.

The Government of Saint Lucia adopted the OECS model building code in 2001 (as part of the 2001 Physical Planning Bill). This building code is focused primarily on safety but could be updated to include efficiency measures.

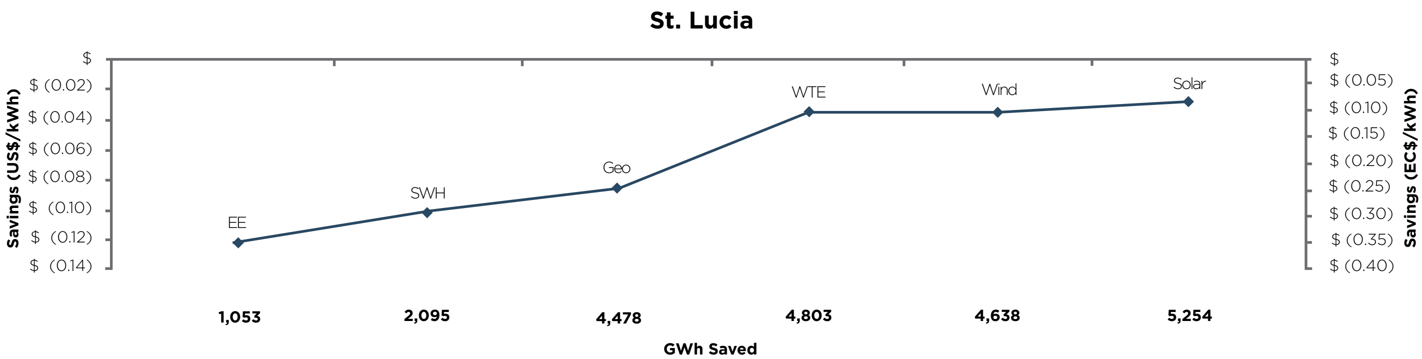
C.5.2 Renewable energy resources

Both LUCELEC and IPPs have shown interest in developing geothermal, wind, and waste-to-energy projects in Saint Lucia. However, despite several initiatives, no projects have been brought to completion to date. In 2014, the government received grant funding from the World Bank and the New Zealand Government for its Geothermal Resource Development Project, to carry out surface exploration, support negotiations, and support reform of the legal and regulatory framework for geothermal power.[65] The government has a project agreement with ORMAT to carry out surface exploration and test drilling.[66] A new project agreement will need to be developed once the geothermal resource is confirmed to carry out production drilling and power plant construction.

Figure 4.6 presents the potential for replacement of fossil fuel generation by sustainable energy in Saint Lucia between 2015 and 2034.

[65] "St. Lucia Receives $2.8 mn for Geothermal Project" (2014).
[66] "St. Lucia Says Geothermal Exploration Will Begin in 2015," Caribbean Journal, December 18, 2014, accessed December 4, 2015, http://caribjournal.com/2014/12/18/st-lucia-says-geothermal-exploration-will-begin-in-2015/#.

Figure 4.6: Sustainable Energy Supply Curve for Saint Lucia



Note: This curve is generated using the same model as Figure 2.1.

Availability and commercial viability of renewable energy resources

Table C.5 assesses the viability of RE technologies in Saint Lucia by examining their maturity, as well as the availability of corresponding resources in the country. Technologies with a combined maturity and resource availability score of three or greater are potentially economically viable in Saint Lucia. These include solar water heaters, solar PV, wind power, waste-to-energy, and potentially geothermal.

If RE enters the generation matrix, the government will need to carry out changes to the grid code, regulatory framework, and tariffs. For example, if intermittent power enters the generation matrix, the government will need to modify the tariff structure to ensure that all customers pay an appropriate price.

Table C.5 Renewable Energy Options in Saint Lucia

RE Technology	Maturity (0–2)	Availability of resource (0–2)	Comments	Viable?
Geothermal	2	Unknown	Mature technology. Saint Lucia may have upwards of 75 MW of geothermal potential, but further studies are required to confirm the resource. Past studies indicate that the chemical composition of the resource may pose problems for electricity production. The government is carrying out additional surface exploration with a grant from the World Bank and the Government of New Zealand under a PPP agreement with ORMAT. If drilling is successful, a new project agreement will need to be prepared. LUCELEC is open to participate in that new project agreement.	Maybe
Wind	2	2	Mature technology. LUCELEC has investigated the resource at several sites. Studies suggest that cost per kWh would be below the fuel cost of diesel generation. Total potential has been estimated at 40 MW.	Yes
Solar Water Heaters	2	2	Mature technology and high-quality resource. Solar water heaters are in use in Saint Lucia, but there is significant room for expansion.	Yes
Solar PV	1	2	Mature technology, although further improvements expected. A study (Nexant, 2010) estimated the total potential at 36 MW due to good GHI. Few systems are already in use. LUCELEC operates several demonstration programs involving small grid-connected PV systems. It commissioned the first grid-tied PV small renewable energy system (RES) in March 2009. The 5.7 kW system was connected to facilitate net-metering. That phase of the pilot was concluded in December 2009. Between November 2009 and May 2010 three more small PV systems were installed: Castries Market (4 kW); Vieux Fort Secondary School (4 kW); and the National Trust building at Pigeon Island (12 kW, 3 phase). The second phase of the pilot project was concluded in August 2010. Generally, the project was regarded to be a success and no safety issues were identified. LUCELEC has therefore decided to offer its domestic customers the facility to connect to the network small PV systems rated at 5 kW or less under a net metering arrangement using	Yes

RE Technology	Maturity (0–2)	Availability of resource (0–2)	Comments	Viable?
			smart bidirectional meters. It is also considering offering this facility to its commercial customers for RE systems up to 25 kW (3 phase), but has identified the need for special tariffs. The next step in the process is a tariff study to identify a suitable tariff for commercial PV systems, a public information and education campaign on small PV systems, and the installation of PV systems at LUCELEC's various premises. One system has already been installed at the Customer Service Outlet in Vieux Fort.	
Waste-to-Energy	2	0	There are several mature technologies available (landfill gas to energy, waste-to-energy). Requests for Qualifications (RFQs) have been issued to 10 companies which aim to establish their ability to design, build, finance, maintain, and operate a waste-to-energy plant on the island. The proposed waste-to-energy plant is expected to generate 1–3 MW of base load electricity and the project developer will be selected through a competitive bidding process. The project is expected to provide an alternative to the existing landfill sites that are environmentally unsound and are near the end of their permitted capacity. The Ministry of Sustainable Development, Energy, Science and Technology is promoting this project with support from the Carbon War Room, which has so far commissioned a grid integration study for the project. This study will determine what capacity of RE can be added to the country's electricity grid without compromising the reliability of the system. The winning bidder will be required to enter into a PPA with LUCELEC, through which the electricity produced from the waste-to-energy plant will be delivered to LUCELEC for distribution on the national grid.	Yes
Biomass Cogeneration	2	0	Mature technology. A study (Nexant, 2010) suggested that biomass generation would be marginally uneconomic.	No
Hydropower	2	0	Mature technology, but there is virtually no hydro resource available in Saint Lucia.	No
Concentrated Solar Power (CSP)	1	1	In commercial operation, but significant improvements and cost reductions are expected. The solar resource is not appropriate for CSP in Saint Lucia due to low direct normal irradiance.	No
Seawater Air-Conditioning (SWAC)	0	2	Technology based on other commercially proven ones, but further improvement expected.	No
Biofuels for Power Generation	2	0	Mature technology, but limited resource available.	No
Ocean Thermal Energy Conversion (OTEC)	0	2	Saint Lucia's resource is potentially good, but this technology is at an experimental/pilot stage.	No
Ocean Wave Energy Conversion	0	2	Saint Lucia's resource is potentially good, but this technology is at an experimental/pilot stage.	No

Source: OAS (2009), Nexant (2010).

C.6 Saint Vinvent and the Grenadines

Saint Vincent and the Grenadines has relatively low emissions per capita. However, the country could further reduce its emissions by using available RE resources, including geothermal, wind, solar, waste, and hydro, and increasing its use of EE technologies. Several of these technologies appear to be economically viable in Saint Vincent and the Grenadines. The commercial viability of these technologies is presented in the following section.

C.6.1 Energy efficiency

EE technologies are available in Saint Vincent and the Grenadines, and the government has provided incentives for their use. For example, CFLs are not subject to the 100 percent excise tax or the 15 percent value-added tax that applies to incandescent lights. The government's energy action plan calls for several measures to further promote the adoption of EE technologies; however, these measures have not yet been implemented.[69]

Between January and November 2010, a European Union–funded program performed energy audits for 70 government buildings that Saint Vincent Electricity Services Limited (VINLEC) had identified as the most consumptive government buildings. The audits informed action plans for reducing energy consumption in the buildings.

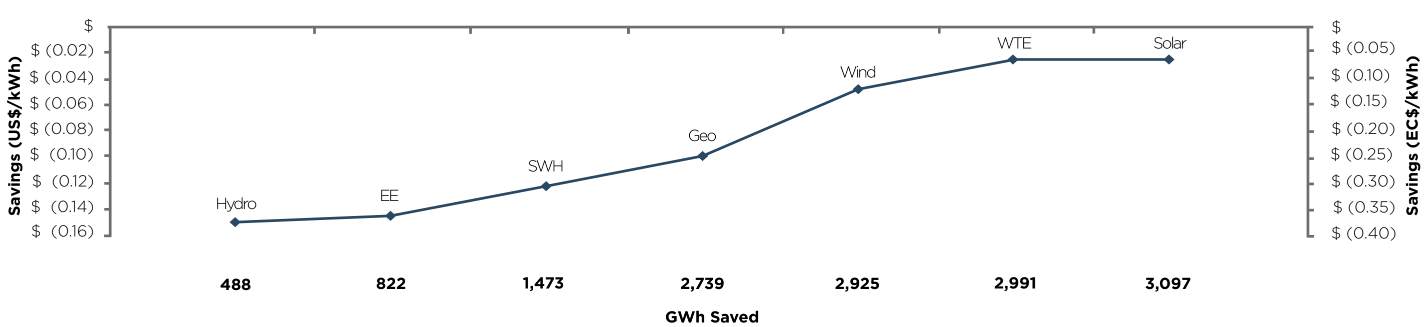
C.6.2 Renewable energy resources

Saint Vincent and the Grenadines already uses RE in the form of small hydro and solar generation. The government recognizes that there is potential to increase RE generation, and established a goal in the action plan of having 30 percent of electricity output come from renewables by 2015 and 60 percent by 2020.[70]

In Saint Vincent, the government is working with private companies to develop their geothermal resources. Emera (based in Barbados) and Reykjavik Geothermal completed surface exploration in July 2015. The project developers will not carry out slim-hole drilling and will proceed directly to exploratory drilling. The government met with Emera and Reykjavik Geothermal in August 2015 to negotiate the finalized business plan for the geothermal project.[71] Project developers expect to begin drilling in the second quarter of 2016.[72] Also, the Abu Dhabi Fund for Development is providing the government of Saint Vincent with a US$15 million loan to support the development of its geothermal plant.[73]

Figure 4.7 presents the potential for replacement of fossil fuel generation by sustainable energy in Saint Vincent and the Grenadines between 2015 and 2034.

Figure 4.7: Sustainable Energy Supply Curve for Saint Vincent and the Grenadines



Note: This curve is generated using the same model as Figure 2.1.

[69] Government of Saint Vincent and the Grenadines, Sustainable Energy for SVG: The Government's National Energy Policy, March 2009, accessed March 21, 2015, http://www.gov.vc/images/stories/pdf_documents/svg%20nation%20energy%20policy_approved%20mar09.pdf.
[70] Ibid.
[71] Dacon (2015).
[72] "St. Vincent Geothermal Project On Track to Start-up in 2018" (2015); Dacon (2015).
[73] Kenton X. Chance, "St. Vincent Embarks on Renewable Energy Path," IPSnews.net, January 12, 2015, accessed March 19, 2015, http://www.ipsnews.net/2015/01/st-vincent-embarks-on-renewable-energy-path/.

Availability and commercial viability of renewable energy resources

Saint Vincent and the Grenadines could increase the share of electricity generated from renewables through the expansion of hydropower, as well as the exploitation of solar, wind, and potentially geothermal resources. The government estimates that Saint Vincent has 5–10 MW of unused hydro capacity.[74] Insolation is good on the islands, meaning that there is good potential for using solar water heaters and solar PV.

VINLEC has measured wind speeds at Ribishi Point, Belle Isle, and Brighton. Ribishi Point and Brighton appear to have a suitable resource for power generation.[75] An economic study of the site concludes that a 3 MW plant would be economically viable at Ribishi Point as long as oil prices remain above US$50 per barrel.[76] VINLEC evaluated tenders to develop the site in 2009, but neither VINLEC nor a third party were physically developing the site as of February 2015.

Geothermal and biomass resources may also be exploitable, but require further study. VINLEC has an interconnection agreement in place for distributed generation. Despite the availability of economically viable renewable resources in the country, there have been limited developments in RE to date. In its action plan, the government states that the main barriers preventing RE development in the country are:

- Inadequate legal framework for IPPs,
- Lack of local financing, and
- Lack of quality site-specific information.

Table C.6 assesses the maturity of RE technologies, as well as the availability of their resource in Saint Vincent and the Grenadines. Technologies with a combined maturity and availability score of three or greater are potentially commercially viable. These include hydropower, solar water heaters, wind, solar PV, waste-to-energy, and potentially geothermal.

[74] “Sustainable Energy for SVG: The Government’s National Energy Policy,” March 2009, accessed March 21, 2015, http://www.gov.vc/images/stories/pdf_documents/svg%20nation%20energy%20policy_approved%20mar09.pdf.
[75] Ibid.
[76] CARICOM, GIZ, Caribbean Renewable Energy Development Programme, Wind Power in the Caribbean: On-going and Planned Projects, May 2011, accessed March 21, 2014, http://www.credp.org/Data/CAWEI_Wind_Survey_Report.pdf.

Table C.6 Renewable Energy Options in Saint Vincent and the Grenadines

RE Technology	Maturity (0–2)	Availability of resource (0–2)	Comments	Viable?
Hydropower	2	2	Mature technology. Untapped hydro resources on Saint Vincent, as well as the potential to upgrade existing facilities for increased power production.	Yes
Solar Water Heaters	2	2	Mature technology. The country has a good solar resource and this technology is economically viable	Yes
Wind	2	2	Mature technology. Several islands have good wind resource, particularly on their eastern shores. The government has identified Ribishi Point as a good site for development, and VINLEC has received offers by developers interested in the site. Canouan Island has been considered for a 2 MW wind farm	Yes
Solar PV	1	2	Mature technology, although further improvements expected. The low-lying parts of the country have good resources for PV.	Yes
Waste-to-Energy	2	1	Several mature technologies are available (landfill gas to energy, waste-to-energy). Studies on Saint Vincent in 2009 suggested a combination of municipal waste and crop residues could power a biogas plant of 3–4 MW. The concept needs to be explored further.	Yes
Geothermal	2	1	Mature technology. Surface exploration performed by Emera and Reykjavik Geothermal and completed in July 2015 estimates the size of the geothermal resource at upwards of 75 MW. By early to mid-2015 the government and private developers finalized a detailed technical project business plan that will serve as the foundation for project agreements. The government received a US$15 million loan for the project.	Yes
Biomass Cogeneration	2	0	Mature technology; biomass resource on its own is insufficient for energy generation, but combined with municipal waste streams could be used to generate energy (see entry for waste-to-energy).	No
Concentrated Solar Power (CSP)	1	1	In commercial operation, but significant improvements and cost reductions expected. The technology likely requires too much land to be considered practical in the country.	No
Seawater Air-Conditioning (SWAC)	1	1	In commercial operation, but significant improvements and cost reductions expected. The technology likely requires too much land to be considered practical in the country.	No
Biofuels for Power Generation	2	0	Mature technology. Not enough available land to produce biofuels in power-generating quantities.	No
Ocean Thermal Energy Conversion (OTEC)	0	2	Technology at an experimental/pilot stage.	No
Ocean Wave Energy Conversion	0	2	Technology at an experimental/pilot stage. Possible availability of good ocean kinetic energy, but not ascertained.	No

Source: OAS/NREL (2011), Government of Saint Vincent and the Grenadines (2010, 2014).

Appendix D: Eastern Caribbean Utility Comparison

Table D.1 provides a brief comparison of the utilities covered in this report.

Table D.1 : Eastern Caribbean Utility Comparison (US$)

Utility	Avg. Electricity Tariffs (US$/kWh)	Fuel Surchase per kWh	Peak Demand (MW)	Base Load (MW)	Customers	Peak kW Demand per Customer
APUA (Antigua and Barbuda)	$0.41 (2014)	$0.22 (2010)	51 (2010)	42 (2009)	31,3567 (2010)	1.63 (2010)
DOMILEC (Dominica)	$0.37 (2014)	$0.18 (2014)	17 (2014)	7.2 (2009)	35,354 (2014)	0.48 (2014)
GRENLEC (Grenada)	$0.37 (2014)	$0.21 (2010)	$30.2 (2010)		46,478 (2010)	0.65 (2010)
NEVLEC (Nevis)	$0.32 (2014 est.)	$0.15 (2014 est.)	10.4 (2015)	5 (2013)	6,737 (2010)	1.19 (2010)
SKELEC (Saint Kitts)	$0.32 (2014 est)	N/A	24.0 (2015)	16 (2011)	15,714 (2008)	1.91 (2008)
LUDELEC (Saint Lucia)	$0.32 (2014)	$0.18 (2014)	57.2 (2014)		67,100 (2014)	0.85 (2014)
VINLEC (Saint Vincent and the Grenadines)	$0.35 (2014)	$0.17 (2014)	25.6 (2013)	12 (2015)	41,370 (2013)	0.62 (2013)

Source: National Renewable Energy Laboratory (2015a, 2015c); 2014 Annual Reports for DOMLEC, GRENLEC, and LUCELEC; VINLEC, 2014 Financial Statements; CARILEC (2010, 2014); Dacon (2015); Humpert (2013); Gardner (2011); Powell (2015).

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