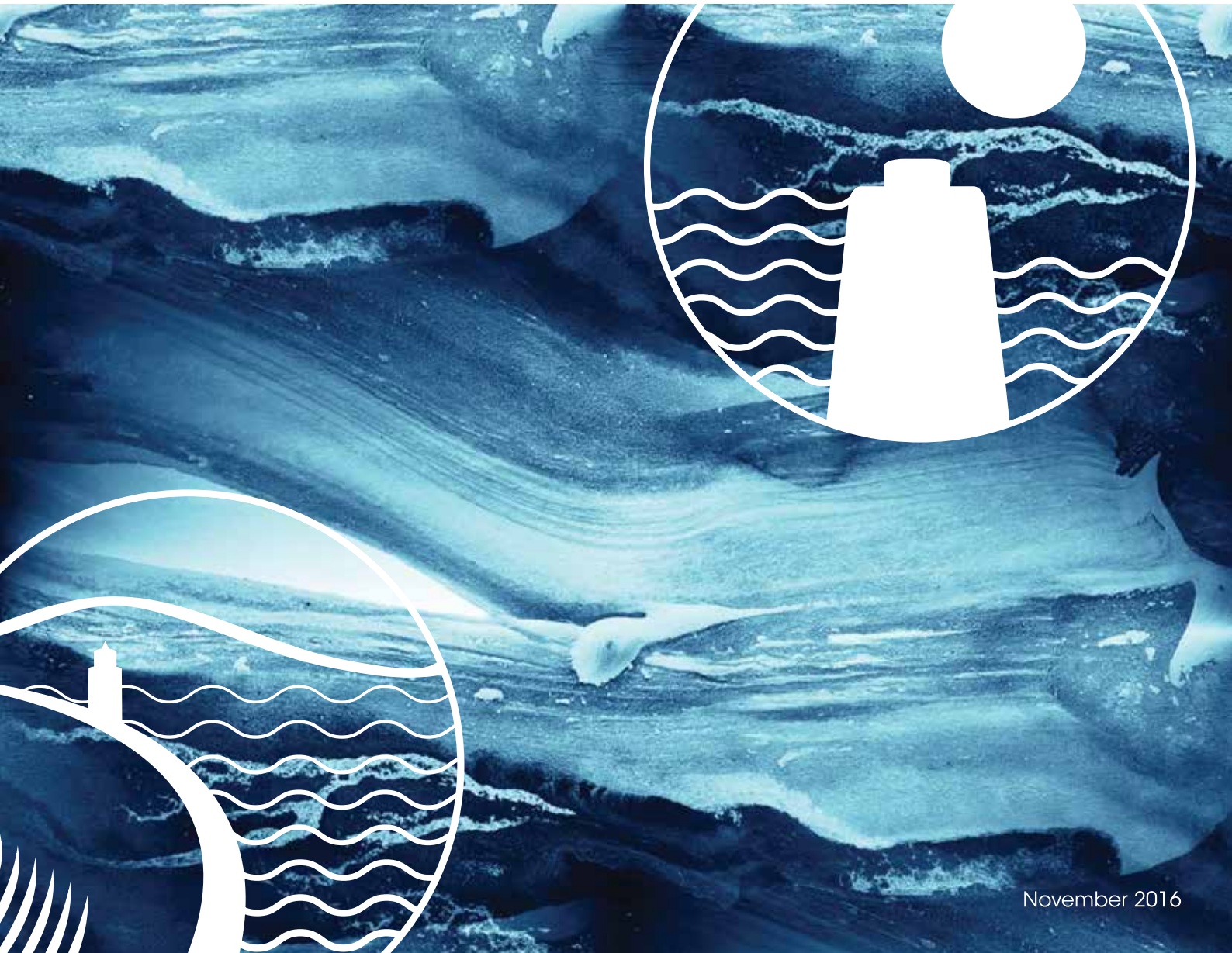
IRENA
International Renewable Energy Agency

ANTIGUA & BARBUDA

RENEWABLES READINESS ASSESSMENT



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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.
www.irena.org

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Disclaimer

RENEWABLES READINESS ASSESSMENT:

ANTIGUA AND BARBUDA

FOREWORD

from the Minister of Tourism, Economic Development, Investment and Energy, Antigua and Barbuda

Antigua and Barbuda, like many Caribbean island states, possesses abundant renewable energy resources, including considerable solar, wind, ocean and biomass potential. The challenges in harnessing these resources are significant and include financial, technological, environmental and other barriers.

The Ministry of Tourism, Economic Development, Investment and Energy, on behalf of the Government of Antigua and Barbuda, therefore, welcomes this opportunity to partner with the International Renewable Energy Agency in the preparation of a Renewables Readiness Assessment (RRA) for Antigua and Barbuda, aimed at identifying a pathway to utilise our clean energy resources.

The Government, led by the Honorable Gaston Browne, has from its first days in office pursued a strategy of seeking to develop renewables as a cornerstone for economic and social development.

Considerable progress has been achieved within a short time, with achievements including the successful initiation of a 10-megawatt solar photovoltaic project, passage of a Renewable Energy Act, removal of charges and duties on renewable energy technologies, and negotiation of millions of dollars in soft loans for renewables through the Abu Dhabi Fund for Development. The result has been to surpass our initial targets, with renewables already approaching 20% of peak electricity demand.

Our commitment to renewables stems from a number of perspectives. Firstly, we are anxious to use our own resources to reduce foreign exchange leakage, stabilise energy costs, provide sustainable employment to our people, and combat the reality of global climate change.

As a small island developing state, Antigua and Barbuda is among the most vulnerable to the ravages of climate change. Coming out of the 2015 Paris climate conference, our government has pledged ambitious targets to reduce emissions of greenhouse gases, with the Prime Minister personally depositing our instrument of ratification of the Paris Agreement on 22 September. Assistance from IRENA has helped bring together stakeholders from a range of sectors to discuss the challenges and opportunities of accelerating renewable energy development. In that regard, I would like to thank all who participated in and supported the RRA process. This includes the Permanent Secretary in my ministry and her staff, particularly the Energy Unit. Invaluable support has also come from the Antigua and Barbuda Mission to the United Nations in New York.

The resulting report presents a set of clear and practical steps for Antigua and Barbuda to pursue to maximise renewables its energy mix.

I also take this opportunity of thanking IRENA for its invaluable support in charting a path for us to advance our government's sustainable energy agenda. We look forward to continuing to work with IRENA and other international partners in the public and private sectors to develop our renewable energy resources in a sustainable and pragmatic manner.

Honorable Asot A. Michael
Minister of Tourism, Economic Development, Investment and Energy
Antigua and Barbuda

FOREWORD

from the IRENA Director-General

Small island states all over the Caribbean face daunting costs for fuel imports and a recurrent risk from global oil price volatility. Antigua and Barbuda has resolved to improve its energy security and achieve carbon-neutral development, joining worldwide efforts to achieve energy security and combat climate change.

This Renewables Readiness Assessment (RRA) presents clear and practical steps for the country to make maximum use from all forms of renewable energy. Undertaken by Antigua & Barbuda officials in co-operation with the International Renewable Energy Agency, the study examines the energy sector holistically, identifies barriers and highlights actions to accelerate deployment. This is a country-led process, with IRENA providing technical support and expertise to facilitate consultations among different national stakeholders.

Some 30 countries, spanning Africa, the Asia-Pacific region, Latin America, the Middle East and the Caribbean, have undertaken the RRA process since 2011, exchanging knowledge and encouraging international co-operation to promote clean, indigenous renewable energy technologies.

Renewables have already grown, in a relatively short time, to cover one fifth of the country's peak electricity demand. A new national power purchase agreement, due in 2019, offers the chance to accelerate the uptake of renewables substantially.

An IRENA grid-integration study, for example, underlines the potential for Antigua and Barbuda to adopt solar photovoltaic (PV) power on large scale. The island nation's existing grid system could integrate at least 37.5 megawatts of on-grid PV, equivalent to three quarters of current electricity consumption.

IRENA wishes to thank the Honourable Minister Asot A. Michael and his team for their commitment to this study and their valuable insights on island energy challenges. Their perspective is much appreciated as we continue our work to support renewable energy deployment in the Caribbean and beyond.

I sincerely hope these RRA findings will strengthen the pursuit of renewable energy solutions. IRENA stands ready to provide continuing support as Antigua and Barbuda strives for a sustainable energy future.

Adnan Z. Amin
Director-General
IRENA

Barbuda's isolated highlands have the potential to support up to 400 megawatts of wind power capacity
Photograph: PV Energy

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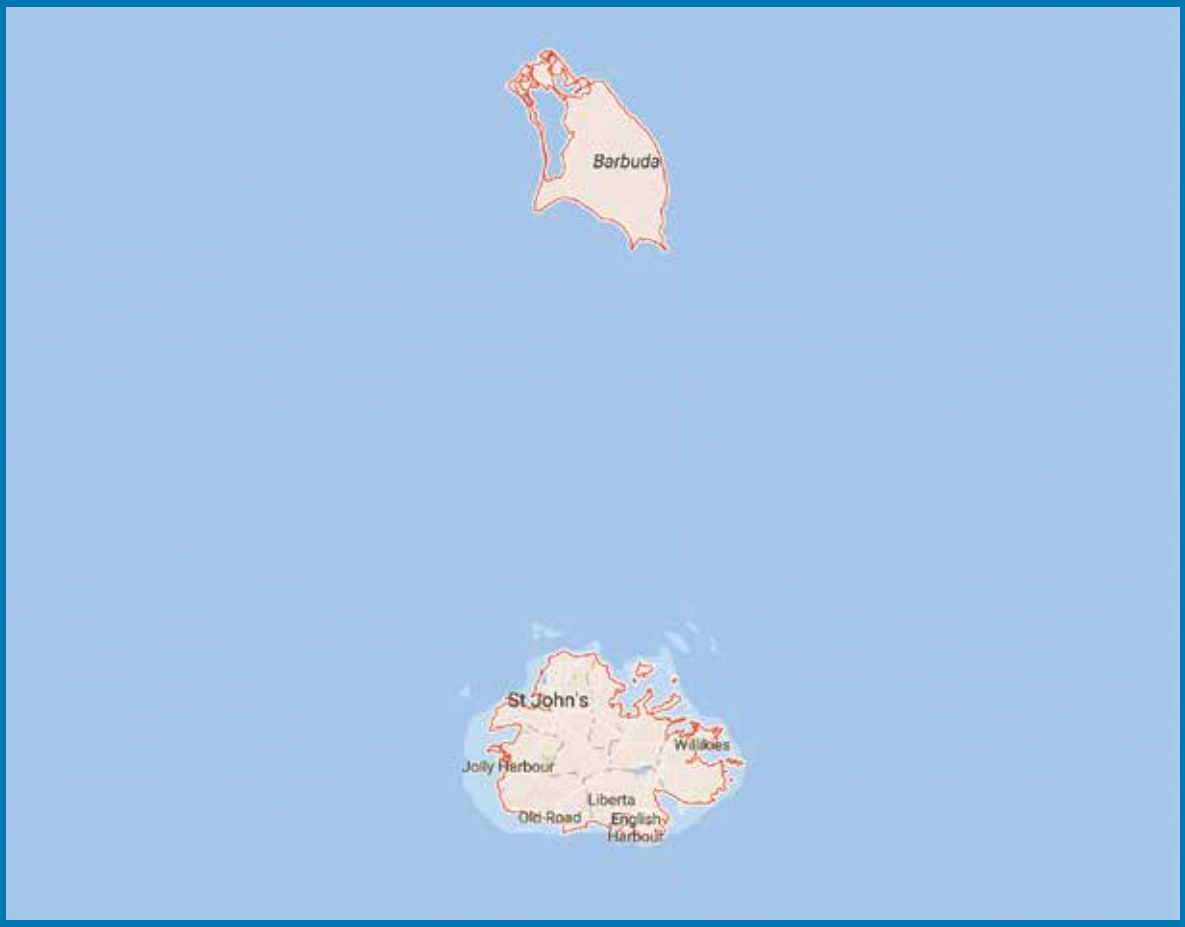
ABBREVIATIONS

APUA	Antigua Public Utilities Authority
CARICOM	Caribbean Community
CREDP	CARICOM Renewable Energy Development Programme
GDP	gross domestic product
GIZ	German International Cooperation Agency (Deutsche Gesellschaft für Internationale Zusammenarbeit)
GoAB	Government of Antigua and Barbuda
HFO	heavy fuel oil
INDC	intended nationally determined contribution
IPP	independent power producer
kW	kilowatt
kWh	kilowatt-hour
kWp	kilowatt-peak
OLADE	Latin American Energy Organization (Organización Latinoamericana de Energía)
m/s	metre per second
MSW	municipal solid waste
MTEDIE	Antigua and Barbuda Ministry of Tourism, Economic Development, Investment and Energy
MW	megawatt
MWh	megawatt-hour
MWp	megawatt-peak
NEP 2011	National Energy Policy 2011
OECS	Organisation of Eastern Caribbean States
PPA	power purchase agreement
RRA	renewables readiness assessment
UNFCCC	United Nations Framework Convention on Climate Change
V	volt
XCD	East Caribbean Dollar



Source: Google Maps

ISLAND CONDITIONS AND CLIMATE

Land area: 443 km² (171 square miles)

Population: 89,985

GDP per capita (2014): USD 13,432

Electricity use per capita: 3,723 kWh

Peak electricity demand: 51 MW

Firm electrical capacity: 108 MW

Retail electricity price: USD 0.37/kWh (December 2015)

Renewable energy on the grid (% of peak): 1.6% (April 2015)

Antigua and Barbuda is an archipelagic island nation at the northern end of the Eastern Caribbean archipelago, between the Caribbean Sea and the Atlantic Ocean. Its total area is 443 square kilometres (km²), consisting of two major inhabited islands Antigua and Barbuda, 43 km apart, as well as several smaller, uninhabited islands, and low-elevation, coral reef islets known as Cays (Central Intelligence Agency, 2015).

The climate is tropical, and over the course of a typical year, ambient temperature varies from 23°Celsius (°C) to 31°C. Average precipitation is about 114 centimetres per year (Antigua and Barbuda Meteorological Services, 2015), and the rainfall pattern varies considerably from the dry season (December–April) to the rainy season (June–November). The country is located within the tropical Atlantic hurricane belt and is at risk of being affected by hurricanes during the hurricane season, which coincides with the rainy season.

The islands are generally low-lying, except for the south-western quadrant of Antigua. This is more mountainous terrain, rising to a peak of 402 metres (m) at Mount Obama (formerly Boggy Peak), the remnant of an extinct volcanic crater. The island of Barbuda is entirely low-lying. There are no permanent rivers anywhere in the country.

EXECUTIVE SUMMARY

Antigua and Barbuda is a small, upper-middle-income country in the Caribbean with a population of 89,985. It is highly dependent on petroleum-based fuels and consequently experiences volatile and often high energy costs. Drinking water supply is mostly based on seawater desalination powered by fossil fuels. Peak electricity demand is 51 megawatts (MW) and is forecast to grow slowly to about 55 MW in 2025. The country enjoys good solar and wind resources all year round, and its bioenergy resources are considered suitable for utility-scale application.

The energy sector is governed by the 2015 Renewable Energy Act, the 1973 Public Utilities Act as amended by the 1993 Public Utilities (Amendment) Act, and the 2004 Public Utilities (Amendment) Act, along with associated legislation. Electricity is supplied by Antigua Public Utilities Authority (APUA), a government-owned, vertically integrated corporation. APUA purchases 80-90% of the electricity supplied from a locally owned independent power producer (IPP) through two supply arrangements, one of which is a formal power purchase agreement (PPA). It also owns sizeable in-house generating capacity, which has resulted in surplus capacity of about 30 MW, equating to 60% of peak demand.

The Government of Antigua and Barbuda has published a national energy policy known as NEP 2011, which sets out the country's sustainability vision, objectives, policies and targets. Rapid early progress has ensued; the 2015 renewable energy target has been exceeded, and the 2030 target is scheduled to be achieved in 2016.[1] In parallel, the Antigua and Barbuda Department of Environment is working on several project concepts for funding, including a proposed 8 MW off-grid wind and solar project.

By 2017,[2] the implementation of the planned grid-connected installations will exceed APUA's existing 15% installed capacity threshold for the integration of variable renewable sources to its grid. However, a recent study by the International Renewable Energy Agency (IRENA) confirmed the technical possibility to integrate at least 37.5 MW of photovoltaic (PV) generation to the grid on Antigua (IRENA, 2015, unpublished). Given that peak system demand currently stands at 50 MW, and minimum demand at 23 MW, the additional renewable capacity would correspond to a variable renewable capacity penetration of 75% of peak demand.

This Renewables Readiness Assessment (RRA) recommends a study forming the first milestone of a roadmap towards the goal of 75% grid-based renewables capacity by 2025. The proposed recommendations outlined below are the first building blocks towards a shift to renewable energy in Antigua and Barbuda.

The RRA process has generated the following recommendations:[3]

1. **Devise an action plan to scale up renewable energy deployment.** The action plan should work out the measures and activities necessary to achieve new targets such as the intended nationally determined contribution (INDC), given the country's high potential for renewable energy deployment. The action plan will consider relevant technical, economic, financial, policy, regulatory, institutional, social and environmental factors that would enable higher renewables penetration.

2. **Review and rationalise the policy and tariff structure for grid interconnection with distributed renewables.** The policy and tariffs should now be reviewed and rationalised in light of the potential for significantly higher renewable energy targets.

3. **Undertake a comprehensive public awareness and engagement programme aimed at all levels of society. This would educate people about the costs and benefits of renewables, promote awareness and understanding of the influence**

[1] There are already around 80 distributed PV systems and one utility-scale PV system of three megawatt-peak (MWp), amounting to less than 4 MWp in total. The government has plans to finance and implement another 7 MWp in the short term.
[2] The intermittent rated capacity must be no more than 15% of APUA's system peak demand.
[3] More details in chapter 4.

of personal behaviour on energy efficiency and sustainability outcomes, and engage consumers in the daily business of sustainability. Public awareness campaigns are typically useful for increasing public knowledge about an issue but often lack a design that results in actual long-term change to relevant behaviour.

4. Develop a national strategy for bioenergy and waste management development. Bioenergy is considered an important cross-cutting area because it spans the energy and waste management sectors. A comprehensive review of Antigua and Barbuda's options and considerations is proposed alongside an evaluation of the commercial potential of this resource.

5. Establish an independent energy commission with appropriate authority to regulate the electricity supply market in relation to sources of supply, grid interconnection, pricing and quality of service of all parties. The development of a renewables-ready energy sector will require an efficient, transparent and equitable regulatory framework to facilitate new and ongoing investment in renewables by businesses, individuals and the government.

6. Support renewable energy penetration in the power generation mix through standardised, technology-specific renewable energy PPAs. A set of standardised renewable PPA templates is needed to ensure investors are on a level playing field and to reduce administrative requirements and implementation time. The standardised PPA templates should provide greater certainty and fair risk allocation between stakeholders.

Solar panels provide clean power at V.C. Bird International Airport
Photograph: PV Energy

1. INTRODUCTION

1.1 GENERAL

The development of an economy largely powered by renewable energy has the potential to create significant social, economic and environmental value. In the context of the United Nations Sustainable Development Goals and the Paris Agreement on climate change, a transition to sustainable energy is central to meeting development and climate objectives. Moreover, within the timeline of the Sustainable Development Goals, as the International Renewable Energy Agency (IRENA) has noted, "renewable energy can offer solutions for the dual objective of ensuring economic growth and the imperative to decarbonise economies across the globe" (IRENA, 2016).

IRENA's research confirms that accelerating renewable energy deployment generally fuels economic growth, creates new employment opportunities, enhances human welfare and contributes to a climate-safe future. These benefits, seen in all sizes and types of economies worldwide, will also accrue to Antigua and Barbuda if it successfully makes a transition to renewables.

1.2 COUNTRY OVERVIEW

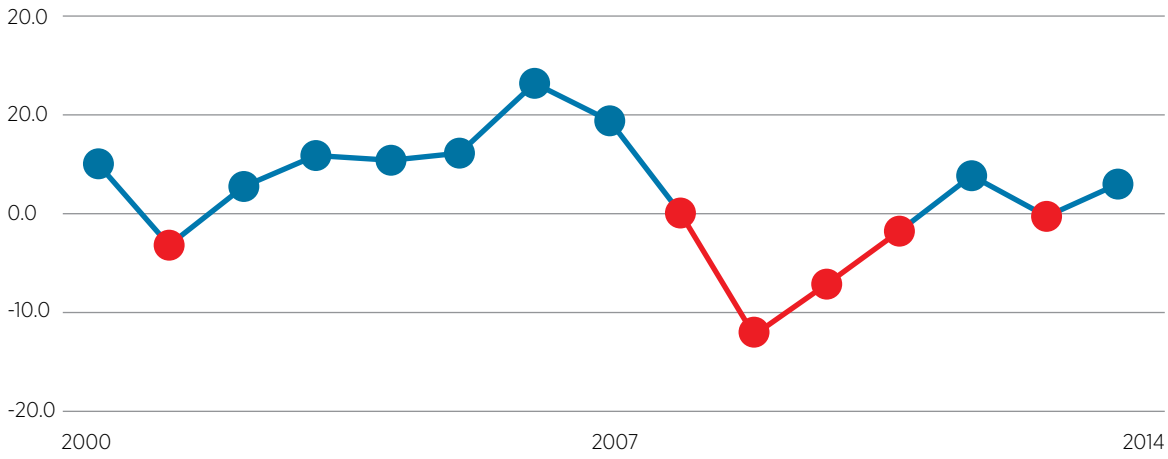
The total population of the country is 89,985 (World Bank, 2013), most of which is concentrated around St Johns, the capital city. The population on Barbuda is approximately 1,200. Overall population density is 204.5 per km^2, and the population growth rate in 2013 was 1.03%.

Education levels are generally high by regional standards. Primary school enrolment is 98%, and 60% of primary school teachers have been through teacher training (World Bank, 2012). Data on long-term unemployment is not available, but the figure is probably within the range typical of the region at approximately 10%.

Antigua and Barbuda's economy is heavily dependent on tourism. This accounts for about 80% of output of gross domestic product (GDP), about 70% of direct and indirect employment, and 85% of foreign exchange earnings (GoAB, 2014). A small manufacturing sector assembles a limited number of products for export. Agricultural production is nominal due to relatively low rainfall and an absence of permanent rivers on the island for irrigation purposes.

GDP per capita in 2014 amounted to USD 13,432. This places Antigua and Barbuda in the upper-middle-income category of countries overall (World Bank) and in fifth place among the Caribbean Community (CARICOM) group. Real GDP growth in 2000-2014 averaged 2.1% per annum; the time series is shown in Figure 1.

Figure 1: Real GDP growth, Antigua and Barbuda, 2000-2014



Source: World Bank, 2014 (data.worldbank.org)

The country has no indigenous fossil fuel resources and is dependent on imported petroleum-based fuels for its energy supply. The total value of fuel imports amounted to USD 165.4 million in 2013 (equivalent to 13.7% of the country's GDP) and USD 160.1 million in 2014 (West Indies Oil Company, 2015).

As a result of its dependence on petroleum-based fuels, the country's energy costs are highly volatile. The average electricity retail price was USD 0.44 per kilowatt-hour (kWh) in July 2013. By January 2016, this had fallen to USD 0.37/kWh as a result of falling oil prices from mid-2014 – a decrease of 16% (APUA, 2013).

The country is a member of CARICOM[4] (CARICOM, 2015). Antigua and Barbuda is also one of ten members of the Organisation of Eastern Caribbean States (OECS), an economic grouping of islands in the Eastern Caribbean (OECS, 2015).

1.3 THE RENEWABLES READINESS ASSESSMENT PROCESS IN ANTIGUA AND BARBUDA

The RRA is a country-led consultative process developed by IRENA to determine appropriate policy and regulatory choices and ensure the broadest possible engagement and acceptance from stakeholders.

The RRA is a comprehensive tool for assessing key conditions for renewable energy technology development and deployment in a particular country, and the action necessary to further improve these conditions. The RRA considers the current situation and defines the necessary action to further improve these conditions. It aims to identify the elements necessary for an effective policy framework to support the accelerated development of the renewable energy market. Its collaborative design ensures it builds consensus on action to be taken by relevant actors to address the key barriers to the uptake of renewable energy technologies.

The Ministry of Tourism, Economic Development, Investment and Energy (MTEDIE) was the stakeholder that initiated the RRA process.

The completed RRA included a background paper, further identification of stakeholders and definition of service-resource pairs, an RRA expert workshop and additional consultations with stakeholders.

The government hosted the Antigua and Barbuda RRA workshop through the MTEDIE and in collaboration with IRENA on 17-18 September 2015. This identified priority action required for facilitating Antigua and Barbuda's transition to renewable energy.[5] Additional stakeholder consultations included a follow-up mission during November 2015 for consultations with key sector stakeholders (some of whom could not attend the RRA workshop)[6] and a brief follow-up survey of stakeholders.

This process generated the set of recommendations in Chapter 4 of this report.

[4] CARICOM consists of 20 countries. Of these, 15 are full members and five are associate members.
[5] The workshop was attended by 24 participants.
[6] These discussions included meetings with the Minister of the MTEDIE, the Department of the Environment, the Utility Company and with two local entrepreneurs in the biofuels and solar PV sectors.

II. ENERGY SECTOR OVERVIEW

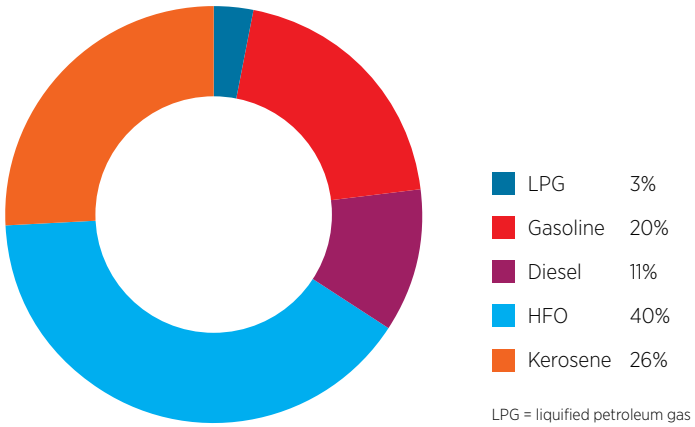
2.1 ENERGY RESOURCES

Antigua and Barbuda is almost entirely dependent on imported fossil fuels for its energy supply. More than one-third of all imports are related to energy.[7] Some solar, wind and bioenergy resources (fuelwood, locally produced charcoal and some biodiesel) are used by private individuals in scattered locations.

Petroleum product imports consist of gasoline, and diesel for use in the transport sector; heavy fuel oil (HFO) for power sector use; liquefied petroleum gas (LPG) for cooking; kerosene/Avgas for aviation and a small amount of domestic use.

In 2014, fuel imports amounted to 192,788 tonnes of oil equivalent. HFO for the power sector made up the largest component of this figure, followed by gasoline and diesel for transportation, as shown in Figure 2 below.

Figure 2: Energy supply and demand in 2011 in tonnes of oil equivalent



Source: West Indies Oil Company

2.2 ENERGY MARKETS

Energy prices and tariffs

The energy market in Antigua and Barbuda has three tiers: importers, distributors/generators and end-users. The import and wholesale distribution of petroleum products is the responsibility of the West Indies Oil Company, in which the Government of Antigua and Barbuda has a majority share. The government levies specified taxes and import duties on these imported products, which are passed on to the end-user via distributors (a network of filling stations across the country) (APUA, 2015).

[7] Calculated according to economic value in East Caribbean Dollars (XCD).

Retail energy prices in Antigua and Barbuda are generally high and volatile because they are locally priced on the basis of the price of petroleum products imported nominally at world market prices. The exception is the price of cooking gas (liquefied petroleum gas), which is fixed in accordance with subsidies provided by the government. The electricity tariff specifies two rate categories: residential and commercial.

Residential customers pay a fixed minimum charge, a consumption charge per unit of electricity consumed in two consumption blocks and a fuel variation charge also calculated per unit.

Commercial customers pay a minimum charge, a demand charge per kilovolt-ampere, consumption charges in three consumption blocks and a variable fuel charge. The current applicable tariff is shown in Table 1.

Table 1: APUA electricity tariff in December 2015

Consumer category	**Minimum charge** USD	**Demand charge** USD/kilovolt amp	**Consumption charge** USD/kWh			**Variable fuel charge** (USD/kWh)
			Block 1	Block 2	Block 3	
Domestic	25.00	-	USD 0.40 per unit (kWh) up to 300 kWh	USD 0.38 per unit (kWh) over 300 kWh	-	Variable charge per kWh
Commercial	45.00	8.00	1st 100 kWh@ USD 0.45 per unit	101 to 250 kWh@USD 0.42 per unit	All remaining kWh@USD 0.38 per unit	Variable charge per kWh

Source: APUA

Consumers are subject to a variable fuel charge that allows a utility operating in a highly volatile fuel cost environment to legally pass on the full cost of fuel to its customers without needing to modify the tariff each month.[8]

For liquid fuels, the government has developed a pricing mechanism which incorporates a methodology for making price adjustments at retail level. However, this methodology is not well understood by a large proportion of consumers, who are often confused about price changes at the pump.

a) Energy for water desalination

Antigua and Barbuda's drinking water sector is heavily dependent on desalination: approximately 60% of the public water supply on Antigua is desalinated seawater. During extended periods of drought, desalination can account for up to 90% of the public water supply (GoAB, 2015). The public water supply on Barbuda is derived from the desalination of brackish water.[9]

On Antigua, demand for water from the Antigua Public Utilities Authority (APUA) varies from 25.5 million litres per day (5.6 million imperial gallons per day) during the rainy season to 29.5 million (6.5 million) during the dry season, when APUA has to supply more to offset reduced in-house customer capacity. On Antigua, four desalination plants supply APUA's water system, and two new plants are scheduled to be commissioned over the next year. Table 2 below provides a summary of the desalination water system.

[8] Public water is supplied free of charge on Barbuda and is of variable and typically lower quality than the desalinated seawater supplied on Antigua. APUA has constructed a seawater desalination plant on Barbuda, but this is not yet operational, pending agreement on a suitable water rate to be charged to consumers.

[9] INDC communicated to the United Nations Framework Convention on Climate Change (UNFCCC) on 15 October 2015.

Photograph: PV Energy

Table 2: Existing and planned public water desalination facilities

Location	Facility	Feed-water type	Production (litres per day)	Ownership	Operational status
Antigua	Sembcorp	Seawater	17.3 million	Private	Operational
	NS Management	Seawater	2.73 million	Private	Operational
	Camp Blizzard	Seawater	1.82 million	APUA	Operational
	Ffryes Beach	Seawater	2.73 million	APUA	Operational
	Pigeon Point (planned)	Seawater	1.82 million	APUA	Scheduled for commissioning
	St Johns (planned)	Seawater	9.09 million	APUA	Scheduled for commissioning
Barbuda	APUA Barbuda 1	Brackish water	189,000	APUA	Operational
	APUA Barbuda 2	Brackish water	189,000	APUA	Operational
	APUA Barbuda 3	Seawater	378,000	APUA	Completed, not yet operational

Source: APUA

Table 3 below shows the associated electricity consumption rates and the estimated electricity consumption for the plants. These estimates indicate that public desalination facilities account for approximately 10% of total electricity consumption on Antigua.

Table 3: Estimated electricity consumption of public desalination facilities on Antigua

Desalination facility	Average production (litres per day)	Energy rate (kWh per litre)		Estimated annual energy consumption (GWh)
		Contract	Actual	
Sembcorp Plant	17.3 million	4	4.3	27.05
NS Management Plant	2.7 million	3.3	3.3	3.29
Camp Blizzard Plant - APUA	1.8 million	3.6	3.6	2.41
Ffryes Beach RO Plant - APUA	2.7 million	3.1	3.1	3.10
Total estimated electricity consumption for desalination (GWh)				**35.85**
Total APUA electricity supply (net generation) in 2011 (GWh)				328.10

Source: APUA, consultant's estimates (2015)

According to APUA, desalination is expected to become increasingly important in the country's water sector. The Antigua and Barbuda Department of Environment notes[10] that the country's 2025 goal is to increase seawater desalination capacity by 50% above the 2015 level (Antigua and Barbuda, 2015). At present, no renewable sources are used for desalination at any scale.

b) The Petrocaribe Energy Initiative

Antigua and Barbuda is a beneficiary of the Government of Venezuela's Petrocaribe Initiative. This was launched in 2005 in the face of dramatically increasing global oil prices to assist participating countries[11] with their balance of payments. This credit scheme allows participants to receive shipments of petroleum products from Venezuela and to defer up to half of the payment for each shipment.

[10] INDC communicated to the United Nations Framework Convention on Climate Change (UNFCCC) on 15 October, 2015.
[11] PetroCaribe members include 12 CARICOM countries, excluding Barbados, Montserrat, and Trinidad and Tobago.

Petrocaribe has made an impact on a national scale but its implementation has been criticised in some quarters for a) increasing the country's long-term debt and b) incentivising dependence on fossil fuels. By financing subsidies on cooking gas, the Petrocaribe Initiative has somewhat affected the retail price of energy to the consumer. It also subsidises the consumer electricity tariff on Barbuda, where the electricity rate is fixed and does not include a fuel variation charge.

2.3 ELECTRICITY SECTOR

Overview

Electricity on Antigua and Barbuda is supplied by APUA, a government-owned, vertically integrated corporation. This operates separate systems on Antigua and Barbuda and provides electricity access to nearly all the population. The corporation consists of three discrete business units responsible for the public supply of electricity, water and telecommunications.

At present, 80-90% of the electricity supply on Antigua is generated by the Antigua Power Company, a locally owned IPP which supplies generation capacity (MW) and energy (kWh) to APUA under the terms of a Power Purchase Agreement (PPA). The balance is made up by APUA's own plant. Nearly all the generation on Antigua is fuelled by HFO, and all electricity generated on Barbuda is produced by APUA using diesel-powered plant servicing a peak demand of 0.5 MW.

On Antigua, APUA transmits power at a maximum of 69 kilovolts and a frequency of 60 hertz via its transmission and distribution system to more than 33,000 customers of various categories. Power is supplied at 400/230 volts (V), 480/277 V, 120/208 V, 120/240 V, 230 V and 115 V. The energy balance is not closed, and unexplained losses average 21% (not reported as technical losses)[12] (see Table 4). However, the Latin American Energy Organization (Organización Latinoamericana de Energía) (OLADE) estimate of the energy balance differs, showing 30% losses in net electricity generation. For example, APUA total net generation for 2011 amounted to 328,054 megawatt-hours (MWh) in contrast to OLADE's figure, 272,308 MWh. More detailed information about the OLADE energy balance for Antigua and Barbuda is available on the OLADE website.

Despite the unavailability of recent data on reliability of the power supply, in 2011 approximately 10% of households were reported to have at least one standby power generator installed.[13]

The commercial sector is the largest consumer on Antigua, followed by households. In Barbuda, households are the biggest consumers. The commercial sector is dominated by customers in the tourism sector – mainly the hotels. The domestic sector on Antigua consists of approximately 33,000 households. According to the 2011 population and housing census, about 10% of households contain air conditioning units. The 2009-2012 electricity statistics for Antigua are shown in Table 4 below.

[12] APUA produces the official data on net electricity generation and sales. However, the energy balance is not closed, and unreported losses (defined as net electricity minus reported losses minus sales) average 21%.
[13] The Antigua and Barbuda 2011 Population and Housing Census indicates 2,931 out of 30,213 households have between one and four generators.

Renewable energy supports a growing range of economic activities
Photograph: PV Energy

Table 4: Electricity statistics for Antigua[14]

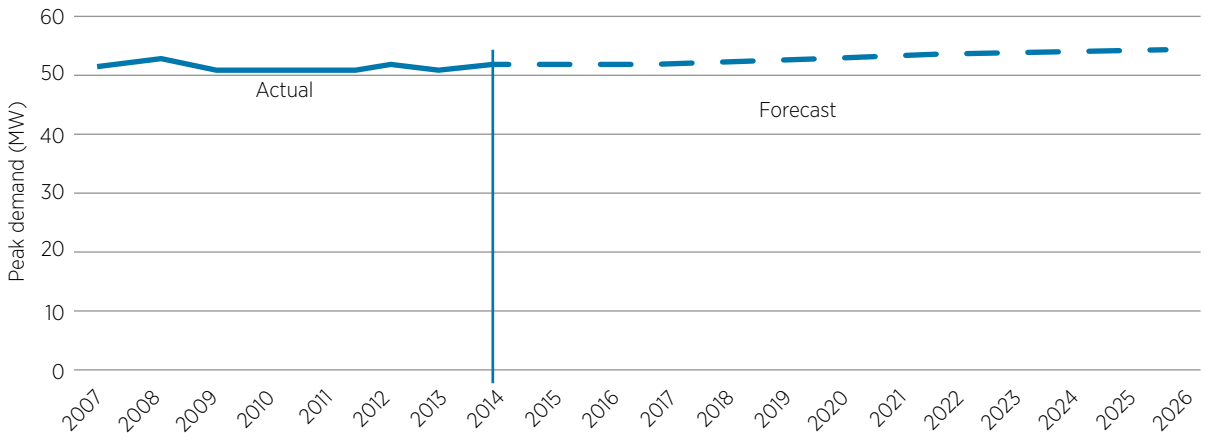
			APUA	APUA	APUA
			2009	**2010**	**2011**
Power capacity (MW)	Thermal capacity	APUA + rental	19	12.7	40.5
		Under contract	54	97.9	77.9
		Total thermal	73	110.6	118.4
	Renewable capacity	Renewable	0	0	0
			0	0	0
	Total power capacity		73	110.6	118.4
Peak demand (MW)			50.6	50.4	50.9
Net generation (MWh)	Thermal generation	APUA + rental	160,970	168,475	168,049
		Under contract	160,000	160,000	160,000
		Total thermal	320,970	328,475	328,049
	Renewable generation	Renewable	0	5	5
		Total renewable	0	5	5
	Total net generation		320,970	328,480	328,054
% Losses (includes non-technical losses)			24%	20%	17%
Sales (MWh)		Residential	85,659	89,598	86,900
		Industrial	5,944	7,827	6,921
		Commercial*	99,919	105,810	104,952
		Street lighting	520	550	550
		Total sales	**192,042**	**203,785**	**199,323**
Difference between generation and sales			128,928	124,695	128,731
Calculated losses between generation and sales			40.2%	38.0%	39.2%

* The commercial category includes electricity supplied to the government. Source: APUA and OLADE

Electricity demand

Peak demand for electricity on Antigua in 2014 was 51.5 MW. APUA's electricity demand analysis and forecast for Antigua indicates that peak demand has been flat since 2007 but is forecast to grow by 6%, reaching 55 MW in 2025.

Figure 3: Antigua peak demand forecast to 2025



Source: APUA (2014)

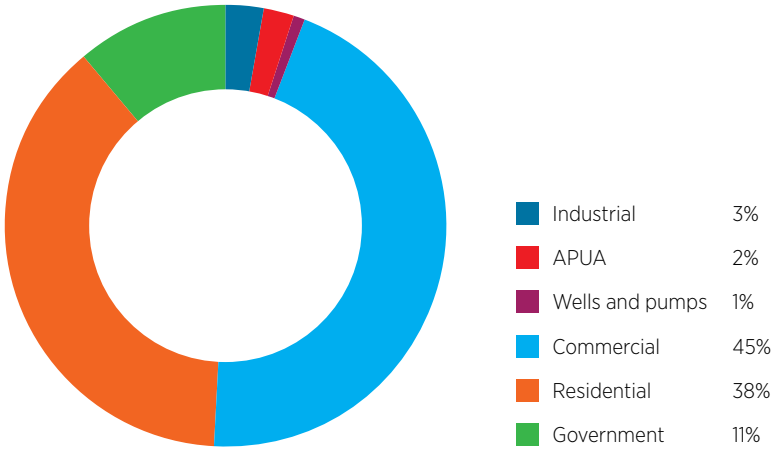
[14] Ibid. 12.

This forecast projects very low demand growth (less than 0.5% per annum based on existing and new customers). Since 2014, the landscape has changed, particularly in relation to prospective power demand from new developments in the tourism sector planned for the next three to five years. MTEDIE has compiled a list of ten prospective tourism developments with the potential to significantly increase demand, even if the proposed projects are not all implemented.

The current APUA demand forecast can thus be considered a low-growth scenario for electricity demand to 2025.

The country's distribution of electricity consumption by sector is shown in Figure 4. Total (technical and non-technical) losses are not included in the chart. Electricity consumption for water desalination is not shown separately.

Figure 4: Electricity consumption by sector, 2010



Source: Organization of American States, 2010

Power capacity

The 1973 Public Utilities Act, as amended by the 1993 Public Utilities (Amendment) Act and the 2004 Public Utilities (Amendment) Act, governs the operations of the power sector and grants exclusive rights to APUA to generate, distribute, supply and sell electricity within Antigua and Barbuda. However, the Public Utilities Act goes on to state that APUA "may give written permission to any person to generate and supply electricity at any place within Antigua and Barbuda." Under this sub-clause, APUA entered into a PPA in 1996 with the Antigua Power Company (APCL), an IPP, for the supply of power. The PPA was extended in 2003 and will expire in February 2019.

Under the terms of this PPA, APCL makes available at its Black Pine plant an installed generation capacity of 27 MW and supplies a minimum guaranteed 160,000 MWh per year of electricity to APUA, under a 'take or pay' arrangement.[15] The price per kWh is fixed with 1% escalation per annum.

Financed by a loan from the Export-Import Bank of China, APUA's existing Wadadli Power Plant was upgraded by the addition of 30 MW (six 5 MW generator sets) of new generation capacity commissioned in September 2011. Reportedly, however, only 20 MW of this plant's capacity can be dispatched at any one time due to transformer capacity constraints.[16]

In addition, APUA is requested to purchase power from the Antigua Power Company's Crabbs power plant, which has a generation capacity of 50.9 MW (Judicial Committee of the UK Privy Council, 2013).

APUA's present capacity balance is summarised as follows:

- APUA has a binding PPA valid until February 2019 with the Antigua Power Company for the supply of 160,000 MWh per year from its 27 MW Black Pine power plant.

[15] The minimum sale of 160,000 MWh per year from that particular facility is guaranteed, even if APUA does not actually take that amount of energy from the plant.
[16] Noted during discussions with APUA and Antigua Power Company stakeholders at a presentation/meeting on 16 September 2015.

- APUA owns and operates the Wadadli Power Plant, which has 30 MW of capacity commissioned in 2011, of which 20 MW is dispatchable.

This represents an available generating capacity of 107.9 MW. On the demand side, the system peak demand has been flat at approximately 51 MW over the past five years and is only forecast to grow to 55 MW by 2025 under a low-growth scenario.

Sound generation capacity planning typically requires a power system with firm capacity equal to its peak demand plus the capacity of the two largest generator sets on the system. For APUA, this works out at a figure of about 78 MW. Thus APUA now has a large surplus capacity of about 30 MW – 60% of its peak demand – compared to shortfall a decade ago.

Antigua experienced some power outages in 2013 (NREL, 2015), as did Barbuda more recently in 2015 (Gordon, 2015b).

In addition to this, the government intends to install 10 MWp of photovoltaic (PV) capacity on Antigua and Barbuda, as follows: 3 MWp of solar PV has already been installed at the VC Bird International airport site and plans are in progress to install, by the end of 2016, another 6 MWp at a solar farm in the east of Antigua and on various government buildings.[17] APUA is the intended owner of these various facilities and is due to assume full operational responsibilities after two years of support from the project's builder. The remaining 1 MWp is earmarked for Barbuda.

APUA at present limits capacity for variable renewable sources to its grid to 15% of peak demand,[18] but the planned 9 MWp PV installation would exceed this. This 15% limit is based APUA's own rule of thumb rather than a formal study providing a more scientific basis for specifying the limit. In 2015, IRENA provided the Government of Antigua and Barbuda and APUA with technical assistance to carry out research with this aim. Accordingly, the agency produced a report entitled "Study on the Integration of Renewable Energy in Antigua" in December 2015 (IRENA, unpublished).

In its conclusions and recommendations, the report states (page 70), "the assessment for the PV absorption capacity in Antigua has shown that, from a technical perspective, it is possible to integrate at least 37.5 MW of PV generation."

Under the present conditions, in which peak system demand is 50 MW and minimum demand is 23 MW, this amounts to 75% variable renewable energy capacity penetration in the system.

Financial risk

The utility appears to be highly financially dependent to the government, the country's largest electricity consumer, due to its need for investment in grid infrastructure, controls or storage. This critical issue has perhaps not been addressed in the sector. The utility supplies electricity to the government and related institutions, for which it receives no direct revenue. When successfully implemented, the proposed 9 MWp PV project is expected to reduce its exposure in the short term.

SWOT analysis for Antigua and Barbuda's electricity sector

A SWOT analysis was performed to describe the strengths and weaknesses, and the opportunities and threats that the Antigua and Barbuda's electricity sector faces.

[17] This project is being implemented with funds from the Antigua and Barbuda Citizenship by Investment Program.
[18] The intermittent rated capacity must be no more than 15% of APUA's system peak demand.

Airport solar plant
Photograph: PV Energy

	HELPFUL	RISKY
INTERNAL ORIGIN	**STRENGTHS** • universal electrification • solar and wind resources • national energy policy in place • generation capacity enough to cover peak demand • IRENA grid study available for planning	**WEAKNESSES** • 100% reliance on imported fossil fuels • one of the highest tariffs in the Caribbean • low energy efficiency levels • high grid losses • high per capita greenhouse gas emissions • power outages
EXTERNAL ORIGIN	**OPPORTUNITIES** • potential to use economically viable renewable energy technologies • government commitment to reduce electricity costs through renewable penetration and improve the relevant regulatory and institutional framework • potential for reducing greenhouse gas emissions	**THREATS** • low security of energy supply due to oil price volatility • utility potential financial difficulties • risk of natural disaster damaging power sector infrastructure • potential need for investment in grid infrastructure, controls or storage

Energy policy, strategy and reforms

In 2011, the Government of Antigua and Barbuda published its national energy policy, NEP 2011. This set out the vision, objectives, policies and targets for developing a sustainable energy future for the country. NEP 2011 specified five priorities for the energy sector, listed below (Sanguinetti, G. and Gomes, C., 2013).

1. "Energy cost reduction: targeted efficiency and conservation measures designed to reduce the overall energy intensity of the economy within ten years by 10% below the 2010 baseline".

2. "Diversification of energy sources: reformed market framework and mandated targets to achieve 15% renewable energy in the electricity supply by 2030".

3. "Electricity reliability improvement: regulatory reform designed to protect consumer interest and improve the quality of electricity supply".

4. "Environmental protection: laws and regulations which ensure that environmental considerations are an integral part of the energy permit process and included in the planning and execution of projects related to energy".

5. "Stimulate new economic opportunities: incentives and market mechanisms to create an enabling environment for private investment in renewable energy and energy efficiency measures, including support for education and training".

A draft sustainable energy action plan started to take shape in 2013 but has not yet been finalised.[19]

[19] Published by the Organization of American States, Washington, D.C.

III. RENEWABLE ENERGY DEPLOYMENT

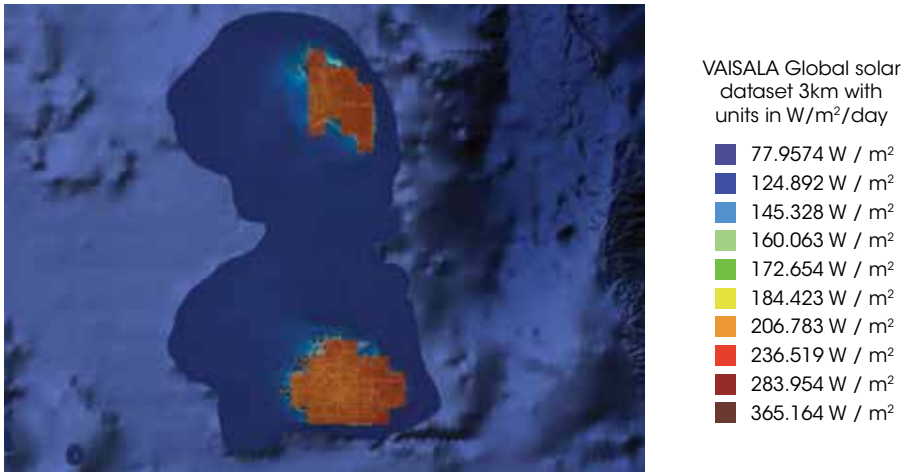
3.1 RENEWABLE ENERGY RESOURCES

According to the CARICOM Renewable Energy Development Programme (CREDP), in collaboration with the German International Cooperation Agency (Deutsche Gesellschaft für Internationale Zusammenarbeit) (GIZ), the Caribbean possesses renewable energy resources for five technologies. These include bioenergy,[20] geothermal, hydropower, solar and wind. GIZ suggests availability of solar PV and wind in Antigua and Barbuda amounts to 27 MW and 400 MW respectively. The country has no hydropower and geothermal potential, and bioenergy potential has thus far not been assessed.

Solar energy

The country enjoys good insolation all year round. Figure 5 below shows global horizontal irradiance values of 206-236 watts per m^2, which is more than sufficient for the technical application of solar water heating and solar PV systems.

Figure 5: Global horizontal irradiance



Source: Global Atlas for Renewable Energy (2016), Map data: VAISALA solar irradiation map in W/m^2, accessed October 2016. Google Hybrid Map has been used as base map layer (Google, 2016)

It has been estimated (Nexant, 2010) that the existing 27 MW potential solar PV would produce 47,000 MWh of electricity annually.[21] In practice, only a small fraction of the potential for solar energy use has been realised. To date, about 80 distributed PV systems totalling about 0.85 MW of installed capacity (including several at approximately 50 kilowatts (kW) – the largest size allowed by the utility) are connected to the grid. One 3 MW system owned by the Government of Antigua and Barbuda was commissioned in December 2015. The installed base of solar thermal systems is low; in 2012, approximately 32 thermal kW were installed per 1,000 inhabitants (Gardner, 2012).[22]

[20] For the purposes of this review, bioenergy is considered to consist of biofuels, biomass and municipal solid waste (MSW). Although much MSW now includes plastic wastes, these are generally derived from petroleum products, which are of organic origin.
[21] This potential is 'technical' potential estimated by Nexant, which may be higher than the commercially viable potential.
[22] This is one-tenth of the 323 thermal kilowatts per 1,000 inhabitants in Barbados.

Wind energy

Barbuda's isolated highlands have the potential to support up to 400 MW of wind power capacity, generating 900,000 MWh per year, with little visual impact due to their remote location (Energy Engineering Corporation, 2008).

The wind resource map at Figure 6 shows that average annual wind speeds at 80 m in height range between 6.6 m per second (m/s) and 7.2 m/s. From September 2011 to August 2012, CREDP-GIZ provided technical assistance to the Government of Antigua and Barbuda to perform wind studies at five sites (four across Antigua and one on Barbuda). The results indicated average annual wind speeds of 6.5-7.9 m/s at 60 m above ground. The capacity factor range was 37-49%, and average energy production was 5,800-7,800 MWh per annum, based on the use of a 1.8 MW capacity reference turbine. Based on these results, a pre-feasibility study report was submitted to APUA and the Government of Antigua and Barbuda recommending an 18 MW wind farm at Crabbs Peninsula.

To date, the only operational wind energy installation is a small-scale (less than 5 kW) grid-connected wind turbine at a private residence.

Figure 6: Average annual wind speed

Source: Global Atlas for Renewable Energy (2016), Map data: DTU wind map, accessed October 2016. Google Hybrid Map has been used as base map layer (Google, 2016)

Bioenergy

There is significant potential for bioenergy, but no assessment of the energy value of these sources has been made. The National Solid Waste Management Authority operates the Cooks sanitary landfill a few miles southwest of the capital, St Johns. This landfill site receives around 123,000 tonnes of municipal solid waste per year. The Antigua Distillery, a distiller of local rums and spirit products, generates some 1,300 tonnes per year of biomass waste that has the potential to be converted to biogas (Enprocon, 2012).[23]

A very preliminary review of the annual waste streams managed by the National Solid Waste Management Authority suggests 80,000 tonnes annually of feedstock could be converted if an appropriate waste-to-energy facility were available. Detailed technical studies are needed to evaluate real bioenergy potential across the country.

Around 192 tonnes per year of used cooking oil are collected from hotels, restaurants, bars and cruise ships and converted to biodiesel by Themba Biofuels, a company owned and operated by a local entrepreneur. This waste is processed into about 218,208 litres of biodiesel per year, which is used in the hospitality, construction, transportation, marine, agriculture and waste management sectors. It powers vehicles, heavy equipment, standby generators, furnaces and marine vessels.[24]

[23] Based on Enprocon study as well as information provided by Mr Mario Bento of Antigua Distillery.
[24] Source: emails of 8 and 9 May 2015 from Mr Elliott Lincoln, Managing Director of Themba Biofuels.

3.2 RENEWABLE ENERGY TECHNOLOGY OPTIONS

As of today, one utility-scale renewable energy project is providing electricity to the grid. This is the 3 MWp solar PV installation at the airport, which represents approximately 6% of Antigua's estimated 2015 peak demand. This installation is financed by the Government of Antigua and Barbuda and will be owned and operated by APUA. The government intends to install another 6 MWp of PV capacity distributed across Antigua, and 1 MWp on Barbuda. However, the sizes of the individual installations have not yet been determined. In addition, some US companies are interested in assessing the geothermal potential (Richter, 2015).

Table 5 below presents a summary of the renewable energy technology options relevant to Antigua and Barbuda, along with existing and planned projects, and activities related to the technologies.

Table 5: Technology options, existing and planned projects

Renewable energy source	Renewable energy technology options	End-use sectors or applications	Existing projects and activities		Planned activities (studies, projects etc.)	
			Utility scale	Distributed scale	Utility scale	Distributed scale
Biomass	Biomass conversion plants, from kW scale (biogas digesters) to MW scale (MSW waste-to-energy plants)	Residential, utility-scale electricity generation	None	None	Study of waste-to-energy resource potential The Renewable Energy Act requires a comprehensive environmental impact assessment of the use of biomass for renewable energy	None
	Biofuels	Transport	None	A local company is producing and marketing biodiesel from used cooking oils	None	Unknown
Solar	PV modules (~350 watts) mounted in arrays of any practical size up to allowable capacity limit	Residential, business, institutional electricity users	None	80 roof-mounted, grid-connected systems; largest is 50 kW	3 MW PV project installed at the VC Bird International Airport 7 MW of PV projects to be installed at other GoAB sites and facilities	Grid integration study is being carried out with support from IRENA to determine feasible level of renewable penetration
Wind	2 kW to 1.8 MW range wind turbines for individual and wind park application	Residential, business, institutional electricity users	None	1 grid-connected horizontal-axis wind turbine < 5kW	Off-grid 8 MW wind/solar project	
Geothermal, offshore wind, maritime technologies (ocean thermal, tidal etc.) need technical assessment	N.A	N.A	N.A	N.A	N.A	N.A

Note: GoAB = Government of Antigua and Barbuda

Renewable technology installation constraints

Antigua and Barbuda is in the Atlantic hurricane belt and exposed to a high risk of severe storms during the annual hurricane season, which lasts from June to November. Certain types of renewable energy infrastructure (PV, wind) are inherently vulnerable to hurricanes because they are installed outside buildings. They have to resist strong and gusty winds, flying debris and mitigate risk with appropriate insurance.

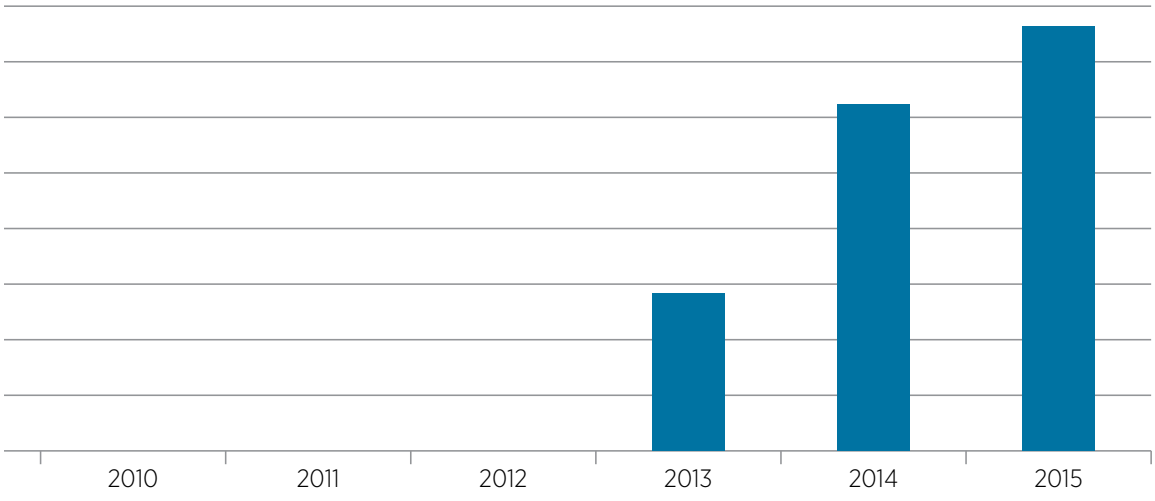
There are other physical constraints to the installation of renewable technologies (particularly at utility scale). These include, for instance, land availability and competition for land use by other sectors – important issues on a small island;[25] roadway size for plant component transportation (e.g. wind turbine rotor blades), and availability and accessibility of heavy haulage and lifting equipment. Careful planning, design and procurement is required to mitigate the attendant risks and deal with the relevant issues.

Installed distributed renewable capacity amounted to about approximately 0.85 MW (1.7% of peak demand) as this RRA report was being produced. This consisted of approximately 80 solar PV systems of up to 50 kilowatt-peak (kWp) installed by businesses and households.

In December 2011, APUA published a grid interconnection policy and related documentation (APUA, 2011). Its stated aim was to "allow for a maximum distributed non-fossil fuelled power penetration level of fifteen percent (15%) of feeder/system yearly maximum demand", as well as a limited number of large-scale commercial/industrial pilot systems (50 kW-225 kW) "for the purpose of gathering interconnection study data".

After a slow start, the number of distributed-scale PV installations has risen steadily since 2013, as shown in Figure 7. The enthusiasm would have partly been driven by rising electricity prices over the period. In 2015, APUA modified its interconnection tariff from a 1:1 net metering tariff to a net billing tariff[26] which priced each kilowatt-hour supplied to the grid at a flat rate of USD 0.167.

Figure 7: New distributed-scale PV installed capacity in Antigua and Barbuda, 2009-2015



Source: MTEDIE

[25] It is assumed that no-one is considering offshore wind installations.
[26] The interconnection tariff is not explicitly stated on its website but has been publicly advised as XCD 0.45/kWh. APUA advises verbally that this tariff will be reviewed every six months.

Renewable energy projects

Renewable-based power plants planned for construction in Antigua and Barbuda include 10 MW of solar PV generation units. Of that capacity, 6 MW is to be distributed across Antigua via rooftop panels (2 MW) or ground-mounted arrays (4 MW). Since the exact locations for that distributed PV generation are not known at the time of research, they are assumed in this study to be distributed among all island feeders in proportion to the peak loading of each. In addition, a single 3 MW installation is to be installed near the airport.

IRENA and the Abu Dhabi Fund for Development (ADFD) are supporting a transformative wind and solar project selected for funding through the IRENA/ADFD Project Facility. The 4 MW project has been put forward by the Ministry of Health and the Environment. It is part of a wider 25 MW initiative to transform the water sector, reduce the cost of electricity and increase the climate resilience of the country. ADFD will provide a USD 15 million concessional loan to offset part of the total costs of the project and fund the installation of wind turbines, solar PV panels and battery systems for electricity storage. This project aims to meet the national objective to make energy for water production and for government operations 100% renewable by 2020.

3.3 GOVERNMENT COMMITMENTS

Governance structure

During 2014 and 2015, new legislation was introduced and passed in Antigua and Barbuda with the potential to affect the energy sector:

- Environmental Protection and Management Act 2014;
- Renewable Energy Act 2015.

A list of legislation related to the energy sector is attached in Annex C.

The operations and management of the sector consists of a number of central government, statutory and private sector organisations, which collectively provide policy guidance, governance and operations. These entities are listed in Table 6 below.

Local workers installing PV panels
Photograph: PV Energy

Table 6: Responsibility for the energy sector in Antigua and Barbuda

Entity	Type	Responsibility
Office of the Prime Minister	Seat of government	Responsible for overall national policy and planning matters
MTEDIE	Government ministry	Responsible for specific energy sector planning and policy matters
Ministry of Public Utilities, Civil Aviation and Transportation	Government ministry	Oversees the electric utility APUA and the power sector
Ministry of Health and the Environment	Government ministry	Responsible for climate change, environmental policy and management, and is involved in conceptualising several renewable energy projects
Ministry of Finance	Government ministry	Responsible for overall national economic planning; also responsible for setting local prices (duties and taxes) of imported petroleum products and other energy-related imports
APUA	Government-owned, vertically integrated utility	Responsible for the generation, distribution, supply and sale of electricity; may grant licences to other operators as IPPs and has done so since 1996
Antigua Power Company	IPP	Provision of generation capacity and energy to the APUA grid under appropriate contractual arrangements
West Indies Oil Company	Locally owned oil storage and marketing company	Provides storage facilities for 200,000 barrels of refined products; responsible for all imports and wholesale distribution of petroleum products
PDV Caribe Antigua and Barbuda	Wholly owned government company incorporated in 2005	Oversees the local operation of the PetroCaribe Initiative, which provides for imports of petroleum products from the Government of Venezuela on a concessionary credit basis
Antigua and Barbuda Bureau of Standards	Statutory corporation	Responsible for promoting and encouraging the maintenance of mandatory and voluntary standards in relation to goods, processes and practices

There is no public utility regulatory body or other formal electricity sector regulator, and the utility is regulated by the government within the context of the Public Utilities Act.

The legal and regulatory framework relating to renewables has improved since the Renewable Energy Act passed in 2015. Article 3 states that the act "shall establish the framework for the accelerated development and advancement of renewable energy resources." The act compels the minister responsible for energy to "prescribe middle and long-term national targets for the use of renewable energy resources in electricity generation, which may include targets related to geographic location and diversity, technology, total capacity and unit size."

Some of the key action described in the act is set out below.

- Encourage the use of renewable energy technologies to achieve energy independence, reduce the exposure to fossil fuel price volatility, toxic emissions, in Antigua and Barbuda.

- Increase deployment of renewable energy by developing national technical capacities and providing both fiscal and non-fiscal incentives.

- Modernise primary electricity legislation and create new legislation to reflect current objectives, such as an environment appropriate for IPPs for utility-scale renewable energy developments. This would ensure a level playing field and fair access to the grid for all producers of electricity as an important addition to primary legislation.

- Revoke the utility exclusivity and ability to issue sub-licences to IPPs, and amend utility licences accordingly in relation to renewable energy.

- Develop a procurement framework that would ensure wind and solar utility-scale PV IPPs could be obtained on a competitive and transparent basis at least cost to the buyer.

- Develop regulations for enabling distributed generation of renewable energy.

The legislation demonstrates the government's commitment to the necessary legal framework for the country's transition to an energy future based on renewables.

Renewable energy policy objectives and targets

The government's general policy on renewables is to increase their penetration in the country's energy mix. NEP 2011 set a minimum target of 5% for the penetration of renewables in the electricity supply mix by 2015, rising to 15% by 2030.

It is worth noting that the 2015 target has already been exceeded on schedule with the implementation of the 3 MW solar PV airport project. Moreover, the 2030 target is expected to be exceeded in 2016 with another 6 MW of solar PV on Antigua and 1 MW PV on Barbuda.[27] This is a result of the government's policy to finance and implement utility-scale[28] PV installations, ownership of which will then be transferred to the state-owned utility, APUA.

To incentivise private investment in distributed-scale renewables, taxes and duties are waived on a list of items (see Annex B) in an effort to reduce the capital cost of renewable energy installations. Meanwhile, commercial installations are eligible for additional tax breaks. Private investment in distributed PV installations is expected to further increase renewable penetration above the levels achieved by public sector investments.

Regulatory framework for renewable energy

The Renewable Energy Act 2015[29] is legislation specifically enacted in Antigua and Barbuda that governs the implementation of renewable energy. The Renewable Energy Act introduces new legal concepts like feed-in tariffs and net billing to support renewable energy deployment and the consumer transition to sustainable energy sources, as described below.

- "Feed-in tariff" is introduced as the system for electricity produced from eligible renewable resources, as well as the concept of "net billing". Based on this methodology, the electricity generated and delivered to the grid may be used to offset the cost of electricity supplied from the grid. Net billing is endorsed by CARICOM as the preferred approach to boost renewables deployment in the Caribbean region.

- A Renewable Energy Fund is created. The fund is regulated by the provisions of section 43 of the Finance Administration Act No. 23 of 2006. Under this framework, the Cabinet is able to approve the funding of renewable energy projects through the Antigua and Barbuda Citizenship by Investment Program.[30] With this mechanism the government will be able to use resources generated under the Citizenship by Investment Program. Its purpose is to finance renewable energy initiatives, services related to renewable energy development, or to fund research and development into renewable energy in Antigua and Barbuda.

[27] Calculated as installed capacity as a percentage of peak demand.
[28] In this document, the term "utility-scale" refers any renewable energy resource or system with a capacity greater than the maximum capacity allowed by the utility for interconnection of privately owned renewable systems. "Distributed-scale" refers to systems or resources with a capacity equal to or less than the maximum capacity allowed by the utility.
[29] The Department of Environment advises that it has already received a commitment to some funding from the Green Climate Fund, a fund established by the UNFCCC.
[30] For example, some customers knowledgeable in principle about the issues have suggested that there is a level of arbitrariness in APUA's billing practices. They think that sometimes their electricity bills would rise even if they consumed far less than in previous billing cycles. This, incidentally, is a typical perception of utilities in other countries in the region.

- A set of general incentives are devised that aim to promote the use of these indigenous resources and, as far as possible, harmonised incentives across the Organisation of Eastern Caribbean States (OECS). Some of the general incentives are:

    1. registered project resources exempt from import duty on the actual plants, machinery and parts thereof imported for renewable energy generation for a period of five years

    2. waiver of customs duties payable on the importation of all plant, machinery, appliances, apparatus, equipment and materials for a project registered

    3. relief from the payment of corporate tax in favour of registered projects for a period of ten years

    4. exemption from Antigua and Barbuda Sales Tax under the Antigua and Barbuda Sales Tax Act 2006 for a period of two years for a registered project utilising the feed-in tariff and net billing mechanism for the sale of such electricity to the responsible network utility.

- A biomass strategy is developed instructing the ministry to carry out a life cycle assessment of the use of biomass to generate electricity.

- The concept of "energy wheeling" is introduced, which allows renewable electricity generator access to the grid against payment of a fee to the grid operator (utility).

Cross-cutting policies and regulations

As per the Environmental Protection and Management Act 2014, the pathways identified to reduce the release of pollution into the environment can be formed by using renewables to reduce/replace fossil fuel consumption by end-users.

In October 2015, the Department of Environment formally communicated its INDC to the UNFCCC (Antigua and Barbuda, 2015). This includes a statement of its climate mitigation and adaptation targets. The targets are of two types. They are either binding unconditional targets or conditional targets, which are contingent upon receiving international support for technology transfer, capacity-building and financial resources. Table 7 below shows the impact of the INDC targets on the energy sector.

Table 7: Antigua and Barbuda INDC targets affecting the energy sector

INDC targets with impacts on the energy sector	Adaptation targets	Mitigation targets
Unconditional targets	Enhance the established enabling legal, policy and institutional environment for a low-carbon emission development pathway to achieve poverty reduction and sustainable development	
Conditional targets	By 2025, increase seawater desalination capacity by 50% above 2015 levels By 2030, 100% of electricity demand in the water sector and other essential services (including health, food storage and emergency services) will be met through off-grid renewable sources	By 2020, establish efficiency standards for the importation of all vehicles and appliances By 2020, finalise the technical studies with the intention to construct and operate a waste-to-energy plant by 2025 By 2030, achieve an energy matrix with 50 MW of electricity from renewable sources both on and off-grid in the public and private sectors

In relation to desalination, the Department of Environment notes the following in its INDC: "implementing resilience in energy systems for water resources is a critical adaptation measure" and "off-grid renewable energy resources can enhance resilience in the water sector. By 2030, 100% of electricity demand in the water sector and other essential services (including health, food storage and emergency services) will be met through off-grid renewable sources to enhance resilience to drought and hurricanes."

In connection with these projections, the Department of Environment is working on several project concepts for funding. One is a proposed off-grid 8 MW wind/solar project that will be classified as an adaptation project in its funding application.[31]

In addition to sourcing external funding for such projects, the Department of Environment will seek funding from the Sustainable Island Resources Framework Fund, a vehicle established under the Environmental Protection and Management Act. The fund's general purpose is to provide "adequate and sustainable financing" for the implementation of the multilateral environmental agreements and their associated projects and programmes.

3.4 RENEWABLE ENERGY SUPPORT SCHEMES

NEP 2011 envisages different approaches and business models for implementing renewable energy systems, including grid-tied, utility-scale and distributed systems, stand-alone systems in remote areas and hybrid systems.

Net metering and net billing

Most of the existing distributed systems were installed on a net metering business model implemented by APUA in December 2011. In August 2014, APUA suspended all interconnections (ostensibly for a review) and then reintroduced them two months later. Then in January 2015, another suspension took place. Interconnection was reintroduced in March 2015 on a net billing business model, which paid renewable energy system owners a flat rate of USD 0.167/kWh (XCD 0.45) (APUA, 2015; Gordon, 2015a).

A net metering model is clearly favoured by customers installing grid-connected renewable systems because it provides a one-to-one price equivalence for kilowatt-hours used by the customer and supplied to the grid by the customer. It thus provides the largest incentive to customers contemplating an investment in renewables. However, in several cases in the region, utilities that started out by offering net metering models have since reverted to net billing models.

It is assumed that the increase in PV use by homeowners and businesses has been facilitated by the available incentives but the weight of these incentives compared to other variables is unclear. Consumers are also motivated by other factors, such as poor perception of the utility and its electricity pricing/billing practices,[32] a desire to be independent of the utility, and increasing awareness of the costs and financial benefits of being a PV system owner.

On the other hand, some investors view the uncertainty surrounding APUA's interconnection policy and tariff as an obstacle to investing in the distributed-scale renewable energy market.

Antigua and Barbuda already has a large off-grid installation in the form of standby generators. This suggests the country should also focus its efforts on prospective business models to provide off-grid renewables and decarbonise the current grid.

Renewable Energy Fund

The Renewable Energy Act established the creation of a Renewable Energy Fund, which will be financed by the National Development Fund created pursuant to the Antigua and Barbuda Citizenship by Investment Act. The act says the Renewable Energy Fund shall be used:

[31] The Department of Environment advises that it has already received a commitment to some funding from the Green Climate Fund, a fund established by the UNFCCC.

[32] For example, some customers knowledgeable in principle about the issues have suggested that there is a level of arbitrariness in APUA's billing practices. They think that sometimes their electricity bills would rise even if they consumed far less than in previous billing cycles. This, incidentally, is a typical perception of utilities in other countries in the region.

Financing utility-scale projects

The recently commissioned 3 MWp PV plant at the VC Bird International Airport was financed by the Government of Antigua and Barbuda as part of a package to provide the country with 10 MWp of PV. Other sources of public financing (e.g. government loans and grants) have been identified for large-scale renewable energy projects, even if specific projects may not have yet fully secured financing.

APUA's poor financial position will pose a risk to utility-scale investment via the IPP route. This is indicated, for instance, by the Prime Minister of Antigua and Barbuda's budget address of 12 January 2015, in which he noted, "The West Indies Oil Company was owed in excess of [XCD] USD 80 million [by APUA] and was threatening to discontinue the supply of fuel to APUA on a weekly basis", and that "the Antigua Power Company was owed in the range of [XCD] USD 40 million [by APUA] for providing electricity" (GoAB, 2015). The situation is perhaps exacerbated by the fact that APUA does not currently publish its annual reports. On the other hand, large receivables are reported to be owed to APUA by its customers,[33] including significant government receivables.

- to fund renewable energy projects approved by the Cabinet
- to fund research and development into renewable energy resources
- to procure goods and services for renewable energy projects
- for any other purpose related to generation of renewable energy as the Cabinet may from time to time approve.

Financing distributed-scale projects

Demand for the installation of distributed renewable energy systems is growing, and many local firms and individuals now offer supply and installation services to the general public. However, there are no financing instruments offered by financial institutions specifically to fund renewables, even though some of the institutions are clearly aware of growing demand. The uptake of PV by households and businesses appears to represent a practical financial dilemma.

The national utility can ill afford to lose valuable members of its paying customer base. The customers who are able to invest in solar are precisely those who would normally be most valuable to APUA in terms of overall average revenue per customer. This is because relatively high capital investment is still needed to install household PV systems.

On the other hand, private sector stakeholders face barriers to the incorporation of distributed renewables into the market due to the absence of transparent market regulation. An appropriate mix of regulation, incentives, equitable interconnection policy and tariff to facilitate the optimal level of investment are all required in the context of the national targets.

[33] http://antiguaobserver.com/172-million-owed-to-apua/ accessed August 2015

IV. KEY CHALLENGES AND RECOMMENDATIONS

Key challenges

The government has started to move Antigua and Barbuda's energy sector in the direction of renewables and is making rapid early progress. The NEP 2011 target for 2015 has already been exceeded, and the 2030 target is due to be exceeded in 2016.

At this stage, two fundamental features of the energy sector are of critical importance. They are described below.

1. The existing large surplus of conventional generation capacity, which is mostly held by an IPP. Nevertheless, the situation relating to the PPAs is not entirely straightforward: one PPA, which expires in February 2019, refers to the provision of energy, not capacity. The other PPA has not yet been legally formalised. Thus, over the next three years, The government will potentially be reviewing and negotiating the terms of two PPAs with the incumbent IPP.

2. the Government of Antigua and Barbuda has a clear commitment and proven ability to finance and implement utility-scale PV projects in the short term. In 2015, IRENA completed a variable renewable grid integration study. This concludes that up to 37.5 MWp of PV generation capacity could be integrated into the existing grid without endangering the reliability of the power system and without introducing energy storage (battery) systems. However, the update of parameters in the grid integration study is recommended in order to introduce the latest changes in the grid and understand the new changing conditions affecting renewables integration into the grid. This allows more aggressive targets to be assigned for renewable penetration into the grid and opens the door for more PV and wind installations than previously considered feasible.

The high-level challenge is to design an energy sector policy and regulatory framework that allows the optimal allocation of investment from the public and private sectors. This needs to ensure the new renewable energy penetration targets are achieved.[34]

The following are noted.

- Plans already being implemented by the Government of Antigua and Barbuda mean APUA will shortly own 10 MWp of PV capacity.

- At the time of the study, existing residential PV installations amount to less than 1 MWp. A significant market for privately owned distributed PV installations is thought to exist, although this perception is not based on factual assessments.

- APUA forecasts that peak demand will grow very slowly up until 2025, but demand growth will accelerate if planned tourism developments are delivered during the period.

[34] For details, see Table 7.

- The IRENA grid integration study shows this provides room for a minimum additional 27.5 MWp out of the 37.5 MWp of solar PV generation available to be installed under present technical conditions. Such capacity additions would need to be aligned with the power purchase obligations under the existing PPA.

The Government of Antigua and Barbuda should continue to build on its early successes in meeting its targets for renewable energy deployment with a view to maximising the benefits associated with scaling up renewables. This includes benefits related to energy security, national economics and environmental sustainability. This development will position Antigua and Barbuda as one of the clean energy leaders in the region.

The proposed recommended action below will lay the foundation to help Antigua and Barbuda complete its optimal transition to a future driven by renewables.

Recommendation 1	Details
Action plan	**Devise an action plan to scale up renewable energy deployment'**
The challenge	A clear roadmap is needed to enable a transition to 75% renewable energy penetration in the grid by 2025. This should encompass short-term, medium-term and long-term action designed to ensure the effective implementation of the policies and regulatory frameworks described mainly in NEP 2011 and the Renewable Energy Act.
Description	The action plan should determine the precise steps and activities with an established timeline necessary to achieve targets in light of the country's great potential for renewable energy deployment. The action plan will consider relevant technical, economic, financial, policy, regulatory, institutional, social and environmental factors that would enable higher renewable penetration. The roadmap should also consider the status and effects of the existing and pending PPAs and options for an optimal approach that will ensure a secure, affordable energy supply that meets renewable energy penetration targets. To succeed, the implementation of the action plan must be considered one of the very highest priorities for the government. MTEDIE is responsible for devising an action plan to implement NEP 2011 but also to set the guidelines for the widespread use of renewable resources. The process for developing the action plan should ensure the active participation of regional and international development partners.

Recommendation 2	Details
Interconnection policy	**Review and rationalise the policy and tariff structure for grid interconnection with distributed renewables**
The challenge	The existing grid interconnection policy and interconnection tariffs have been subject to modification and debate since first introduced in December 2011. Decisions on these matters were made in the context of a rule-of-thumb 15% renewable energy penetration rate on the grid.
Description	The policy and tariffs should now be reviewed and rationalised in light of the current potential for significantly higher renewable energy targets. This recommendation addresses the uncertainty affecting prospective private sector investment in distributed renewable energy systems.

Recommendation 3	Details
Public awareness and engagement campaign	**Undertake a comprehensive public awareness and engagement programme aimed at all levels of society. This would educate people about the costs and benefits of renewables, promote awareness and understanding of the influence of personal behaviour on energy efficiency and sustainability outcomes, and engage consumers in the daily business of sustainability.**
The challenge	Public awareness campaigns are typically useful for increasing public knowledge about an issue but often lack a design that results in actual long-term change to relevant behaviour. A comprehensive public programme of awareness, knowledge-building and engagement will yield long-term sustainability outcomes beneficial to the country and its citizens.
Description	This recommendation addresses widespread ignorance of renewables in the general public, as highlighted by stakeholders and participants at the expert workshop. The public is neither fully informed nor well engaged with renewables and sustainability.

Recommendation 4	Details
National bioenergy strategy	**Develop a national strategy for bioenergy and waste management development:** • **resource assessment (biomass, organic waste of all kinds)** • **technological options and applicability for Antigua and Barbuda** • **economic, environmental and social benefits** • **environmental impact assessment** • **risk assessment and management options** • **legal and regulatory framework.** • **assess waste management in Antigua and Barbuda**
The challenge	Bioenergy is considered an important cross-cutting area because it spans the energy and waste management sectors. A comprehensive review of Antigua and Barbuda's options and considerations is proposed alongside an evaluation of the commercial potential of this resource.
Description	This recommendation aims to encourage the introduction of an overall conceptual framework for the efficient and effective utilisation of available bioenergy resources. This has cross-cutting benefits in the area of waste management, for example.

Recommendation 5	Details
Independent Energy Commission	**Establish an independent energy commission with appropriate authority to regulate the electricity supply market in relation to sources of supply, grid interconnection, pricing and quality of service of all parties.**
The challenge	The development of a renewables-ready energy sector will require an efficient, transparent and equitable regulatory framework to facilitate new and ongoing investment in renewables by businesses, individuals and the state.
Description	This recommendation aims to assist in the implementation of an economy based on renewables via the legal and regulatory provisions necessary to give stakeholders fair and equitable market access.

Recommendation 6	Details
Promote bankable renewable energy generation through renewable energy PPAs	**Support renewable energy penetration in the power generation mix through standardised, technology-specific renewable energy PPAs**
The challenge	A set of standardised renewable PPA templates is needed to ensure investors are on a level playing field and to reduce administrative requirements and implementation time. The standardised PPA templates should provide greater certainty and fair risk allocation between stakeholders. Its purpose is to reduce investment barriers arising as a result of grid connection costs and timelines, market risks related to price and volume, absent or incomplete tariff adjustments, integration costs and/or significant misalignment of project lifetimes and contract durations. The extent of PPA standardisation should be appropriate to the technology, with greater standardisation for smaller project sizes. The tariff could be set by competitive price determination processes such as auctioning or continuously updated feed-in tariffs, with price certainty as the objective.
Description	If broadly applied, this recommendation will resolve one renewables deployment challenge and allow the development of and access to a new market for Antigua and Barbuda.

Renewables promise a bright future for island states like Antigua and Barbuda
Photograph: PV Energy

V. REFERENCES

Antigua and Barbuda (2015), Intended Nationally Determined Contribution (INDC) Communicated to the UNFCCC *http://www4.unfccc.int/submissions/INDC/Published%20Documents/Antigua%20and%20Barbuda/1/INDC_Antigua_Barbuda.pdf*

APUA (2015a), APUA Interconnection Policy press release, APUA, St. John's, *www.apua.ag/wp-content/uploads/2015/03/EPR-Interconnection-Policy.pdf.*

APUA (2015b), English Harbour Reverse Osmosis Plant, APUA, St. John's, *www.apua.ag/wp-content/uploads/2015/06/WPR-English-Harbour-RO-Plant.pdf.*

APUA (2013), Production Summary July 2013, APUA, St. John's, *www.apua.ag/wp-content/uploads/2013/09/july-2013.jpg,* viewed 24 May 2015.

APUA (2011a), Interconnection Policy Statement [Non-Fossil Fueled Distributed Generation Facilities of Capacity < or = 50kW], APUA, St. John's, *www.apua.ag/wp-content/uploads/2012/07/Policy-Statementweb.pdf,* viewed May 2015.

APUA (2011b), Interconnection Procedures Guideline [Non-Fossil Fueled Distributed Generation Facilities of Capacity < or = 50kW], APUA, St. John's, *http://www.apua.ag/wp-content/uploads/2012/07/Procedures-Guidelinesweb.pdf,* viewed May 2015.

APUA (2008), Wind Energy Survey Antigua and Barbuda, APUA, St. John's, study conducted by Energy Engineering Corporation on behalf of APUA, *www.reeep.org/antigua-barbuda-2012.*

CARICOM (Caribbean Community) (2015), CARICOM Website, Guyana, *http://caricom.org/about-caricom/who-we-are/our-governance/members-and-associate-members/.*

CARILEC (Caribbean Electric Utility Services Corporation) (2012), Tariff Survey 2012 (printed version only), CARILEC, Saint Lucia.

Central Intelligence Agency (2015), The World Factbook, CIA, Virginia, USA, *www.cia.gov/library/publications/the-world-factbook/geos/ac.html.*

Contreras, R., et al. (2012), Energy Policy and Sector Analysis in the Caribbean (2010–2011) Assessing Antigua and Barbuda; the Bahamas, Dominica, Grenada, St. Lucia, St. Kitts and Nevis; and St. Vincent and the Grenadines, Department of Sustainable Development of the Organization of American States (OAS/DSD), US National Renewable Energy Laboratory, Renewable and Appropriate Energy Laboratory at the University of California, Berkeley, OAS, Washington D.C., USA, *http://www.oas.org/en/sedi/dsd/Energy/doc/LCCC_Report.pdf.*

CREDP-GIZ (Caribbean Renewable Energy Development Program (CREDP) and the German International Cooperation Agency (GIZ)) Analysis of the Potential Solar Energy Market in the Caribbean, CREDP-GIZ, Castries, St. Lucia, *http://credp-giz.org/Data/Solar_Market_Analysis_Caribbean.pdf,* viewed May 2015.

CREDP-GIZ (2011), Windpower in the Caribbean - Ongoing and Planned Projects, Caribbean Renewable Energy Development Programme (CREDP-GIZ), St Lucia, *http://credp-giz.org/Data/CAWEI_Wind_Survey_Report.pdf, viewed May 2015.*

CREDP-GIZ (2013), A Review of the Status of the Interconnection of Distributed Renewables to the grid in CARICOM Countries, CREDP, Castries, St. Lucia, *http://www.credp.org/Data/CREDP-GIZ_Interconnection_Report_Final_Oct_2013.pdf.*

Enprocon Environmental Project Consulting GmbH (2012), Alternative Energy Production Proposals and Integrated Waste Management: Solutions for Eastern Caribbean States with Specific Focus on Biogas Production, Solar Cooling, Small Scale Hydro Power, Advanced Tire and Synthetic Material Recycling, OPEC Fund for International Development, UN Development Programme Barbados and Organisation of Eastern Caribbean States (OECS), OECS-UNDP, Castries, Saint Lucia, *http://energie.mq/wp-content/uploads/2014/11/OECS-feasibility-study-final-230312.pdf.*

Gardner, D. (2012a), Development and Implementation of a Strategy for the Promotion of Solar Water Heating in CARICOM Member States, CARICOM Renewable Energy Development Programme, CARICOM Secretariat, Guyana, *www.scribd.com/document/126406225/Devon-Gardner-Development-and-Implementation-of-a-Strategy-for-the-Promotion-of-Solar-Water-Heating-in-CARICOM-Countries-Dec-2011.*

Gardner, D. (2012b), Strategies for Accelerating the Solar Water Heating Market in CARICOM States, Caribbean Sustainable Energy Forum III, St Kitts and Nevis, *www.scribd.com/document/117717771/Devon-Gardner-Strategies-for-Accelerating-the-Solar-Water-Heating-Market-in-Caricom-States-9-2012.*

Global Atlas for Renewable Energy (2016a), Map data: VAISALA solar irradiation map in W/m2, accessed October 2016, Google Maps (2016), Google Hybrid Map has been used as base map layer.

Global Atlas for Renewable Energy (2016b), Map data: DTU wind map at 100 m in m/s, accessed October 2016. Google Maps (2016), Google Hybrid Map has been used as base map layer.

GoAB (Government of Antigua and Barbuda) (2014), Building a new economy for growth and prosperity, budget statement 2014, Government of Antigua and Barbuda, St. John's, *http://www.caribbeanelections.com/eDocs/budget/ag_budget/ag_budget_2014.pdf*

GoAB (2015), Budget Statement, Government of Antigua and Barbuda, St. John's, *www.caribbeanelections.com/eDocs/budget/ag_budget/ag_budget_2015.pdf.*

Google Maps (2016), Map of Antigua and Barbuda, online, available from: *https://www.google.ae/maps/place/Antigua+and+Barbuda/@17.3243309,-62.0375195,10z/data=!4m5!3m4!1s0x8c0d6eb96db8d1c1:0x276a3788e18b7994!8m2!3d17.060816!4d-61.796428*, accessed 20 August 2016.

Gordon, T. (2015a), "APUA implements changes to interconnection policy", Antigua Observer, St. John's, *http://antiguaobserver.com/apua-implements-changes-to-interconnection-policy*, viewed 8 May 2015.

Gordon, T. (2015b), "APUA to investigate Barbuda power outage problem", Antigua Observer, St. John's, viewed 8 May 2015.

IRENA (International Renewable Energy Agency) (2016), Renewable Energy Benefits: Measuring the Economics, IRENA, Abu Dhabi, United Arab Emirates.

IRENA (2015, unpublished), Study on the Integration of Renewable Energy in Antigua, prepared by IRENA on behalf of GoAB (printed version only)

IT Power Consultants (2013), Antigua and Barbuda Country Profile, WC3 Report, Caribbean Sustainable Energy Programme (CSEP), Washington D.C. (printed version only).

OLADE (Latin American Energy Organization) (2012), Antigua and Barbuda Energy Balance 2010-2012, OLADE, Quito, Ecuador, *http://www.olade.org/publicaciones/antigua-and-barbuda-energy-balances-2010-2012.*

Nexant (2010), Caribbean Regional Electricity Generation, Interconnection and Fuels Supply Strategy, World Bank, Washington D.C, USA, *http://documents.worldbank.org/curated/en/440751468238476576/pdf/594850Final0Report.pdf, viewed October 2016.*

OAS (Organization of American States) (2013), Draft Sustainable Energy Action Plan – Antigua and Barbuda, Department of Sustainable Development of the General Secretariat of the Organization of American States with the expert advice of IT Power Group, OAS, Washington D.C., *http://www.oas.org/en/sedi/dsd/Energy/Doc/EAP_AntiguaBarbuda_web.pdf.*

OECS (Organisation of Eastern Caribbean States) (2015), Member States, OECS, Saint Lucia, *www.oecs.org/index.php/homepage/member-states.*

Richter, A (2015), "Interest in geothermal development in Antigua and Barbuda, Caribbean", thinkgeoenergy.com, Reykjavik, Iceland, *http://www.thinkgeoenergy.com/interest-in-geothermal-development-in-antigua-and-barbuda-caribbean/?utm_source=ThinkGeoEnergy+List&utm_campaign=a81390aac5-TGE_Newsletter_RSS1_12_2015&utm_medium=email&utm_term=0_657e42f767-a81390aac5-415232969.*

Sanguinetti, G. and C. Gomes (2013), An Assessment of Fiscal and Regulatory Barriers to Deployment of Energy Efficiency and Renewable Energy Technologies in Antigua and Barbuda, UN-Economic Commission for Latin America and the Caribbean/GIZ, United Nations Economic Commission for Latin America and the Caribbean (ECLAC), Port of Spain, Trinidad and Tobago *www.giz-cepal.cl/publicacion/assessment-fiscal-and-regulatory-barriers-deployment-energy-efficiency-and-renewable, viewed May 2015.*

Scotia Economics (2014), Special Report: Petrocaribe, More Noise than Lifeline, Scotiabank, Ontario, Canada, *http://www.gbm.scotiabank.com/English/bns_econ/isr140904.pdf, viewed May 2015.*

UK Privy Council (2012), Judgment-Antigua Power Company Limited (Appellant) v (1) The Attorney General of Antigua and Barbuda (2) The Hon. Baldwin Spencer (as Minister of APUA & Energy) (3) Antigua Public Utilities Authority (4) Commissioner of Police of Antigua and Barbuda (Respondents), Judicial Committee of the Privy Council, London, *www.jcpc.uk/cases/docs/jcpc-2012-0063-judgment.pdf.*

NREL (National Renewable Energy Laboratory) (2015), Energy Snapshot Antigua and Barbuda, NREL, Colorado, USA, *http://www.nrel.gov/docs/fy15osti/64115.pdf.*

West Indies Oil Company (2015), Annual Report 2015, West Indies Oil Company, Antigua and Barbuda, (printed version only).

World Bank (2014), DataBank, Antigua and Barbuda Country profile, *http://data.worldbank.org/country/antigua-and-barbuda*

World Bank (2013), DataBank, Population Antigua and Barbuda, *http://data.worldbank.org/indicator/SP.POP.TOTL*

World Bank (2012), DataBank, Percentage of teachers in primary education who are trained, both sexes (%) *http://data.worldbank.org/indicator/SE.PRM.TCAQ.ZS?locations=AG*

ANNEXES

ANNEX A
RENEWABLE-ENERGY AND ENERGY-EFFICIENCY ITEMS ELIGIBLE FOR WAIVER OF IMPORT DUTIES AND TAXES

The Antigua and Barbuda Cabinet has reinforced the government's commitment to promoting renewable energy solutions by approving the waiver of duties and taxes on the importation of renewable energy and energy efficient components .

Items to which the concessions apply are listed below.

1. Solar panels
2. Solar panel racks
3. Solar water heaters
4. Solar pumps
5. Solar hot water storage tanks
6. PV module panels
7. Solar cells
8. Solar panel mounts
9. Solar water pool pumps
10. 1Solar lighting systems with mirrors
11. Sun tracer/sun tracker
12. Inverters (to convert direct current to alternating current)
13. Rectifiers (to convert alternating current to direct current)
14. Charge controllers
15. Surge protectors
16. Wind turbine tower
17. Wind turbine blades
18. Wind turbine shaft
19. Wind turbines and generators
20. Solar batteries
21. Deep cell batteries
22. (Battery) charge controller
23. Battery boxes.
24. Battery switches
25. Transfer switches.

ANNEX B
LEGISLATIVE INSTRUMENTS

The main legislative instruments are summarised below.

Name of legislation	General relationship with renewables and electricity
The Public Utilities Act (CAP 359) 1973	Gives APUA exclusive right to generate, distribute, supply and sell electricity. Request written permission to any entity to generate and supply electricity.
Public Utilities (Amendment) Act 2004	No. 7 of 2004. An act to amend the Public Utilities Act, Cap. 359.
Renewable Energy Act 2015	Promotes the use of renewable energy resources; modernises primary electricity legislation; allows the creation of new legislation to reflect current objectives; revokes the utility's exclusivity and ability to issue sub-licences to IPPs, and amends utility's licences accordingly in relation to renewable energy; develops an appropriate procurement framework and regulations for enabling distributed generation of renewable energy.
Environmental Protection and Management Act 2014	Addresses protection and management of the environment, including carbon emissions reduction via increasing penetration of renewables in the national energy mix.
National Solid Waste Management Authority Act 2005 (Act to amend the 1995 Act)	Deals with solid waste management, which will include waste-to-energy options.
The Physical Planning Act, 2003	Addresses land use planning, which will include zoning land for renewable energy installations.
Investment Authority Act, 2006	Relates to national investment, which will include financing and incentives for renewable energy and energy efficiency solutions.
Small Business Development Act, 2007	Relates to small business issues, which will include small business incentives to invest in renewable energy options.
Land Development and Control Act, 1977	Addresses physical planning and development, including the physical development of renewable energy projects and management of building codes.
Tenders Board Act, 1991, and Tenders Board Amendment Act, 2002	Deals with national procurement, including procurement for renewable energy projects.
Petroleum Act, 1949	Provides rules for the importation and storage of petroleum products into Antigua and Barbuda.
Minerals (Vesting) Act, 1949	Rules that minerals, including coal and lignite in, on or underground regardless of land ownership or tenure belong to the Crown, and that any mining of such minerals requires a licence from the

ANNEX C
MEETINGS WITH STAKEHOLDERS

Date	IRENA met with		
	Name	Designation	Organisation
29 April 2015	Mrs Paula Hunte-Cox	Permanent Secretary	MTEDIE
	Amb. Brian Challenger	Ambassador, Energy Advisor to Minister	MTEDIE
	Mr Girvan Pigott	Sustainable Energy Officer	MTEDIE
30 April 2015	Mrs Dianne Rodrigues	Manager	Antigua and Barbuda Bureau of Standards
	Mr Daryl Jackson	Entrepreneur, owner	Owia Energy Solutions
	Amb. Diann Black-Layne	Ambassador, Head of Department	Department of the Environment
	Ms Ruleta Thomas	Deputy Chief Environment Officer	Department of the Environment
	Mr Dwight Laviscount	Technical Officer	Department of the Environment
	Mr Ita Jah Simmonds	Technical Consultant	Department of the Environment
	Amb. Daven Joseph	Ambassador, Advisor to the Prime Minister	Prime Minister's Office
01 May 2015	Mr Emmanuel Dubois	Landfill Manager	National Solid Waste Management Authority
	Mr Andre Matthias	Electricity Manager	APUA
	Mr Winston Whyte	Renewable Energy Engineer	APUA
	Amb. Brian Challenger	Ambassador, Energy Advisor to Minister	MTEDIE
16-18 September 2015 (IRENA presentation on grid stability study by Francisco Gafaro, and RRA technical workshop attended by Ms Sandra Chavez and Mr Yong Chen)	Amb. Brian Challenger	Ambassador, Energy Advisor to Minister	MTEDIE
	Mr Girvan Pigott	Sustainable Energy Officer	MTEDIE
	Mr Andre Matthias	Electricity Manager	APUA
	Mr Winston Whyte	Renewable Energy Engineer	APUA
	Mr Jason Peters	Transmission and Distribution Engineer	APUA
	Mr Ernest George	Plant Manager	Antigua Power Company
	Mr Calid Hassad	General Manager	Antigua Power Company
	Mr Stedroy Roache	Customer Service Engineer	APUA
	Mr Richard Joseph	Substation Engineer	APUA

Date	IRENA met with		
	Name	Designation	Organisation
11 November 2015	Hon. Asot Michael	Minister	MTEDIE
	Amb. Brian Challenger	Ambassador, Energy Advisor to the Minister	MTEDIE
	Mr Girvan Pigott	Sustainable Energy Officer	MTEDIE
	Mr Mali Barnes	Research Officer	MTEDIE
	Mr Elliott Lincoln	Entrepreneur, owner	Themba Biofuels Ltd
12 November 2015	Ms Ruleta Thomas	Deputy Chief Environment Officer	Department of the Environment
	Ms Lia Nicholson	Technical Officer	Department of the Environment
	Ms Nneka Nicholas	Junior Environment Officer	Department of the Environment
	Mr Dwight Laviscount	Technical Officer	Department of the Environment
	Mr Ita Jah Simmonds	Technical Consultant	Department of the Environment
13 November 2015	Mr Andre Matthias	Electricity Manager	APUA
	Mr Winston Whyte	Renewable Energy Engineer	APUA
	Mr Ivan Rodrigues	Water Manager	APUA

Clare Hall School benefits from rooftop solar
Photograph: PV Energy

The country has around 80 000 tonnes per year of waste suitable for energy
Photograph: PV Energy

Renewables promise a bright future for island states like Antigua and Barbuda
Photograph: PV Energy

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