Anguilla Renewable Energy Integration Project

SECOND DRAFT REPORT

presented to the

GOVERNMENT OF ANGUILLA

Ministry of Infrastructure, Communications, Utilities, and Housing (MICUH)

in collaboration with
Anguilla Renewable Energy Office (AREO), and
Climate Knowledge & Development Network (CDKN)

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Executive Summary

The Government of Anguilla, with the support of the Climate and Development Knowledge Network (CDKN), asked Castalia to recommend how to improve Anguilla's legal and regulatory framework to enable integration of renewable energy.

Scope of work—focused on laws and regulations

This assignment is specifically focused on laws and regulations. There are other aspects that, although related to renewables, are outside our scope of work (such as financial or social issues, broader power sector reform matters, or detailed technical matters). We deal with these related matters to a limited extent, to try to provide a more complete picture.

Objectives of renewable energy integration—reduce costs as top priority, while also increasing energy security and environmental sustainability

According to the Government and the overwhelming majority of stakeholders we met, Anguilla's priority objective for integrating renewable energy is to reduce electricity costs in the long term (Anguilla's electricity costs are among the highest in the region). This objective is consistent with one of the primary goals of the National Energy Policy: 'Ensure universal access to an affordable electricity supply for all Anguillans'.

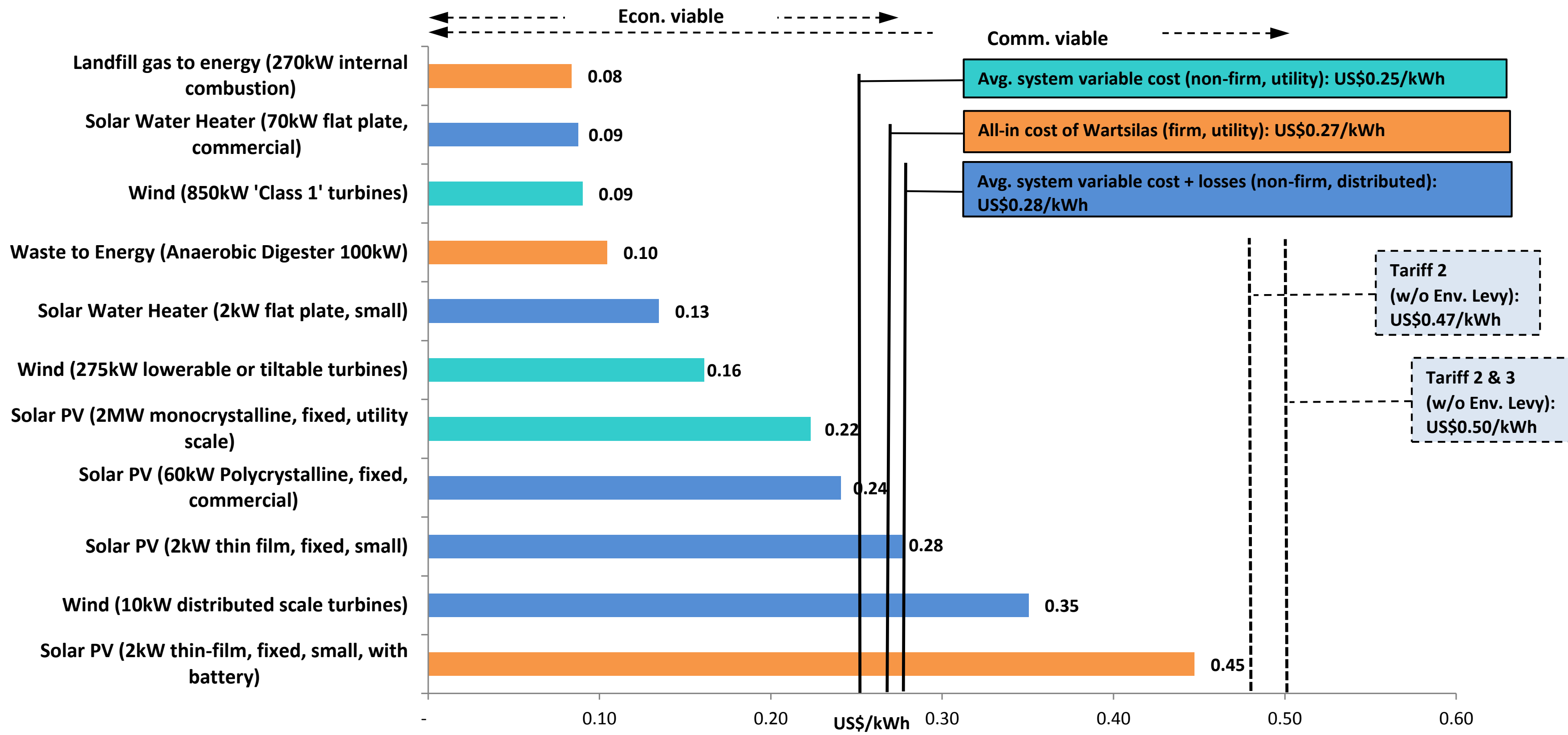
Increasing energy security and enhancing local and global environmental sustainability are two other important objectives, but they should be pursued only to the extent that costs may be reduced at the same time. It so happens that the renewable energy options that are available in Anguilla are also economically viable (that is, they reduce costs to the country), so all objectives may actually be pursued at the same time through win-win options.

Anguilla's renewable energy potential—good, but largely unrealized

As Figure ES1 below suggests, there are various renewable energy options in Anguilla that could be economically viable (that is, that could save on the country's electricity generation costs). Viable options are solar PV at utility (large) and distributed (small) scale; solar water heaters; utility scale wind; and—provided that there be a sufficient waste stream in the medium-long term—a small waste-based project, such as a biogas digester or the smallest landfill gas to energy plant. In the figure, renewable technologies whose cost to generate electricity (US$ per kilowatt hour, represented by horizontal bars) is lower than that of diesel-powered generation (also US$ per kWh, represented by continuous vertical lines) are 'economically viable', which means that they can save money to the country as a whole. Utility scale technologies that cost less than diesel-powered generation are also 'commercially viable'—they can be a profitable business from the perspective of developers; from the perspective of customers, 'commercially viable' are instead those distributed scale technologies that generate at a lower cost than the retail tariff, saving customers money.

Figure ES1 is a simplification, for the purpose of guiding our analysis and recommendations. The cost of each renewable project is highly site-specific. The assumption on the cost of diesel (US$4 per gallon) is a reasonable one, based on price of oil futures observed in the market—but in reality oil prices vary; however, breakeven oil prices for each renewable technology suggest that most renewables in Anguilla would be viable even at lower oil prices, apart from solar PV that would need diesel prices of at least US$3.5 per gallon approximately. Conventional generation costs and tariffs shown are not historical values, but theoretical values based on our fuel cost assumption.

Figure ES1: Viability of Renewable Energy Technologies in Anguilla (US$ per kWh)

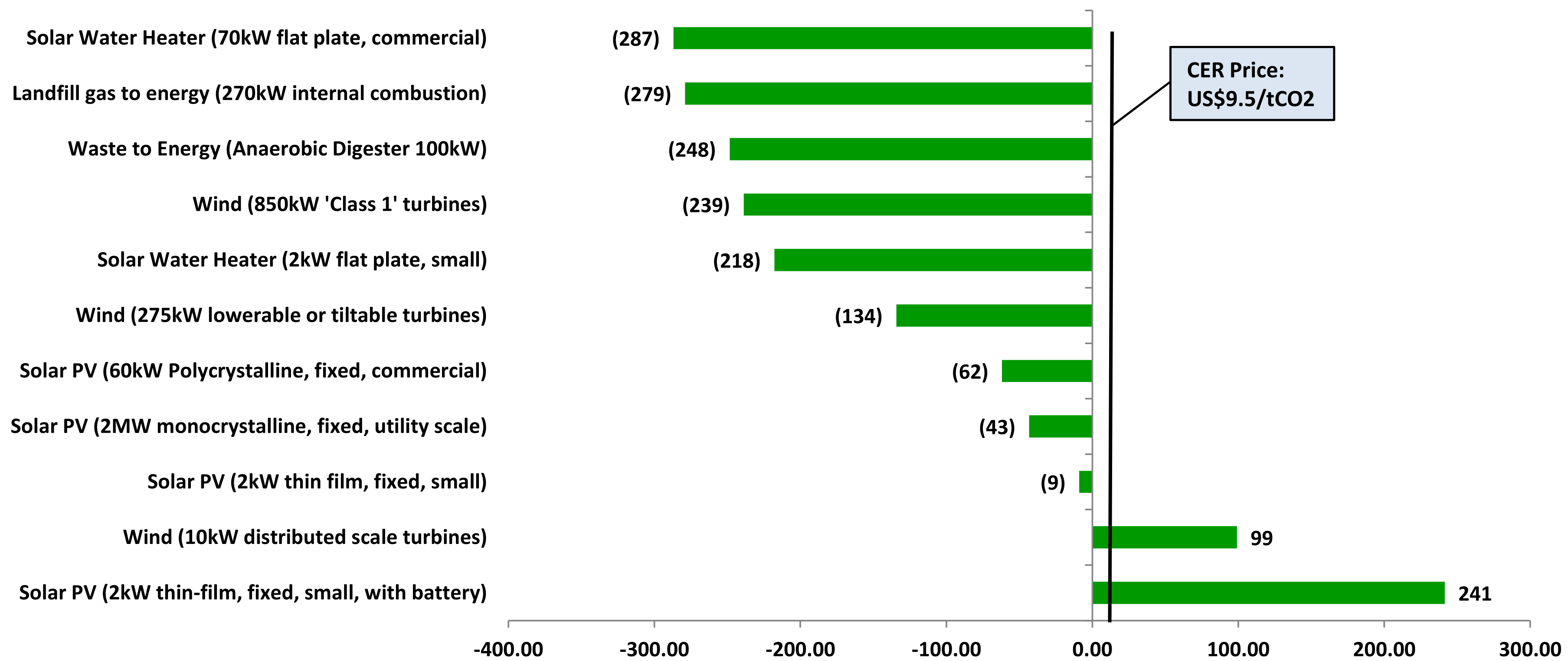


Explanation: This figure analyzes the cost to generate 1 kilowatt hour of electricity (US$/kWh), comparing renewable options (horizontal bars) and conventional options (vertical lines) based on a diesel price assumption of US$4 per Imperial Gallon (IG). Estimated tariffs (dotted vertical lines) allow comparing the cost of generating electricity with small renewables with that of buying it from the grid, based on the same diesel price assumption of US$4 per IG

Note: Conventional generation costs and tariffs shown are not historical values (for example, ANGLEC's highest tariff as of May 2012 is US$0.40 per kWh), but estimates for analytical purposes, based on an assumption of Diesel prices at US$4.00 per IG. In particular, tariffs shown are estimated based on the fuel surcharge that could be applied if diesel cost US$4 per IG; ANGLEC reports that it does not always charge the full fuel surcharge that could be applied, and charges a lower fuel surcharge instead. Indicative Long Run Marginal Costs (LRMCs) of renewable energy technologies are based on assumptions about their cost and performance explained in Appendix G, and using a 11% discount rate for utility scale technologies, and 9% for distributed scale technologies, as explained in Appendix H. Landfill gas to energy and waste to energy estimates are subject to there being enough waste. The average system variable cost benchmark for distributed generation is grossed up for system losses (12%)

Figure ES2 shows that economically viable options could abate CO_2 while saving money. This is particularly important: abating CO_2 and reducing electricity costs in Anguilla is not an either-or matter—renewables viable on the island allow doing both things at the same time, with no need to pay more for electricity in order to reduce CO_2.

Figure ES2: CO_2 Abatement Cost Curve for Renewable Energy Technologies (US$ per tCO_2)



Explanation: This Marginal Carbon Abatement Cost Curve shows what cost the various renewable energy technologies require to avoid 1 ton of CO_2. Technologies that are economically viable (most of them, as shown in Figure 5-1) do that with a negative cost—that is, they avoid emitting CO_2 while also saving money. Just two technologies require spending extra money to avoid emitting CO_2—but instead of doing those two technologies, if one wanted to avoid emitting CO_2 he or she could buy an emission reduction on the market (at a price of about US$9.5 per ton of CO_2

Source: CER price for Carbon from Carbonex on April 15, 2012

In summary, Anguilla's renewable energy potential is good—although not great: it can contribute to saving on fuel costs and stabilize prices, but is unlikely to revolutionize the power system (at least in the near term). The country's main renewable options do not provide firm power for base load (therefore, diesel-fired generation will still be needed even if Anguilla realizes its whole renewable potential). Also, the clearest renewable option (solar PV) is still borderline viable, although further cost reductions in its cost are expected.

Barriers that prevent viable renewable options from happening

In spite of a good potential, viable options are not happening in Anguilla due to barriers summarized in Table ES1 below.

Table ES1: Barriers to Economically Viable Renewable Energy Technologies

	Utility Scale Renewables	Distributed Scale Renewables
Commercial barrier		
Lack of commercial viability	**0** (all commercially viable)	**0** (all commercially viable)
Legal and regulatory barriers		
Lack of clear rights to use a resource	**0** (no unclear property rights for solar, wind, and waste energy)	**0** (no unclear property rights for solar, wind, and waste energy)
Lack of right to access and develop a site	**0** (clear rights in place in the rules—although flaws and social norms affect the efficiency and effectiveness of these rules)	**1** (clear rights—but often buildings are such that solar water heaters are impossible or too costly to install)
Inability to sell electricity generated	**1** (IPPs can operate under ANGLEC's licence; DBOM contracts are possible; but no own licence is possible for IPPs)	**3** (customers cannot connect their systems or sell their excess electricity to the grid)
Economic regulatory distortions	**3** (no obligation to operate on least cost basis; limited rate review process; uncertain cost recovery, unlike for fossil fuels)	**3** (tariff structure is disincentive to allow sale of excess electricity generated from customer-owned distributed systems)
Other barriers		
Limited financing	**0** (no significant financing barrier for larger actors)	**2** (high upfront cost and general limited access to credit)
Limited availability of equipment	**0** (no particular barrier)	**2** (equipment mostly available, but not competitively priced)
Limited institutional capabilities	**1** (limited capabilities, but can be overcome or contracted out)	**2** (limited capabilities, but can be overcome or contracted out; limited capacity for electrical inspection)
Limited technical skills	**1** (limited expertise, but can be contracted or acquired quickly)	**2** (limited expertise, with some exceptions)
Limited information and awareness	**2** (limited information on wind and waste for power generation)	**2** (limited awareness about solar PV and water heating)

Notes: 0 = not a barrier; 1 = low barrier; 2 = medium barrier; 3 = high barrier; NA = Not Applicable. DBOM = Design, Build, Operate, and Maintain; IPP = Independent Power Producer

A good way to understand barriers is to think about them as the lack of **critical factors that ensure the success of any renewable energy project**. These critical factors are: commercial viability (utility scale renewables must generate at a competitive cost compared to other options; distributed ones must generate at a cost that allows saving on one's bill); the right to use the primary renewable energy resource (sunlight, wind, or waste); the right to access and develop the site where the renewable energy project is to be set up and operated; the ability to sell electricity generated at a reasonable price; and an adequate regulatory framework for electricity (meaning, a complete body of rules that ensure good quality of service at a reasonable cost; as well as some regulatory body with the power and ability to effectively administer and enforce those rules). Other critical factors are access to financing at reasonable terms; sufficient availability of equipment that is competitively priced; institutional capabilities; good technical skills; and adequate information and awareness.

Recommendations for overcoming barriers identified

Table ES2 summarizes our recommendations for overcoming barriers identified, showing things that should be done **now** with relatively limited changes to the law, and things that may be done **later** (although as soon as possible—to be really effective, all recommendations should be implemented as a comprehensive package, and not on a piecemeal basis).

First of all, **where there is no barrier, we recommend no measure**:

- There are **no barriers of commercial viability**—if solar, wind, and waste technologies are not happening in Anguilla, it is not because they would not be profitable for those who develop them. In fact, they would—so there must be other reasons for which they are not happening. In particular, we recognize that a profitable technology like solar PV may still not happen in spite of already being viable—we simply emphasize that the problem is not its viability. Therefore, the solution should not be one that further enhances its existing viability for those who can already afford it, at the expense of all customers (such as net metering), but another solution (such as access to dedicated financial instruments);
- There are also **no barriers to the right to use solar, wind, and waste resources**. Anyone who can capture sunlight and wind can use it, and use it to generate electricity; and anyone who owns waste can use it (although only a public supplier can use it to generate electricity, this is not a barrier because if ever any waste-based energy is possible in Anguilla, it will be aggregating all waste available—something is a 'barrier' only if it blocks a sensible project); and
- There are also **no barriers to access and develop sites for utility scale renewables**. All the rights are in place in the law (although enforcement of these adequate rules has been difficult, new procedures in draft legislation are likely to improve the current situation).

The first barrier we encounter is to **access and develop a site for distributed scale renewables**—particularly solar water heaters. All rights are in place, and distributed scale renewables do not qualify as 'developments' (which makes their development easier), but there is a specific problem for solar water heaters: new buildings can go up in a way that makes it impossible or very costly to install one. Our first recommendation is therefore as follows.

Now: Mandate solar water heaters for new buildings—when a building wants water heating, it should be solar, and of a type that is appropriate for the Caribbean. This could be in the draft Building Code, or just as a step in the permitting process (like it happens for underground water tanks in Anguilla: if a new construction does not have it, it gets no permit).

Table ES2: Recommendations for Integrating Renewable Energy Technologies

	Utility Scale Renewables	Distributed Scale Renewables
Commercial barrier		
Lack of comm. viability	**No barrier**—no measure	**No barrier**—no measure
Legal and regulatory barriers		
Lack of clear rights to use a resource	**No barrier**—no measure	**No barrier**—no measure
Lack of right to access and develop a site	**No barrier**—no measure	**Now**—mandate solar water heaters for new buildings
Inability to sell electricity generated	**Now**—adopt ANGLEC corporate rules to directly develop, procure under DBOM, or contract IPPs under ANGLEC's licence; publish request for EOIs for the solar PV tender, and include O&M in RFP **Later**—consider creating autonomous licensing regime for IPPs	**Now**—adopt ANGLEC corporate rules to create SOC; amend Electricity Act by extending licence exemption to the sale of excess renewable electricity to public supplier; issue a pilot SOC with a limited cap and with a pilot disaggregated tariff
Economic regulatory distortions	**Later**—commission COSS; amend Electricity (Rates and Charges) Regulations with disaggregated tariff structure; determine best option for regulator to administer rules	
	Later—amend ANGLEC's licence and Electricity Supply Regulations adding cost recovery principles	**Later**—issue a revised SOC with a revised cap
Other barriers		
Limited financing	**No barrier**—no measure	Use this report to secure low-cost financing, guarantees, and grants for solar projects (water heating, PV); set up consumer financing initiative
Limited availability of equipment	**No barrier**—no measure	
Limited institutional capabilities	Secure funding for further activities, such as a cost of service study or broader power sector reform	Secure funding for further activities; strengthen capacity of Electrical Inspector's Office to deal with SOC
Limited technical skills	Include O&M when procuring a specialized contractor	Check electric wireman's licence and plumbers' licence
Limited information and awareness	Assess quantity and quality of wind and waste resources	Consider adopting external certification for solar installers (water heating, PV)

Notes: DBOM = Design, Build, Operate, and Maintain; O&M = Operations and Maintenance; IPP = Independent Power Producer; COSS = Cost of Service Study; RFP = Request for Proposals; EOI = Expression of Interest; SOC = Standard Offer Contract

With respect to the **ability to sell electricity generated**, barriers are less severe for utility scale renewables than for distributed scale ones:

- For utility scale renewables, the only option that is not possible in the existing framework is for independent power producers (IPPs) to operate under their own licence, which is not even contemplated under the law. On the other hand, there are three other options that are available under the law, the latter two of which can ensure a good role for third parties: (i) ANGLEC can sell electricity generated by renewables it does itself; (ii) IPPs can operate under ANGLEC's licence and sell power to it through a power purchase agreement (PPA) without a new licence, thanks to the possibility for ANGLEC to assign all or some rights of its licence to others; and (iii) ANGLEC can hire a specialized contractor to design, build, operate, and maintain ('DBOM') a renewable energy plant; but
- For distributed scale renewables, on the other hand, there is no option: customers cannot connect their systems or sell their excess electricity to the grid.

Given this situation, our recommendations to overcome barriers to the ability to sell electricity generated from renewables are as follows.

Now: ensure that ANGLEC procures, develops, or contracts renewables in the best possible way through corporate rules. This should be done by amending ANGLEC's by-laws, which can regulate how the business and affairs of the company should be managed—in our case, this could include renewables. We recommend adding a schedule to ANGLEC's by-laws with corporate rules on how to do renewables right (utility, and distributed scale); rules would be binding, but with some flexibility for ANGLEC management, to avoid having to do what would be unreasonable. Rules are contained in Appendix J, and can be summarizes as follows:

- For utility scale renewables, the rules would **establish a best practice process to develop, procure, or contract new renewable energy generation capacity**. The process would include the following phases: (i) demand forecast; (ii) least cost generation plan with full consideration of renewables; (iii) a participation in a consultation with the public; (iv) approval of the least cost generation plan; (v) an identification of the best option to design, build, operate, maintain, and finance projects (fully developed by ANGLEC; procuring a DBOM contractor; or contracting an IPP under ANGLEC's licence); (vi) when using the DBOM or the IPP option, running a competitive, transparent procurement process (with clear eligibility criteria, and evaluation process and rules; and a prequalification stage before requests for proposal); and (vii) an implementation and award; and
- For distributed scale renewables, the rules would lead to a **well-designed Standard Offer Contract (SOC)** that: (i) identifies a technically and economically viable cap for eligible distributed generation to contribute to the energy mix; (ii) creates a grid and distributed generation code setting out rules for interconnecting distributed renewable energy generation to the grid; (iii) establishes a net billing arrangement under which ANGLEC would buy excess power from eligible customers at a fair rate set at actual avoided fuel cost (that is, considering ANGLEC's cost of generation that is offset by distributed generation under realistic dispatching conditions), and for a term no less than a system's useful lifetime (usually 20 years); and (iv) tries to secure under the existing licence any changes to tariffs and conditions of supply necessary to promote the

maximum possible development of economically efficient distributed renewable energy generation.

Later: consider an autonomous licensing regime for IPPs—but in fact discard it, because it would be unnecessary (given there are three options to get the same result anyway), costly and time consuming (because many changes to the laws would be required—meaning lawyers' fees, controversies, and domino effects in legal reform), and difficult to administer (because nobody in Anguilla has experience in licensing).

Now: ANGLEC to publish request for expressions of interest for solar PV. ANGLEC's initiative to procure a 2MW solar PV plant is an excellent idea, and should not be delayed; we simply recommend adding a prequalification stage (expressions of interest), according to best procurement practices.

Now: ANGLEC to add Operations & Maintenance (O&M) in the Request for Proposals for solar PV. ANGLEC's draft RFP to procure the design and build of a 2MW solar PV plant looks sound. We just recommend that it consider adding an O&M component (even a short one), turning it into a DBOM contract; and once the corporate rules for renewable energy are adopted, that it check that the RFP complies with them.

Now: amend the Electricity Act to extend exemption from licence also to the sale of excess electricity. Customers should not need a licence to generate and sell under a SOC with their distributed scale renewables—the SOC 'package' would work like a standardized licence already. This needs a simple, but extremely important, amendment to the Electricity Act—adding to the exemption from a licence to generate with wind and solar the words "or selling excess electricity to a public supplier on terms agreed with the public supplier" (see the full amendment in Appendix section K.1).

Now: ANGLEC to develop pilot SOC with pilot disaggregated tariff. A pilot SOC would allow a quick start, and be the first step of a gradual approach to implement distributed renewables. The pilot SOC should be accompanied by a pilot disaggregated tariff (luckily, the law already allows for special tariffs to be agreed upon between the utility and its customers under special circumstances).

With respect to the existence of an adequate regulatory framework, there are severe barriers that should be addressed later. Anguilla's regulatory framework is rudimentary and outdated: there are limited rules on how to plan, implement, operate, and recover investments; there is very limited regulatory activity and tradition. In short, it is a framework designed for an era when renewables were not even an option—only diesel. Much of these problems relate to broader power sector reform, beyond just renewables—but they do create barriers to renewables too. Investments in diesel generation are safe thanks to the fuel surcharge, but those in renewables are risky: recovery of capital intensive investment in renewables are uncertain. Rate reviews are rare—and unclear as to how to do them, and to what their outcome may be. Tariffs bundle all services together (energy, backup and standby capacity, and connection to the grid)—the effect of this is that customers who self-generate with distributed renewables and remain connected to the grid enjoy costly services without paying for them, which jeopardizes the utility's financial viability. Finally, even if there were more sophisticated rules, there would be no regulatory capability anyway in Anguilla to administer them.

Given this situation, our recommendations to overcome economic regulatory distortions are as follows.

Later: amend ANGLEC's licence and Electricity Supply Regulations by adding tariff setting principles on recovery of sustainable energy costs. This would ensure that good investments in renewables may be recovered through tariffs through a streamlined process. Appendix section K.2 contains our proposed amendments to ANGLEC's licence and Electricity Supply Regulations. In summary, it would work like this: investments done in accordance with ANGLEC's corporate rules (both for utility scale and for distributed scale renewables) would be defined as 'approved renewable energy costs'—and 'approved renewable energy costs' would be automatically considered reasonable, and as such recoverable through tariffs. The effect of this apparently small change would be huge—it would give the right, strong incentive for viable renewables to happen.

Later: commission a Cost of Service Study (COSS). Anguilla should commission a COSS to improve the tariff structure, and identify ways other than renewables to reduce costs.

Later: amend the Electricity (Rates and Charges) Regulations with a disaggregated tariff structure. The good thing about the Electricity (Rates and Charges) regulations is that they do not mandate which tariff components there should be—there could be other and different tariff components. A simple rate adjustment could allow implementing a 'sustainable tariff structure', which would be disaggregated and cost-reflective, charging consumers separately for: (i) supply of energy, measured in kilowatt hours sold (energy charge); (ii) connection to the distribution system (connection charge); and (iii) provision of generating capacity (capacity charge). Cost of fuel should be included fully in just one component (fuel surcharge), and not split between a base charge and the fuel surcharge; and the fuel surcharge (in EC$ per kWh) should be published monthly, for transparency. There could also be a separate 'Renewable Energy Recovery Clause' in the tariff structure, allowing the recovery of all approved renewable energy costs together, in a more transparent way.

Later: issue a revised Standard Offer Contract. Based on the experience of the pilot SOC, and once a COSS allows a general revision of all customers' tariff structure, ANGLEC should issue a revised SOC—following the same principles, but fine-tuning it for a more widespread adoption.

Later: determine the best option for a regulator to administer rules. Anguilla should pick among three options for a regulator to administer the rules of a reformed regulatory framework: (i) maintain the current situation, and appoint an Electricity Commissioner; (ii) assign regulatory functions to the Public Utilities Commission (PUC); or (iii) assign regulatory functions to the Eastern Caribbean Electricity Regulatory Authority (ECERA), once it is actually set up.

Finally, additional measures (other than those related to the legal and regulatory framework) would also help promote cost-effective renewables:

- For problems of limited financing and limited availability of equipment, we recommend ***using this report to secure low-cost financing and other financial resources for distributed solar systems***—both solar water heaters and solar PV. Concessional loans, loan guarantees, and grants for project preparations would be the main financial tools possible;

- To help solve limited institutional capabilities, we recommend ***strengthening the capabilities of the Electrical Inspector's Office***, and ***securing funding for further studies and reforms***—such as a COSS, or broader power sector reform matters;
- To help increase skills for renewables in the country, we recommend ***including an O&M component (even short) when procuring a specialized contractor***, and ***checking whether requirements for a wireman's and plumber's licence are appropriate*** for small PV and wind systems, and for solar water heating, respectively; and
- To help enhance information and awareness, we recommend ***further assessing the quantity and quality of wind and waste resources***; and ***considering external certifications for installers*** of solar water heaters and solar PV systems.

1 Introduction

The Government of Anguilla, with the support of the Climate and Development Knowledge Network (CDKN), asked Castalia to recommend how to improve Anguilla's legal and regulatory framework to enable integration of renewable energy.

Anguilla is a British Overseas Dependent Territory located in the Eastern Caribbean, with a population of about 15,000. The island is very small: 91 square kilometers, about half the size of Washington, DC. The terrain is relatively flat (it is a low lying coral and limestone island). The island is vulnerable to frequent hurricanes and tropical storms. Anguilla has very little portable water, and no arable land. Its economy is primarily based on tourism, banking, and the fishing industry, as well as some limited agriculture. In 2002, 23 percent of the population lived below the poverty line.[1] Anguilla is a member of the Organization of Eastern Caribbean States (OECS), and the Caribbean Community (CARICOM).

This document represents our assignment's Second Draft Report. It takes into account comments and suggestions on our Draft Report (22 April 2012), which we presented in a Stakeholder Workshop in Anguilla on 24 April 2012.

In this introduction, we summarize the scope of work of this assignment, which focuses on the legal and regulatory aspects of promoting renewables (section 1.1). Then, we present the content of this report (section 1.2).

1.1 Scope of Work

Our assignment consists of recommending how to amend current electricity legislation and regulation of Anguilla for providing a clear framework to integrate both distributed scale and utility scale renewable energy into the national electricity grid. We are to do this while involving key stakeholders throughout the entire assignment, and enabling to share Anguilla's experience with other Caribbean countries that are in a similar situation. Ultimately, our work should contribute to a legislative environment that promotes affordable and reliable electricity supply from renewable sources for all Anguillans, particularly the poor.

Several related matters are outside our scope of work, in particular:

- Matters regarding renewable energy that are not legal or regulatory—for example, financial barriers, availability of skills and information, and specific social policies for poverty reduction;
- Broader power sector reform matters (beyond what is needed for renewable energy). For example, Anguilla would need to improve the overall way its electricity tariffs are set; and to identify ways other than renewables to improve the efficiency of its power sector. These matters would require at least a cost of service study and a tariff study, which are not included among our tasks; and
- Technical matters regarding renewables, such as determining whether specific projects are or not viable; how much renewable capacity should be implemented, and when; what price should be paid to renewables; and what technical rules grid-

[1] Central Intelligence Agency. The World Factbook: Anguilla". https://www.cia.gov/library/publications/the-world-factbook/geos/av.html (accessed May 31, 2012).

integrated renewables should comply with. These matters would require detailed feasibility studies, an optimized least cost generation expansion plan, and development of grid code rules, which are not included among our tasks.

To the extent possible, we consider these related matters in this report for providing a more complete picture of opportunities for, and barriers to renewable energy integration; and for making our recommendations sounder and more useful.

1.2 Content of this Report

The remainder of this report is structured as follows:

- To begin with, we explain that the country's priority objective of integrating renewables is to reduce electricity costs in the long term. Increasing energy security and enhancing local and global environmental sustainability are two other objectives. We further discuss these objectives (which are based on indications by the Government and stakeholders we met in Anguilla) in section 2;
- The following step in our work is to provide a brief overview of Anguilla's power sector. Anguilla is a small isolated electricity system where power is provided by a vertically integrated utility using imported diesel, and where electricity costs and tariffs are among the highest in the region. We briefly discuss electricity sector entities, electricity supply and demand, and electricity tariffs in section 3;
- Anguilla's policy, legal, and regulatory framework for electricity completes the analysis of the local setting. In section 4 we provide a concise analysis of the Government's energy and climate change policies, and of Anguilla's electricity sector legislation and regulation that are relevant to renewable energy;
- Having analyzed the context within which renewables may be developed in Anguilla, the following task is to assess the country's renewable energy potential. In section 5, we screen renewable energy technologies to determine resource availability, the existence of commercially proven technologies, and economic and commercial viability. Solar and wind are Anguilla's clearest options; waste-based energy might be an option in the longer term, provided there is sufficient volume;
- Once the viable options are identified, the question to ask is, why are they not happening? In section 6 we analyze barriers related to the legal and regulatory framework, and briefly describe other barriers related to institutional capabilities, technical skills, availability of financing, information and awareness, and availability of competitively priced equipment; and
- To overcome legal and regulatory barriers, Anguilla should pursue a phased approach. In the immediate term, it can pursue large and small renewables with relatively limited changes in the legal and regulatory framework. In the longer term, it can engage in a broader strategy that may involve reforms that go beyond just renewables. We explain this in section 7.

Eleven appendices complete this report. Appendices A to I respond to client and stakeholder requests to make the main body of the report more concise and user-friendly:

- Appendix A provides an institutional outline of Anguilla's power sector;
- Appendix B analyzes in detail electricity demand and supply in Anguilla;

- Appendix C describes Anguilla' electricity tariffs;
- Appendix D analyzes Anguilla's National Energy Policy and draft Climate Change Policy;
- Appendix E contains a detailed analysis of Anguilla's laws and regulations relevant to renewable energy integration;
- Appendix F shows how we estimate conventional electricity generation costs and tariffs for purposes of assessing the viability of renewable energy in Anguilla;
- Appendix G describes in greater detail Anguilla's viable renewable energy options;
- Appendix H explains how the long-run marginal cost (LRMC) of generation of renewable energy technologies is calculated (US$ per kWh); and
- Appendix I explains how the marginal cost of carbon abatement (US$ per ton of CO_2) is calculated for renewable energy technologies.

Appendices J and K contain legal language that may be used directly for amending existing laws, regulations, and by-laws:

- Appendix J provides draft corporate rules that we recommend ANGLEC's Board adopt to implement renewable energy; and
- Appendix K contains our recommended amendments to laws and regulations.

2 Objectives of Integrating Renewable Energy in Anguilla

Our assignment is to recommend legal and regulatory ways to integrate renewables in Anguilla—but why should Anguilla integrate renewables in the first place?

There are three reasons that make renewables important for a small island developing state like Anguilla, and that represent the three objectives justifying our assignment:

1. **To reduce electricity costs in the long term**. Anguilla's electricity costs (and as a consequence its electricity tariffs) are among the highest in the region—so high that they have led to an unsustainable situation commonly described as a crisis. Residential customers have been disconnected because unable to pay (although many have been reconnected under a new arrangement[2]); businesses have closed, due to high electricity costs among other factors. Anguilla fully relies on expensive imported diesel for power generation; it is a small, remote country with limited demand, which means relatively small and inefficient generating units, inability to switch to cheaper fossil fuels, and even higher costs of fuel procurement. As we show in section 5, there are some renewable energy options in Anguilla that can generate electricity at less than the fuel-only cost of diesel plants—this may mean some immediate savings on customers' bills, and good potential to save (or at least to somewhat stabilize costs and prices) in the longer term;

2. **To increase energy security**. As a small, remote country with no fossil fuel resources, Anguilla is particularly sensitive to energy security problems. Energy security "has two key dimensions—reliability and resilience. Reliability means users are able to access the energy services they require, when they require them. Resilience is the ability of the system to cope with shocks and change."[3] Energy security does not mean energy independence—a country can achieve total energy security even with no local primary energy resources. Renewables contribute to greater energy security because they represent primary energy resources that are locally available and reduce the need to import diesel. There are also other ways to achieve energy security (outside the scope of this assignment) such as forward contracts for fuel procurement; and

3. **To enhance environmental sustainability**. Anguilla is a small island country with a delicate natural environment (which is the key resource for its tourism-based economy), and is particularly vulnerable to local pollution from fossil fuel-based generation and risks of oil spills. Anguilla is also exposed to possible effects

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[2] ANGLEC estimates that 400 to 500 people have been disconnected (Castalia meeting with ANGLEC management, 17 February 2012). Some of these customers are vacant rental properties (villas and apartments) that were built during the construction boom, but are empty now because of the global recession. However, this number also includes many customers who cannot afford to pay their electricity bills (customers are disconnected 45 days after the billing date if they do not pay their electricity bill). ANGLEC has a flexible payment plan, based on the individual circumstances of the consumer, and a deferral process if the consumer needs an extra week to pay (it is required to sign an agreement to pay ANGLEC). During Christmas 2011, ANGLEC also instituted a $1 reconnection plan, reconnecting customers who paid at least $1 towards their bill. However, only 30 consumers took advantage of this reconnection plan.

[3] New Zealand Ministry of Economic Development, *Glossary*, Definition for Energy Security. http://www.med.govt.nz/templates/MultipageDocumentPage____32084.aspx

of global climate change, such as sea level rise and increased frequency or severity of climate phenomena. The two dimensions of Anguilla's environmental vulnerability—local pollution, and global climate change—are different with respect to costs and benefits of mitigation: Anguilla can capture all the value of any additional cost it incurs to mitigate local pollution, while it can capture virtually no value of any additional cost to abate greenhouse gases (GHG) since climate change is a global phenomenon created by far larger emitters.

Reducing electricity costs in the long term: priority objective

Reducing electricity costs is the Government's priority objective for integrating renewable energy in Anguilla, consistent with one of the primary goals of the National Energy Policy ('Ensure universal access to an affordable electricity supply for all Anguillans').

Reducing electricity costs is also the priority objective for the overwhelming majority of other public and private actors we met during our visits to Anguilla.

Anguilla should aim towards lower electricity costs in the long term—that is, promote renewable technologies that are likely to achieve a sustainable reduction in costs.

Increasing energy security and enhancing environmental sustainability—objectives to pursue as long as costs decrease

Increasing energy security and enhancing environmental sustainability are also objectives that the Government intends to pursue through renewable energy integration, recognizing their importance for Anguilla—but only as long as they may pursued while decreasing electricity costs. Pursuing energy security and environmental sustainability with renewable energy technologies that are not economically viable (a renewable energy technology is 'economically viable' if it reduces the overall cost of generating electricity in the country) means a tradeoff with the objective of reducing electricity costs.

In Anguilla's case, this tradeoff should be largely a theoretical matter, because renewables can be a win-win option for the country in any case. As we discuss in section 5, the renewable energy resources that Anguilla has—solar energy, wind energy, and perhaps (in the medium-long term) waste—can all be exploited with technologies that are economically viable in the country. This is an ideal situation, because it means that Anguilla can pursue its key renewable potential and achieve all three objectives at one time—it can help the local environment, contribute (symbolically) to mitigating global greenhouse gases, and reduce dependence on imported oil while also saving on electricity bills.

3 Overview of Anguilla's Power Sector

This section provides an overview of key entities in Anguilla's power sector, electricity demand and supply, and electricity tariffs. Appendices A, B, and C complement this section with detailed analyses of these topics.

3.1 Key Entities in Anguilla's Power Sector

Anguilla is a small isolated electricity system, with power provided by one operator, the Anguilla Electricity Company Limited (ANGLEC). ANGLEC is a vertically integrated utility, owned in its majority by the Government.

The Governor, Executive Council (EXCO), and the Ministry of Infrastructure, Communications, Utilities and Housing (MICUH) are the key Government actors that set energy policy, issue licences, and regulate the power sector. The Ministry of Home Affairs is responsible for reviewing and approving applications for new energy projects, and for issuing permits.

The Anguilla National Energy Committee (ANEC), and the Anguilla Renewable Energy Office (AREO) are the two non-profit organizations that complete the country's institutional picture for the power sector.

Appendix A provides a complete outline of institutions involved in Anguilla's power sector.

3.2 Electricity Demand and Supply

Electricity demand has grown consistently since 2003, but may slow down in the future due to increased fuel prices and the economic recession. Peak demand reached 15.3MW in December 2010, having increased by about 7 percent per year since 2001. ANGLEC's most recent load forecast expects peak demand to reach almost 20MW by the end of 2015 (average growth rate of 5 percent), although the company is considering revising this estimate downwards due to the current economic downturn.

ANGLEC's current generation mix consists of high and medium speed diesel generators which, combined with high prices of imported diesel, mean high generation costs. At US$0.25 per kilowatt hour (kWh) in 2010, ANGLEC's generation operating costs (the sum of all fuel and generation-related operating expenditures, divided by gross generation) are higher than those in Barbados, Grenada, Dominica, the Cayman Islands, or Saint Lucia. ANGLEC's fuel efficiency is relatively good compared to its peers in the region; system losses, however, are relatively high.

Appendix B provides a more detailed analysis of Anguilla's electricity demand and supply.

ANGLEC's Renewable Energy Outlook

ANGLEC management is open to including renewable generation in its plant mix. In addition, the Government (ANGLEC's majority stakeholder) is eager to use renewable energy generation to reduce electricity costs in the country in the long term.[4] ANGLEC has drafted a request for proposals (RFP) for the construction and delivery (design and build) of

[4] Information provided by stakeholders in the Government and ANGLEC, January, 14-21, 2012

solar PV plant.[5] The RFP, which has not been issued and is confidential, establishes that bidders should propose:

- An installed capacity of 1.5-2MW;
- A commercially proven and available technology resilient to hurricanes;
- Firm and binding prices; and
- A site for the development in the Corito area under ANGLEC control (or an explanation of how it will deliver electricity from a site outside this area), which would make the development easier given its proximity to the grid.

ANGLEC management has also expressed interest in having the option to purchase renewable power from independent power producers (IPPs), creating a new type of licence, in particular since this would mean having IPPs provide the financing of new plants. As we discuss in section 4.2, however, IPPs could operate in Anguilla and sell power to ANGLEC with no need to create a new type of licence—simply operating under ANGLEC's own licence.

As explained in section 5.2.2, viable renewable technologies with the most potential in Anguilla (solar PV and wind) can provide lower-cost power than diesel generation. However, they do not provide firm power for base load (that is, power that may be ensured at any time). Therefore, conventional generation capacity will still be required in Anguilla.[6]

3.3 Electricity Tariffs

Tariff categories in Anguilla are based on monthly consumption levels, not on customer type. The first category is for customers consuming up to 40 kWh per month; the second for those consuming up to 2,500 kWh per month; the third for those consuming up to 100,000 kWh per month; and the fourth for those consuming over 100,000 kWh per month.

Tariffs charged by ANGLEC to its customers comprise a base rate per kWh, which includes a fixed portion of fuel costs; a fuel surcharge per kWh that depends on the cost per gallon of fuel oil; and an environmental levy that is used to fund waste collection on the island.

Appendix C describes ANGLEC's tariff components and categories in detail.

[5] ANGLEC. "Request for Proposal: Photovoltaic Generating Plan." January, 2012

[6] Anguilla Renewable Energy. "The Anguilla Model: An 8 Year Plan for Achieving a Carbon Neutral Economy as a Replicable Model for Small Island Nations Worldwide." 2009

4 Anguilla's Policy, Legal, and Regulatory Framework for Electricity

In this section we summarize our analysis of Anguilla's policy, legal, and regulatory framework for electricity, focusing on the aspects that are relevant for enabling renewable energy integration. Appendices D and E provide our full analysis of these topics.

4.1 Relevant Policy

Anguilla's policy documents relevant to electricity regulation are:

- The **National Energy Policy**, whose main focus is to provide a reliable and quality supply of electricity to all sectors of society at an equitable price, and which includes as an objective using renewable resources to the greatest extent possible to meet existing and increasing demand for power generation; and
- The **Draft Climate Change Policy**, which aims to manage the impacts and risks from climate change while transforming Anguilla to a climate resilient, energy efficient, and low carbon economy.

The only aspect in these two documents that is not consistent with the Government's objectives and priorities for renewable energy as stated in section 1—to reduce electricity costs as a priority, while increasing energy security and enhancing environmental sustainability—is the Draft Climate Change Policy's goal to 'achieve energy independence' (goal number 8). We would recommend that goal number 8 be rephrased as 'achieve *greater* energy independence' or 'pursue energy security'.

Appendix D analyzes in greater detail these two documents.

4.2 Relevant Legal and Regulatory Framework

The key aspects of Anguilla's legal and regulatory framework from the perspective of renewable energy integration are as follows:

- **Licensing**—there is no need for a licence to generate electricity with wind and solar photovoltaic technologies, if it is for one's own consumption; a licence to supply electricity on a commercial basis to a licensed public supplier is not contemplated under the law (the law contemplates two types of licences: a private supplier's licence, and a public supplier's licence). Only one licence has been issued in Anguilla: ANGLEC's public supplier's licence. Importantly, ANGLEC's licence includes assignment rights thanks to which the utility may (with the Governor's approval) transfer or assign all or part of its licence—for example, to an independent power producer (IPP), which could therefore sell all its generation to ANGLEC with a power purchase agreement (PPA) simply operating under ANGLEC's licence;
- **Corporate instruments**—ANGLEC's by-laws empower the directors to manage the business and affairs of the company, and to impose on the officers any terms and conditions or any restrictions that they think fit in respect of the powers delegated to the management. They may also make, amend, or repeal by-laws for the regulation of the business and affairs of the company. Importantly, this means that (in addition to the terms and conditions in the Act, Regulations, and licence)

ANGLEC is subject to any internal rules—for example, this could include rules on how to assess and implement renewable energy (as we recommend in section 7.1.1);

- **Service standards**—ANGLEC's duty is to provide a regular, sufficient and continuous supply of electricity. However, laws, regulations, and ANGLEC's licence do not control how this overall duty must be met—there are no indications or restrictions as to which plant may be used, and no obligation for ANGLEC's generation expansion plans to be approved. All ANGLEC must show to recover its costs through tariffs, is that its costs are reasonable;
- **Rate adjustment procedure**—it is for ANGLEC to initiate the procedure to request a rate adjustment. The relevant Minister and an Arbitrator decide whether (and to what extent) to approve a rate adjustment. In deciding, they must ensure that rates allow ANGLEC to meet all costs and expenses that are reasonably incurred, and provide an annual return on shareholder equity of at least 12 percent per year. The Electricity Act and ANGLEC's licence only list two types of information that may be requested from ANGLEC as part of the rate adjustment procedure (most recent audited accounts; and an estimate for the 5 following financial years), but Anguilla's laws allow for any other information to be also requested; and
- **Land rights**—Anguilla's legal and regulatory framework is complete with respect to the rights for acquiring land, including the right to access it over the land of others; obtaining the right to develop land; and obtaining rights over the land of others to place poles and other apparatus.

Appendix E contains our full analysis of Anguilla's laws and regulations relevant to renewable energy integration.

5 Anguilla's Renewable Energy Potential

Several renewable energy technologies may be economically and commercially viable in Anguilla. The country has abundant solar resources available as well as good wind resources, and there are commercially proven technologies that can be used to tap into this potential. Solar photovoltaic (PV) technologies at both the utility and distributed scale, solar water heating, and utility scale wind are all economically viable technologies that can be exploited—immediately in the case of solar; with further study and time in the case of wind. Anguilla could also look at waste-based energy technologies in the future, but it would certainly need more waste volume to pursue this option.

In spite of several options being potentially viable, almost none are currently implemented in the country. Furthermore, diesel generation will be needed even if Anguilla realizes its entire renewable energy potential (at least under current technology conditions)—because most of Anguilla's renewable energy potential is represented by technologies (wind, and solar) that cannot provide firm power for base load. Finally, Anguilla should not expect an unrealistically high impact from renewable energy integration in the near term—because its most immediate and clear opportunity for viable renewables (solar photovoltaic) does not cost much less than conventional generation under current and expected oil prices.

In the remainder of this section, we review the current uptake of renewable energy in Anguilla (section 5.1). Then, we screen which technologies should be assessed (based on maturity of the technology, and availability of the primary energy resource), and analyze the potential for and economic viability of renewable energy technologies for Anguilla (section 5.2). Finally, we look at the cost of carbon abatement of renewables (section 5.3).

As a reminder, the purpose of this section is to guide our recommendations for legal and regulatory reform, which is the focus of our assignment. Our assessment of how renewable energy options compare to conventional generation is necessarily a simplified one—or just a first broad step of an assessment, for policy purposes. A detailed feasibility analysis would be required for any specific project. Also, the viability of renewables critically depends on the assumption made for the cost of diesel. Finally, developing a least-cost plan for electricity generation in Anguilla, or assessing and recommending how much renewables should be implemented in the country are technical matters outside the scope of this assignment.

In spite of simplifications, the results of our assessment are broadly valid—assumptions are based on information collected in Anguilla and vetted with local stakeholders wherever possible, and are reasonable and conservative when compared to information collected in other small island countries of the Caribbean and other regions.

All assumptions and sources of information used for this analysis are shown in:

- Appendix F (conventional generation costs and tariff levels assuming that diesel fuel costs US$4 per gallon); and
- Appendix G (costs and performance of renewable energy technologies).

5.1 Current Uptake of Renewable Energy

There is very little uptake of renewable energy in Anguilla. The rare exceptions are small distributed scale solar and wind systems at customer premises, which are not connected to the grid. Below we discuss the uptake of utility scale technologies in more detail, then that of distributed scale technologies.

5.1.1 No uptake of utility scale technologies

There is no utility scale renewable electricity generated in Anguilla. 'Utility scale technologies' are technologies that need to be installed at a dedicated site, and supply power over the transmission and distribution grid.

As noted above (see section 3.2), ANGLEC has prepared a draft Request for Proposals for a utility scale solar PV installation.[7] Additionally, the government has published a redevelopment plan for Corito Bay that includes a utility scale wind installation, and a potential waste-based plant.[8]

5.1.2 Limited uptake of distributed generation technologies

Distributed renewable generation is almost non-existent in Anguilla. 'Distributed generation technologies' are[9] small-scale technologies that are located in close proximity to the load being served. These technologies are called distributed generation because they are installed across the distribution network, at customer premises.

There are a few distributed generation systems in Anguilla:

- ***Solar water heaters***—equipment retailers and installers[10] report installing several solar water heaters, although no precise data are available on residential and non-residential penetration. Uptake is limited compared to other Caribbean countries, mostly because of limited awareness, limited availability of competitively priced equipment, and also for reported problems in the past (some systems installed before Hurricane Luis came off during the hurricane; other were not properly installed, and malfunctioned);
- ***Solar PV***—a few residential and commercial customers have installed small solar PV systems for self-generation (on an apartment building, private health clinic, Princess Alexandra Hospital, and at the airport);[11] and
- ***Small wind***—one residential customer at an apartment building installed a small wind turbine (500W) for self-generation.

5.2 Economic and Commercial Viability of Renewable Energy

Below we assess Anguilla's renewable energy potential. First, we screen which technologies should be considered based on maturity and availability of the primary energy resource

[7] ANGLEC. "Request for Proposal: Photovoltaic Generating Plan." January, 2012

[8] Anguilla National Energy Committee. "Corito 'Zero Energy' Development Zone." 2009

[9] There is no single, commonly accepted definition of 'distributed generation'. Two useful definitions are: (1) "Any electricity generation facility that produces electricity for use at the point of location, or supplies electricity to other consumers through a local lines distribution network" (New Zealand's Ministry of Economic Development); and (2) "Small, modular, decentralized, grid-connected or off-grid energy systems located in or near the place where energy is used" (United States Environmental Protection Agency).

[10] Meeting with Renewable Energy Equipment Retailers and Installers, Anguilla, 21 February 2012.

[11] Conversations with the Government, AREO, ANGLEC, and stakeholders, Anguilla, 13 February 2012 to 22 February 2012.

(section 5.2.1). Then, we analyze the economic and commercial viability of technologies (5.2.2). Finally, we summarize our conclusions (5.2.3).

5.2.1 Screening of renewable energy technologies

To determine if a technology is appropriate for Anguilla, we screen individual technologies based on two criteria:

1. ***Maturity of technology***—a 'mature renewable energy technology' is in commercial operation somewhere in the world; and
2. ***Availability of primary energy resource***—there is sufficient quantity and quality of the primary energy resource used by a renewable energy technology to develop the technology commercially. Given Anguilla's limited land mass, we bundle availability of land in this criterion.

The table below illustrates the results of the screening. As shown in the table, we screen out: Concentrated Solar Power (CSP), Seawater Air Conditioning, Hydropower, Geothermal Energy, Biomass Cogeneration, Biodiesel-based Power Generation, Ocean Thermal Energy Conversion (OTEC), and Ocean Wave Energy Conversion.

Table 5.1: Screening Renewable Energy Technologies to be Assessed in Anguilla

RE Technology	Maturity (0-2)	Availability of primary resource (0-2)	Comments	Screening result (in/out)
Solar PV	1	2	Mature technology, although further improvements expected. Excellent solar potential. Limited land availability	In
Solar Water Heaters	2	2	Mature technology. Excellent solar potential	In
Wind	2	1	Mature technology. Good wind potential, limited land availability	In
Waste-Based Energy	2	1 (medium-long term)	Several mature technologies available (landfill gas to energy, waste to energy). Very limited waste stream, not properly treated, and with unclear composition, may be sufficient only for a small project (if any)	In
Concentrated Solar Power (CSP)	1	1	In commercial operation, but significant improvements and cost reductions expected. Optimal plant size may exceed needs and land availability of Anguilla. Excellent solar potential	Out
Seawater Air Conditioning (SWAC)	1	0	Technology based on other commercially proven ones, but further improvement expected. Likely no availability of deep cool water (shallow water around Anguilla)	Out
Hydropower	2	0	Mature technology. No hydro resources.	Out
Geothermal	2	0	Mature technology. No geothermal resources in Anguilla (conventional geothermal fluids or hot dry rock)	Out
Biomass Cogeneration	2	0	Mature technology. No sufficient biomass available (or sufficient land to grow it)	Out

RE Technology	Maturity (0-2)	Availability of primary resource (0-2)	Comments	Screening result (in/out)
Biodiesel for Power Generation	2	0	Mature technology. No sufficient biodiesel feedstock available (or sufficient land to grow it)	Out
Ocean Thermal Energy Conversion (OTEC)	0	0	Technology at an experimental/pilot stage. Likely no availability of sufficient thermal gradient (shallow water around Anguilla)	Out
Ocean Wave Energy Conversion	0	1	Technology at an experimental/pilot stage. Possible availability of good ocean kinetic energy, but not ascertained	Out

Maturity: 0 = experimental/pilot stage; 1 = commercial stage, but further development expected; 2 = mature stage, no significant further development expected.

Availability of primary resource: 0 = low, 1 = medium, 2 = high.

We estimate the availability of resources based on different sources for each technology:

- Solar energy (including PV, CSP and, SWH)—there is no existing solar irradiation map for Anguilla, but one for the Bahamas may be used given the similar geographic location and weather patterns of the two areas;[12]
- Wind energy—a preliminary study by Mistaya Engineering shows very good availability of the resource, with estimated capacity factors up to 44 percent;[13]
- Waste—data provided by the Anguilla Statistics Unit about waste tonnage received at the Corito landfill shows a very limited waste stream;[14]
- Ocean technologies—a nautical map shows relatively shallow water around Anguilla;[15] and
- Biomass and biodiesel—Anguilla's limited agricultural activity and irrigation potential.[16]

Anguilla should not exclude the possibility that technologies screened out for not being mature (such as wave) may become viable in the future, but should not focus on these until they become commercially viable—especially since there are commercially viable technologies for other available primary energy resources. Also, it is well possible that other technologies not considered in our screening may be viable. Furthermore, the plant size

12 Fichtner, Direct normal solar irradiation on The Bahamas, based on National Renewable Energy Laboratory (NREL), 2010.

13 Lambert, Tony. "Anguilla Wind Data Analysis." Mistaya Engineering Inc., 2008

14 Anguilla Statistics Unit. "Environmental & Climate." Accessed 4/10/2012 at: http://www.gov.ai/statistics/ENVIR_CLIMATE_TAB_10.htm

15 Mappery, accessed April 19, 2012 at http://mappery.com/map-of/Anguilla-St-Martin-St-Barthelemy-Nautical-Map.

16 Anguilla has virtually no arable land. Its GDP composition by sector is as follows: agriculture (2%), industry (26%), and services (72%). See Central Intelligence Agency. The World Factbook: Anguilla". https://www.cia.gov/library/publications/the-world-factbook/geos/av.html (accessed May 28, 2012). Agriculture employment was 344 in 2002 (out of 5,496 total employed)—see Anguilla Statistics Unit. Press Release "Unemployment Rises", July 2002. http://www.gov.ai/statistics/images/Unemployment_Rises.pdf (accessed May 28, 2012)

(installed capacity, expressed in megawatts) that allows certain costs that make a technology viable may exceed the size suitable for Anguilla—this is likely the case for CSP.

On the other hand, even if a technology is screened in, this does not necessarily mean it can be immediately viable in Anguilla. For example, two technologies may be viable in theory, but in practice just one may be developed because they both compete for the same primary energy resource—this is typically the case for waste-based technologies in small island countries.

Finally, a technology may be viable at a size suitable for Anguilla and still not be developed for a few years, if (given the existing and planned demand-supply balance), it is not needed. On the other hand, key options viable in Anguilla are non-firm—they can always save fuel.

5.2.2 Analysis of renewable energy technologies

Figure 5-1 shows our assessment of the economic and commercial viability of potential technologies for renewable generation in Anguilla. The figure shows the Long Run Marginal Cost (LRMC, or all-in cost) of generation (US$ per kWh) for a range of renewable energy technologies, and compares the LRMCs against the estimated average system variable cost and all-in cost of conventional generation, as well as ANGLEC's estimated retail tariffs for different tariff categories.

A renewable technology is **economically viable** if it reduces the overall cost of generating electricity in Anguilla. It is **commercially viable** if a utility or a customer can save money by using it. So, by comparing the cost of renewable generation with the right benchmark, we can see if a technology is economically viable, commercially viable, or both.

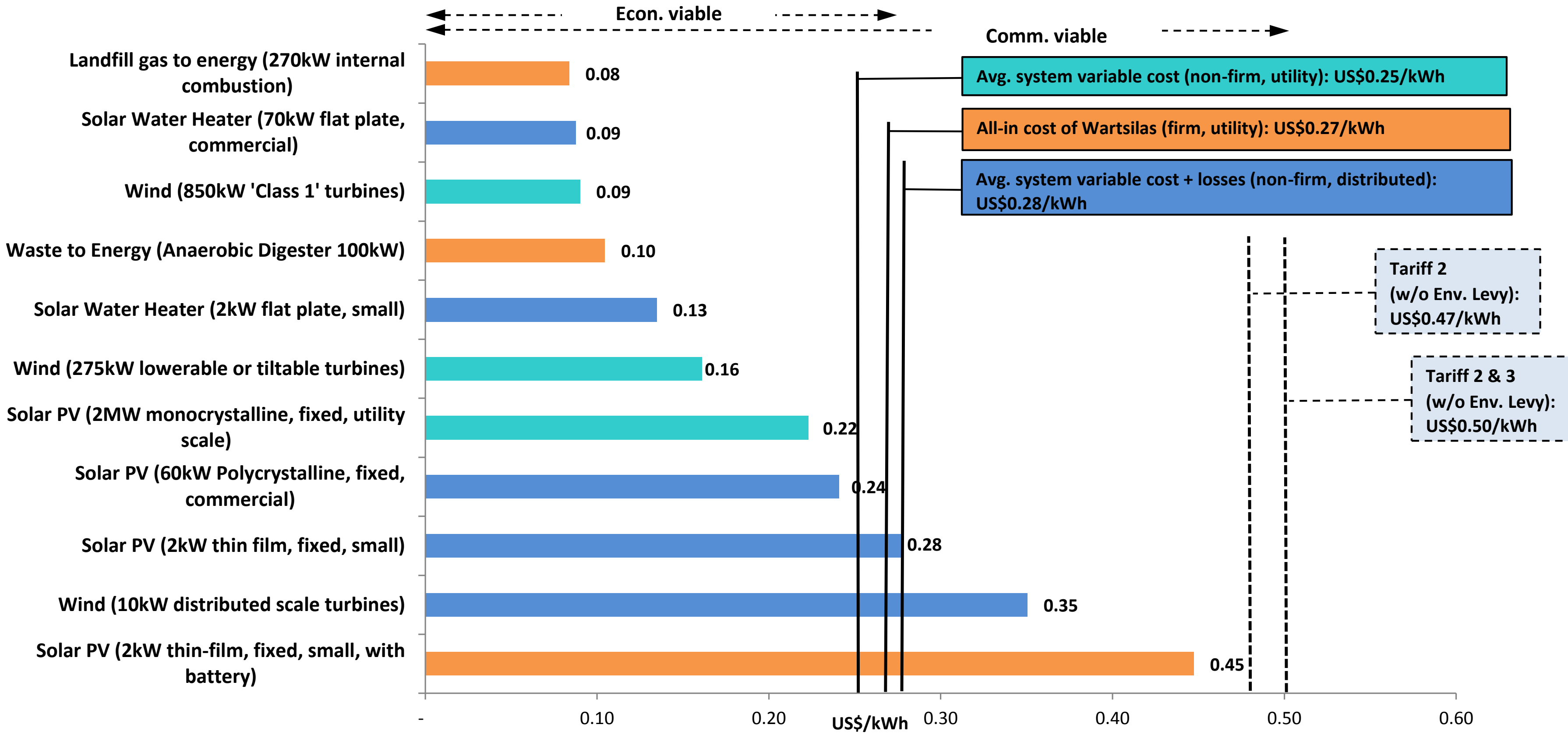
As explained in Appendix F, we estimate generation costs (and retail tariffs) calculated on the basis of a cost of Diesel No. 2 fuel of US$4.00 per gallon—we need to use some estimate of future oil prices, and US$4.00 is a reasonable estimate because it corresponds to oil prices of about US$100 per barrel, which is the price medium term oil futures contracts (3-4 years) are trading at.[17]

Oil prices, of course, vary—and with them the viability of renewable energy technologies. Table 5.2 shows breakeven prices of oil at which the various technologies are viable, suggesting that technologies viable at US$4 per gallon oil would be viable also at lower oil prices (US$1-2.4 per gallon), with the exception of solar PV that would need oil prices between US$3.5 and US$3.9 per gallon.

Figure 5-1 shows an indicative assessment of the LRMCs for all of the renewable energy technologies considered in the screening. The LRMCs are based on estimated values of capital costs, O&M costs, capacity factor, and lifetime of the various technologies. The assumptions we use for each technology are contained in Appendix G—we use data gathered in Anguilla where available, and in other cases, data from similar small island countries we have recently worked in (Turks and Caicos Islands, Barbados, Trinidad and Tobago, the Bahamas, and Mauritius), or gathered from businesses active in the North American and Caribbean market for renewable energy. Of course, the actual LRMC of any project—especially renewable energy projects—is highly site-specific, and requires a detailed feasibility study that is outside the scope of our assignment.

[17] CME Group. "Light Sweet Crude Oil (WTI) Futures." Accessed 4/10/2012 at: http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude.htm

Figure 5-1: Viability of Renewable Energy Technologies in Anguilla



Explanation: This figure analyzes the cost to generate 1 kilowatt hour of electricity (US$/kWh), comparing renewable options (horizontal bars) and conventional options (vertical lines) based on a diesel price assumption of US$4 per Imperial Gallon (IG). Estimated tariffs (dotted vertical lines) allow comparing the cost of generating electricity with small renewables with that of buying it from the grid, based on the same diesel price assumption of US$4 per IG

Note: Conventional generation costs and tariffs shown are not historical values (for example, ANGLEC's highest tariff as of May 2012 is US$0.40 per kWh), but estimates for analytical purposes, based on an assumption of Diesel prices at US$4.00 per IG. In particular, tariffs shown are estimated based on the fuel surcharge that could be applied if diesel cost US$4 per IG; ANGLEC reports that it does not always charge the full fuel surcharge that could be applied, and charges a lower fuel surcharge instead. Indicative Long Run Marginal Costs (LRMCs) of renewable energy technologies are based on assumptions about their cost and performance explained in Appendix G, and using a 11% discount rate for utility scale technologies, and 9% for distributed scale technologies, as explained in Appendix H. Landfill gas to energy and waste to energy estimates are subject to there being enough waste. The average system variable cost benchmark for distributed generation is grossed up for system losses (12%)

Viable technologies

The analysis shows that there are several renewable energy technologies that are economically viable in Anguilla. These are:

- Solar water heating: flat-plate systems on small and commercial scale for homes and businesses (US$0.09 and US$0.13 per kWh, respectively);
- Solar PV: at utility scale (monocrystalline, US$22 per kWh), and distributed commercial and small scale (polycrystalline and thin film, US$0.24 and US$0.28 per kWh respectively);
- Wind ('Class 1', and lowerable/tiltable turbines), on a utility scale (US$0.09 and US$0.16 per kWh, respectively); and
- Assuming there may be sufficient quantity of waste of sufficiently good quality in the medium-long term, waste-based technologies: landfill gas to energy (270kW internal combustion, US$0.08 per kWh), and waste to energy (100kW anaerobic digester, US$0.10 per kWh), on a small scale operated commercially. We screen waste-based technologies in, in spite of an extremely limited amount of waste with uncertain composition (see G.4), given the Government's interest and preliminary work done for this technology, and given the importance of waste management on the island for reasons other than power generation. It is not certain that any waste-based technology may be exploited commercially in Anguilla; however, very small scale units might be implemented, and their cost assessed from the broader perspective of waste management.

These technologies are also all commercially viable. The residential customer and the commercial producer would save money by using solar PV and solar water heating. A utility scale developer could generate cost-competitively by using solar PV, wind, and (assuming this proves technically viable) waste-based technologies.

Analyzing the economic viability for each technology

Figure 5-1 above shows the viability of each renewable energy technology by comparing the LRMC of the technology (shown by the horizontal bar) with the relevant benchmark for that technology (shown by the vertical lines). We use different benchmarks for economic viability depending on the type of conventional generation that the renewable technology displaces:

- **Landfill gas to energy and waste to energy technologies** are benchmarked against the all-in cost of the most economical base load generation option (medium-speed Wartsila units) because (assuming an adequate quantity of waste allows a high enough capacity factor) they are 'firm' technologies—they could be depended on to generate electricity at any time, just like a conventional generation unit. The most economical option is the appropriate benchmark for firm renewable energy technologies, because it is the one that firm renewable energy technologies would displace;
- **Utility scale solar and wind technologies** are benchmarked against the average variable cost of the system operated by ANGLEC, because they are 'non-firm'—that is, they cannot be switched on at will. This means that there needs to be a conventional generator on standby that is used as 'firming' supply when the wind is not blowing. Every unit of energy (kWh) generated by wind technologies will

save fuel and variable O&M costs, but it will not save the fixed costs of capacity (because the firming technology capacity would also be needed); and

- **Distributed scale solar and wind technologies** are also non-firm (for purposes of this analysis, we consider solar water heaters non-firm because they store some, but not all energy in the form of heat). As for distributed scale wind and solar, the appropriate benchmark is the average variable cost of the system, but grossed up for system losses (12 percent) because distributed technologies generate energy consumed at (or very close to) customer premises, and therefore avoid these losses. In other words, distributed technologies are given some additional credit when benchmarked against conventional generation; and
- **Solar PV with a battery** shows an estimated cost for full backup, and should be assessed against the all-in cost of medium-speed units (for simplicity, the figure does not show this value grossed up for losses—the result would be a benchmark similar to that of other distributed scale solar technologies).

A comprehensive analysis could factor in the exact cost of generation displaced for different types of renewable technologies, in different locations and of varying capacity. But it would be of limited value given that the focus of our assignment is not that of a feasibility study, but guidance for policy and regulatory reform; also, our benchmarks for viability are heavily dependent on an uncertain fuel price, and can quickly change significantly. For policy purposes, it is enough to conclude that some technologies (such as solar water heaters, and wind at utility scale) are clearly viable, while others (such as solar PV) may be border-line viable, and will become clearly so if fuel costs rise or the costs of the technologies drop.

Summary assessment of all renewable energy technologies

Table 5.2 briefly describes all renewable energy technologies assessed, and shows their costs, key parameters, and breakeven oil prices at which the various technologies are viable.

As noted, breakeven prices of oil suggest that most technologies viable at US$4 per gallon oil would be viable also at lower oil prices (US$1-2.4 per gallon):

- Landfill gas to energy is viable with oil at US$0.70 per gallon; waste to energy with anaerobic digestion at US$1.05 per gallon;
- Commercial solar water heaters are viable with oil at US$1.01 per gallon, and small solar water heaters at US$1.73 per gallon; and
- Utility scale wind would be viable even if oil dropped at US$1.17 per gallon (for 'Class 1' turbines that are more resilient to hurricanes, or US$2.39 per gallon (for more expensive turbines that can be lowered or tilted to the ground in case of a hurricane).

However, solar PV (at current installed cost for this technology) would need oil prices between US$3.5 and US$3.9 per gallon to be viable, depending on whether it is installed at utility scale or distributed scale, respectively.

5.2.3 Conclusions about the viability of technologies for renewable energy

Table 5.3 summarizes our conclusions about the economic and commercial viability of renewable energy technologies in Anguilla.

Table 5.2: Summary of Potential Renewable Energy Technologies in Anguilla

Name	Description	Size of plant	Unit capital cost (US$/kW)	O&M costs (US$/kW/yr)	Lifetime (years)	Capacity factor (%)	LRMC (US$/kWh)	Viable with Diesel at US$4.00/gal?	Breakeven oil price (US$/gallon)
Landfill gas to energy (internal combustion)	Generation of electricity by combusting methane captured from a landfill	270kW	4,000	150	20	90%	0.08	Yes	0.70
Solar water heater (flat plate, commercial)	Commercial and industrial systems for heating water using solar thermal energy	70 kW	1,100	24	20	19%	0.09	Yes	1.01
Wind (850kW 'Class 1' turbines)	Wind turbines for electricity generation, designed to resist extreme gusts of 250km/hr and average wind of 36km/hr	3.4MW	1,800	50	20	35%	0.09	Yes	1.17
Waste to energy (Anaerobic Digester)	Generation of electricity by combusting municipal solid waste	100kW	5,000	150	20	85%	0.10	Yes	1.05
Solar water heater (flat plate, small)	Domestic systems for heating water using solar thermal energy	2kW	1,600	20	20	17%	0.13	Yes	1.73
Wind (275 kW lowerable or tiltable turbines)	Wind turbines for electricity generation that may be lowered or tilted in case of hurricanes	3MW	3,150	98.5	20	35%	0.16	Yes	2.39
Solar PV (monocrystalline, fixed, utility)	Polycrystalline solar photovoltaic panels with fixed mounting	2MW	3,100	60	20	23%	0.22	Yes	3.46
Solar PV (Polycrystalline, fixed, commercial)	Polycrystalline solar photovoltaic panels with fixed mounting	60kW	3,500	50	20	21%	0.24	Yes	3.36
Solar PV (thin film, fixed, small)	Thin film solar photovoltaic panels with fixed mounting	2kW	4,000	60	20	21%	0.28	Yes	3.91
Solar PV (thin film, small, with battery)	Thin film solar photovoltaic panels with fixed mounting	2kW	6,800	60	20	21%	0.45	No	6.53
Wind (10kW distributed scale turbines)	Domestic wind turbines for electricity generation	10kW	6,000	110	20	25%	0.35	No	5.04

Table 5.3: Conclusions about the Viability of Renewable Energy Technologies in Anguilla

Technology	Scale	Economic Viability with Diesel US$4.00/gal	Likely economic viability in near future	Commercial viability	Explanation
LFGTE (internal combustion)	Utility	✓	Unclear (resource availability to be determined)	Unclear (resource availability to be determined)	If there were sufficient waste stream available, of a sufficiently good quality, LFGTE could generate electricity for as low as US$0.08 per kWh compared to all-in costs of US$0.27 of Wartsilas. Actual costs will depend on waste composition and volumes. However, currently the waste stream is unlikely to be sufficient even for the smallest generator. Gradual development in smaller modules (smaller than 0.270MW) is possible, but would increase costs. Generation costs would be lower than for WTE, but a lower volume of waste would be eliminated.
Solar Water Heaters	Distributed	✓	✓	✓	Solar water heaters would clearly be economically and commercially viable for homes and businesses. They could be used instead of electricity at a much lower cost than the average system variable cost (US$0.13 and US$0.09, respectively as opposed to US$0.28 per kWh), saving money to consumers as well as the utility.
Wind	Utility	✓	✓	✓	Utility scale wind may represent an economically viable option to generate electricity in Anguilla—however, they would be more difficult to design, install, operate, and maintain compared to solar PV. Under an estimate of 35 percent capacity factor (which, given available data, may be conservative), turbines designed to withhold strong winds ('Class 1') could generate for as low as US$0.09 per kWh—which is far less than the average system variable cost of Anguilla of US$0.25. Lowerable or tiltable turbines are more expensive—with an LRMC of at least US$0.16, always assuming high capacity factors of 35 percent—but still viable. Land availability is limited, but off-shore installations may be an option provided that higher capacity factors are ascertained to compensate far higher installation costs. Precise resource assessments conducted over a sufficiently long period, however, would be needed for offshore wind capacity.

Technology	Scale	Economic Viability with Diesel US$4.00/gal	Likely economic viability in near future	Commercial viability	Explanation
Waste to Energy (Anaerobic Digester)	Utility	✓	Unclear (resource availability to be determined)	Unclear (resource availability to be determined)	As above, provided that there be enough primary resource, an anaerobic digester could generate electricity for as low as US$0.10 per kWh compared to all-in costs of US$0.27 of Wartsilas—however, capital costs may be even higher, up to US$8,000 per kW instead of the more optimistic assumption we used (in that case, the LRMC would be US$0.16 per kWh). Actual costs will depend on waste composition and volumes. Smaller volumes are likely to be required compared to those required for landfill gas to energy.
Solar PV	Utility and Distributed	✓	✓	✓	At oil prices of US$4.00 per gallon small, commercial, and utility scale PV technologies are economically and commercially viable in Anguilla, and represent the most immediate option for renewable electricity generation in Anguilla; design, installation, and O&M are relatively easy, especially when compared to wind and waste options. Residential and commercial scale with LRMCs of US$0.28 and US$0.24 per kWh is below or equal to the system cost grossed up for losses of US$0.28 per kWh, and lower than the tariff. Utility scale installations are also viable, provided there is enough land. The LRMC of US$0.22 is lower than the average system cost of US$0.25.
Solar PV with battery	Distributed	x	x	✓	With high electricity tariffs, even solar PV with batteries (which for full backup increase cost by up to US$2,800 per kW) may save on bills. However, utility services for backup and standby and connection to the grid are likely to be more cost-effective solutions compared to systems with batteries large enough to provide full backup to a consumer, at least until batteries significantly improve in performance and reduce in cost.
Wind	Distributed	x	x	✓	The capital costs of wind turbine technology, although decreasing in recent years, is still too expensive to make it economically viable in the Anguilla on a commercial or small scale.

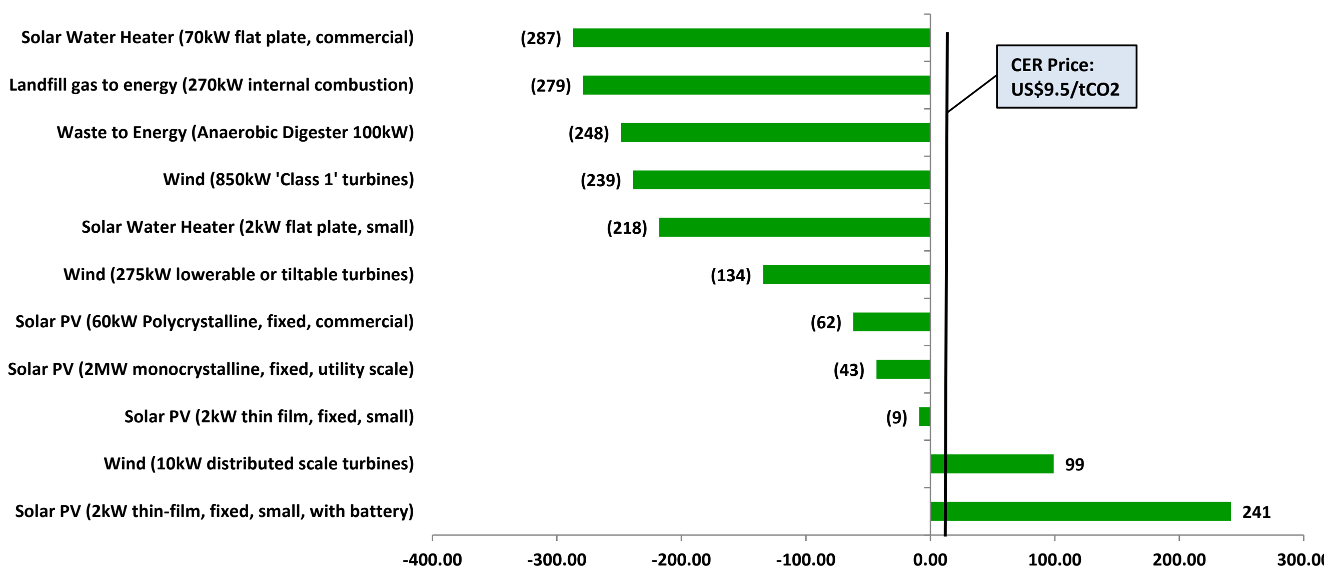
5.3 Assessing the cost of additional CO_2 abatement

If the Government wishes to reduce carbon dioxide (CO_2), it should do so by supporting economically viable technologies only—this would allow it to reduce CO_2 while also saving money for the country. Reducing CO_2 by supporting non-economically viable technologies would carry an additional cost, as illustrated in Figure 5.2 for renewable energy technologies.

The figure shows that after the renewable energy technologies that are economically viable—with a negative cost of abatement—are exhausted, the cost of reducing one additional ton of CO_2 begins at around US$99 for small scale distributed wind. There are no technologies that cost less than the current price for Certified Emissions Reductions (CERs)—about US$9.50. Small scale solar PV with full battery backup has a marginal abatement cost of US$241 per tCO_2.

Importantly, this means that if the UK Government or any another donor were interested in reducing CO_2 emissions by supporting projects in Anguilla, it should only support renewable energy projects that are win-win solutions (those that have a negative abatement cost). There are no technologies that have a positive abatement cost that is less than the market cost for one ton of carbon dioxide that are not already justified because they cost less than conventional generation.

Figure 5.2: CO_2 Abatement Cost Curve for Renewable Energy Technologies (US$/$tCO_2$)



Explanation: This Marginal Carbon Abatement Cost Curve shows what cost the various renewable energy technologies require to avoid 1 ton of CO_2. Technologies that are economically viable (most of them, as shown in Figure 5-1) do that with a negative cost—that is, they avoid emitting CO_2 while also saving money. Just two technologies require spending extra money to avoid emitting CO_2—but instead of doing those two technologies, if one wanted to avoid emitting CO_2 he or she could buy an emission reduction on the market (at a price of about US$9.5 per ton of CO_2

Source: CER price for Carbon from Carbonex on April 15, 2012

Appendix I explains the calculation of marginal carbon abatement.

6 Barriers to Renewable Energy

Having identified which renewable energy technologies may make economic sense, we now assess the barriers that are blocking them. We define 'barrier' as something that prevents an economically viable renewable energy project from happening. For this, we only focus on solar, wind, and waste-based renewable energy technologies identified as viable in the previous section (as noted, we include waste in spite of an uncertain availability of the primary energy resource, since smaller sized units might be viable in the medium-long term).

One way to understand barriers is to think of them as the lack of critical success factors that allow viable renewables to happen. Critical factors for the successful development of any renewable energy project are summarized in the table below, divided into three categories (commercial, legal and regulatory, and other)

Table 6.1: Critical Factors for the Successful Development of Renewable Energy

Commercial	Commercial viability	Utility scale renewables must be able to generate electricity at a competitive cost (US$ per kWh) Distributed scale renewables must be able to generate at a cost that saves money on a customer's bill
Legal and regulatory	Right to use the primary renewable energy resource	The legal and regulatory framework should ensure that there are clear processes for establishing the right to use a resource. Primary renewable energy resources that are available in Anguilla usually have clear property rights (anybody who owns land should be allowed to harness the solar and wind energy on their property; and anybody who owns solid waste should have the right to use it to generate electricity); other types of primary renewable energy resources not available in Anguilla, such as water or geothermal energy, pose greater problems
	Right to access and develop the site where the renewable energy project is to be set up and operated	The legal and regulatory framework should ensure there is a clear process for developing on Government land and for acquiring private land, including a process for the compulsory acquisition of land and the granting of easements
	Ability to sell electricity generated	The legal and regulatory framework should ensure that a developer can sell their electricity at a profitable price. Different rules are needed for distributed scale generation (for which, to reduce transaction costs from many small projects, a standardized authorization and price is best), and utility scale generation (for which there may be individual authorizations and a customized price, case-by-case)
	Adequate regulatory framework for electricity	There needs to be a complete body of rules that ensure good quality of service at a reasonable cost; as well as some regulatory body with the power and ability to effectively administer and enforce those rules
Other	Financing	Sufficient funding should be available at terms that correctly reflect project risk
	Equipment availability	Sufficient availability of good quality equipment at competitive prices
	Institutional capabilities	Institutions involved in the sector should have adequate financial and human resources, and adequate skills in the renewable energy field
	Technical skills	Expertise in assessing, installing, operating & maintaining, and inspecting projects
	Information and awareness	Knowledge about costs, benefits, and functioning of renewable energy projects

Based on our assessment of the existence of these critical success factors in Anguilla, Table 6.2 summarizes our analysis of barriers for utility scale and distributed scale renewable energy technologies in Anguilla. The sections below explain our assessment in detail (as a reminder, the focus of our assignment is on legal and regulatory barriers; we assess other barriers to the extent possible).

Table 6.2: Barriers to Economically Viable Renewable Energy Technologies

	Utility Scale Renewables	Distributed Scale Renewables
Commercial barrier		
Lack of commercial viability	**0** (all commercially viable)	**0** (all commercially viable)
Legal and regulatory barriers		
Lack of clear rights to use a resource	**0** (no unclear property rights for solar, wind, and waste energy)	**0** (no unclear property rights for solar, wind, and waste energy)
Lack of right to access and develop a site	**0** (clear rights in place in the rules—although flaws and social norms affect the efficiency and effectiveness of these rules)	**1** (clear rights—but often buildings are such that solar water heaters are impossible or too costly to install)
Inability to sell electricity generated	**1** (IPPs can operate under ANGLEC's licence; DBOM contracts are possible; but no own licence is possible for IPPs)	**3** (customers cannot connect their systems or sell their excess electricity to the grid)
Economic regulatory distortions	**3** (no obligation to operate on least cost basis; limited rate review process; uncertain cost recovery, unlike for fossil fuels)	**3** (tariff structure is disincentive to allow sale of excess electricity generated from customer-owned distributed systems)
Other barriers		
Limited financing	**0** (no significant financing barrier for larger actors)	**2** (high upfront cost and general limited access to credit)
Limited availability of equipment	**0** (no particular barrier)	**2** (equipment mostly available, but not competitively priced)
Limited institutional capabilities	**1** (limited capabilities, but can be overcome or contracted out)	**2** (limited capabilities, but can be overcome or contracted out; limited capacity for electrical inspection)
Limited technical skills	**1** (limited expertise, but can be contracted or acquired quickly)	**2** (limited expertise, with some exceptions)
Limited information and awareness	**2** (limited information on wind and waste for power generation)	**2** (limited awareness about solar PV and water heating)

Notes: 0 = not a barrier; 1 = low barrier; 2 = medium barrier; 3 = high barrier; NA = Not Applicable. DBOM = Design, Build, Operate, and Maintain; IPP = Independent Power Producer

6.1 Commercial Barrier—Lack of Commercial Viability

If any economically viable renewable energy project is not happening in Anguilla, it is certainly not for lack of commercial viability:

- Utility scale solar PV and wind projects could generate at less than the variable cost of generation, and waste-based projects (if technically feasible) could generate at less than the all-in cost of medium speed diesel plants. There is enough margin to accommodate cost savings and profits for developers; and
- Distributed scale technologies could generate electricity at less than the tariff (solar PV), or (in the case of solar water heaters) heat water at a lower cost than that required for electricity generated by the utility. There are enough savings on the electricity bill to make these systems very attractive to customers who implement them. If anything, tariffs provide an excess of incentives for distributed scale technologies, since also non-economically viable options can be commercially viable (such as small wind).

That there should not be any commercial barrier seems like a foregone conclusion, but it helps focus attention on what is in fact important. The reason why renewables are not happening is not that they do not allow making or saving money, so the reasons must be others—as we explore below. It also has important policy implications: policy measures that further enhance the commercial viability of distributed scale technologies (such as duty exemptions) are well intended, and may be very visible and well perceived by the public—but limited financial resources could be employed otherwise to tackle actual barriers.

6.2 Legal and Regulatory Barriers

For economically viable renewable energy projects to happen, persons or entities interested in developing them need to ensure three basic things:

- The right to use an energy resource (6.2.1);
- The right to access and develop a site (6.2.2); and
- The ability to sell electricity generated (6.2.3).

The right regulatory framework for electricity also needs to be in place (6.2.4).

6.2.1 The right to use an energy resource—no barriers

Developers of renewable energy need to secure the right to use any particular renewable energy resource. Each resource has different physical characteristics and economic constraints. Also, some resources are adequate for own use, while others allow selling electricity to the grid or other third parties.

Harnessing solar and wind generation does not require any special licensing. Anybody who owns land is allowed to harness the solar and wind energy on their property. Also, whoever owns biomass or solid waste has the right to use it.

Using solar, wind, and waste *to produce electricity* is regulated, and Anguilla's laws provide a legal framework that controls the right to use these resources to produce electricity through a licensing regime. This regime has already allocated the legal right to produce electricity at both the utility scale and the distributed scale. In particular, ANGLEC is authorized by a public supplier's licence to use any type of electric plant—including a solar, wind, or waste-based plant—to supply electricity to the public. At the distributed scale, anyone can use a solar or wind system to generate electricity for their own consumption without the need for a licence under the Electricity Act, E035. Only a public supplier can use waste to generate electricity—however, waste is so little in Anguilla that, if anything makes sense, it would be a very small plant that uses all and any waste available; therefore, there is no actual barrier to the right of using waste for electricity generation.

6.2.2 The right to access and develop a site—no barriers for utility scale renewables, but solar water heaters face a problem

Anguilla's laws are complete with regard to accessing and developing a site for utility scale renewables. Laws provide clear rules for obtaining land (including easements for access to it) to locate energy plants, obtaining the right to develop the land, and obtaining the necessary rights over land in the possession of others for electric poles and other apparatus.

Under the Registered Lands Act, R30 the following rights can be obtained by private treaty for wind power, solar power or waste-based renewable energy projects: absolute title to land, leasehold interests in land, and easements for access to the land in which these interests are held. In addition, contractual licences, if desired, can be obtained for solar systems, and *profit-à-prendre* can be obtained for waste-based projects.

Under the Electricity Act, E035 and the Land Acquisition Act, L010 absolute ownership of land and easements over neighbouring land existing for the benefit of the land can be compulsorily acquired by the Government and transferred to a renewable energy developer. Further, the Registered Land Act, R30 declares that all land in Anguilla is held subject to the Government's right of compulsory acquisition.

Obtaining the right to develop land to establish a renewable energy plant is provided for under the Land Development (Control) Act, L015. The relevant authorities have powers and discretion that are broad enough to grant the necessary approvals after considering issues of environmental sustainability and other matters.

As to the statutory rights, ANGLEC has statutory rights to place its poles and other apparatus on any land under the Electricity Act, E035.

The only significant barrier is at distributed scale, for solar water heaters. Viable technologies may not happen when agents who should make the decision to invest in them (paying for their purchase) are not the same people who would use them (paying for their operation). This mismatch between capital and operating expenditure decisions is known as an 'agency problem', and its effect for the purposes of our analysis is to neutralize incentives for solar water heaters—in the development of new construction (residential or non-residential) there may be a perverse incentive for both the developer and the buyer to keep capital costs down, and disregard the possibility to install water heating. Or, a buyer may want to install one, but be unable to because the building cannot accommodate one (or require a very high cost for doing so). Building codes specifying requirements for material, equipment, and design can make it compulsory to comply—but Anguilla's Building Code is still in draft form.

Although the rules are (with the exception of solar water heaters) complete, there are additional legal flaws and social norms that affect the efficiency and effectiveness of these rules:

- ***Acquisition of land rights for locating utility scale renewable energy plant is complex***—most land is privately owned, ownership is fragmented, and there is no land use zoning that enables renewable energy plants to be given priority in any area. Enforcement of compulsory land acquisition rules has been frustrated in the past by political considerations and opposition from private interests despite the legal rules giving the Government clear compulsory powers and clearly imposing restrictions on legal title;

- ***The development process is inefficient being allocated to different Ministries***—planning approval, handled under the Land Development (Control) Act by the Ministry responsible for lands and planning, is separate from building monitoring and enforcement in accordance with a draft Building Code administered by the Ministry of Works. The streamlined approach proposed under the Physical Planning Bill is designed to address this issue;
- ***Enforcement of building rules is difficult***—as noted, the Building Code is still in draft form. The proper functioning of the enforcement process through the use of stop orders is affected by political considerations;
- ***Planning powers and discretion, though ample, are vague***—the broad discretion in the rules enable the Land Development Committee to do what they consider necessary in reviewing development applications. The downside is that the rules do not give sufficient guidance to ensure that relevant matters (like environmental sustainability) are taken into consideration, and the criteria with which environmental sustainability is to be assessed. Obtaining setbacks for a wind project would be difficult, because there is no utility corridor or setback rules. Further, a potential developer is not sufficiently informed about what is expected of it to obtain approval. More detailed rules such as those in the draft Physical Planning Bill and the Environmental Protection Bill would be an improvement on the existing rules;
- ***Enforcement of planning powers is difficult***—the adoption of special development areas, a streamlined planning and development process, and the detailed rules concerning environmental sustainability assessment in the Physical Planning Act are hindered by political and social norms that give precedence to private interests in a manner that conflicts with the legal restrictions on a landowner's rights as spelt out in the Registered Lands Act, R30; and
- ***Enforcement of statutory rights of the public supplier is difficult***—cultural norms dictating that the placement of electricity supply apparatus be placed along public roads have, for all intents and purposes, displaced the statutory norms under which the utility can place apparatus on any land. There is no extensive public road network in Anguilla, and the prevalence of private land ownership again may negatively impact the establishment of roads adequate for locating electrical apparatus.

6.2.3 The ability to sell electricity generated—minor barrier for utility scale renewables, significant barrier for distributed scale renewables

Of the two types of licences that are possible under Anguilla's framework, only one—the public supplier's licence—gives authorization to sell electricity. Private suppliers must only produce for their own consumption. This means that:

- ***At utility scale, options to sell renewable electricity exist, but are somewhat limited***—ANGLEC's licence enables IPPs to enter the sector through the assignment rights given in clause 11—operating under ANGLEC's own licence. Specialized contractors can also enter the sector under a design, build, operate, and maintain (DBOM) contract with ANGLEC. However, ANGLEC's licence is exclusive and covers the whole of Anguilla, and the Electricity Act, E035 does not have any mechanism for an IPP to obtain its own licence to generate electricity to supply to ANGLEC. There is also no adequate framework of rules governing the terms of power purchase agreements to allow the effective participation of third party generators without imposing unnecessary restrictions. The current arrangements have the advantage of ensuring that IPP participation is possible in the near term without any legal or regulatory reform setting up a new licensing regime; it also has the advantage of ensuring that IPP participation is compatible with ANGLEC's interests. The downside is that may limit Anguilla's options for renewable energy integration for plant that ANGLEC may be unwilling or unable to develop; and

- ***At distributed scale, customers cannot interconnect their systems, or sell excess electricity to ANGLEC***—current laws allow customers who own small scale renewable energy systems to benefit from the reduction in their electric bills, since they can generate for own consumption with solar and wind energy without a licence. However, the exemption from needing a licence does not cover the case of selling excess electricity to the public supplier, and the framework includes no rule to authorize them to do so. There are also no grid code or rules that make it easy and safe for customers to interconnect while preserving reliability and power quality (for which the utility, as grid operator, is responsible). Therefore, customers are prevented from capturing the value of any excess generation—which would be valuable to them individually as well as to Anguilla as a whole, in the case of solar PV that can generate at an economically viable cost and save money to the country. This means that if a householder or business does not require the full capacity of a small renewable generation unit, it has no way of fully using that capacity, so investing in the system becomes more costly.

6.2.4 Existence of adequate regulatory framework for electricity—significant barriers at both utility and distributed scale

In addition to the three basic needs for developers of renewable energy systems to be able to access the resource, access and develop the site, and sell their generation, an adequate regulatory framework for electricity needs to be in place. This means the existence of an adequate body of rules that ensure good quality of service at reasonable price; and of someone with the power and ability to effectively administer and enforce those rules. Specifically for renewable energy:

- ***For utility scale renewable energy***, an adequate regulatory framework would ensure that renewables are treated on a par with conventional generation options when planning and developing generation capacity, and enable the utility to recover efficiently incurred costs through tariffs; and

- ***For distributed scale renewable energy***, an adequate tariff structure would not jeopardize the utility's financial viability as an increased number of its customers generate with their own small renewable energy systems, and would allow the utility to be remunerated for services it offers to customers (and for which it incurs costs).

As explained in detail in Appendix E, Anguilla's regulatory framework is rudimentary—rules are limited, as are arrangements and institutional capacity to administer them. The public supplier's service standards (section E.2) and criteria for tariff adjustments are broad (section E.3). The regulatory function of monitoring and enforcement of licence conditions is equally broad, and fragmented (section E.1).

The existing framework does not act as a barrier to integrating renewable energy per se. However, it does contain some economic regulatory distortions that prevent Anguilla from doing that integration well, because ANGLEC is not given the correct economic incentives to integrate renewable energy:

- ***ANGLEC has no obligation to operate on a least cost basis***—ANGLEC is able to recover all of its costs once it shows that they are reasonable. It is not required to show that they are based on least cost planning—in particular, that its choice of generation investment is likely to lead to the lowest cost power for the country. This means that ANGLEC is not required to consider renewable technologies (including those that may be developed by third parties, large and small), and to adopt them if they offer lower cost power to conventional generation. This does not mean that ANGLEC has not considered renewable energy—in fact, it has, including those from third parties (as noted in section 3.2). The flaw is in the regulatory framework, not in the actual management of utility operations;
- ***There is no requirement for periodic reviews of the tariff, and no detailed rules on the application process***—Rate reviews adjustments must be initiated by ANGLEC, and there is no requirement as to the frequency with which this must be done. The last rate review was requested almost two decades ago. The rate review principles do not comprehensively detail the information required or the form in which it should be submitted. The resulting process is subjective, and uses outdated approaches to presenting and assessing financial information;
- ***The design of the fuel surcharge provides a disincentive to ANGLEC to use renewable technologies***—ANGLEC may be able to lower the total cost of power generation by using renewables, but still be unable to recover all of that lower cost. With conventional generation, ANGLEC is more certain to recover the full cost of generation. With renewable generation, ANGLEC trades a variable cost (fuel) with a capital cost (much higher for renewables), but there is no equivalent tariff mechanism to recover that capital cost. This is not to argue against a fuel surcharge mechanism, which is needed to avoid the utility's bankruptcy, but simply to point out that the situation reduces incentives for the use of renewables, even when they are lower cost; and
- ***The tariff structure is a disincentive to allowing sale of excess electricity from customer-owned distributed systems***—Anguilla's tariff structure bundles all services provided by ANGLEC into one base rate, which is adjusted with the fuel surcharge. Although many customers may not realize, they receive more than one service from ANGLEC: (i) the sale of electricity (kWh), which requires high variable cost of generation (in most part fuel); (ii) provision of backup and standby capacity, which requires fixed capital and O&M costs; and (iii) connection to the distribution grid, which also requires fixed costs. Under the

current tariff structure, if ANGLEC sells less kilowatt hours because more and more customers generate with their own systems while keeping their utility interconnection, ANGLEC is unable to recover the costs of services (ii) and (iii), because their recovery is bundled together with the service of providing kilowatt hours (i). This means that connected customers keep on enjoying services that ANGLEC provides, and incurs costs for, without paying for them.

Most of the limitations above cannot be solved in the near term, or simply with the drafting of new rules—because even in that case, since the rules require expertise that is costly and not currently available in the Government, there would be financial and technical constraints for the Government to perform the regulatory function by being responsible for administering these new rules. Also, the best way to solve them is not necessarily to create a complex and sophisticated regulatory system specifically for Anguilla as larger countries have—this would entail high costs that would not be justified by the limited amount of regulatory activity. Finally, some of the limitations (such as the lack of a well-established process for rate reviews) go beyond renewable energy integration per se, and involve broader power sector reform.

6.3 Other barriers

There are other reasons that help explain why viable renewable energy projects may not be happening, and that relate to: financing (6.3.1), institutional capabilities (6.3.1), limited skills and information (0), and availability of equipment (6.3.2).

6.3.1 Financing—a barrier for viable distributed scale renewables

According to several stakeholders we met during our assignment, access to credit is a general problem for many households and businesses in Anguilla, particularly in the current economic situation—financing does not seem like a barrier specific to renewable energy. Interest rates are as low as 9 percent—but only for creditworthy entities. In particular, entities in the business of utility scale projects certainly do not face constraints that households and smaller businesses do.

The upfront cost of distributed renewable technologies is high. Many households in Anguilla have limited access to credit, so that expensive equipment is unaffordable for them, even if the equipment would pay for itself overtime. Access to credit is made worse by the fact that the technologies are new and unfamiliar, so banks are unwilling to lend against them, and equipment suppliers have not yet developed hire purchase schemes or other consumer finance arrangements for them—the most likely way to obtain a loan is as part of a larger development project.

6.3.2 Limited availability of equipment—a barrier for viable distributed scale renewables

Distributed renewable energy equipment is available, but it is relatively expensive since it has to be imported (for example, solar water heaters that are being imported from Barbados, St. Lucia, and even Australia), and Anguilla's small size limits bulk purchases. This is a chicken and egg problem: given limited uptake of solar technologies in Anguilla, they can be harder to purchase on the island, or are sold only at uncompetitive prices. In turn, limited availability and high costs slow down uptake.

6.3.3 Institutional capabilities—minor barriers, but limited electrical inspection capacity

MICUH, AREO, and ANGLEC are the three main institutions with a key role for renewable energy development in Anguilla. To do so, they need: availability of adequate financial resources; availability of adequate human resources; and adequate skills and experience in renewable energy.

Table 6.3 below summarizes our assessment for MICUH, AREO, and ANGLEC based on these three aspects. The assessment focused on what is related to renewables, and considers the functions that each institution should be able to carry out on a continuous basis.

Table 6.3: Assessment of Institutional Capabilities

	MICUH	AREO	ANGLEC
Availability of financial resources	Low—budget constrained, limited resources and options for renewable studies or activities	Medium—budget for renewable energy activities, dependent on donor funding with limited duration	Medium—financially viable, but constrained for new investments
Availability of human resources	Medium—structure and management in place, although only one full time staff member working on public utilities	Medium—structure and management in place; one full time staff member; administrative and public relations support available	High—adequate quantity of qualified management and staff
Skills and experience in renewable energy	Medium—adequate familiarity and experience although no formal training	Medium—adequate familiarity and experience although no formal training	Medium—no internal capability to inspect distributed renewable systems or operate and maintain utility scale plant, but could acquire relatively quickly

In addition, the Government's **Electrical Inspector's Office** plays a critical role for inspecting renewable energy installations, and enforcing safety and operating standards that they must meet.

MICUH

MICUH has limited financial resources and options available to fund renewable energy activities for Anguilla, but has overall adequate human resources and skills regarding renewable energy:

- ***Availability of financial resources***—MICUH is funded by the Government's general budget, which the UK Government stresses should be balanced. In 2010, the Government was able to balance its budget given revenues obtained through the development of a new resort in Anguilla; fuel taxes are also an important source of revenue (Government gets 40 to 50 EC cents per IG in tax revenue on 80 percent of the diesel consumed by ANGLEC). Since 2011, the Government's budget is tighter, and MICUH has very limited funds for studies on renewable energy or electricity sector reform. As pointed out by AREO, Anguilla's options to obtain funding for renewable energy activities are limited. Anguilla is not eligible for funding by entities such as the World Bank, the Inter-American Development Bank, or the Organization of American States. Anguilla can access funding from the Caribbean Community (CARICOM) and the Caribbean Development Bank, but only for investment stage activities; securing pre-feasibility funding has been difficult. The funds that are secured often have to go through the public sector, but the public sector has little time to search for or apply to these funds;

- ***Availability of human resources***—MICUH's energy department comprises the Permanent Secretary; one full time officer, the Director of Public Utilities and Telecommunications; and a Chief Engineer responsible for all infrastructure, who provides support to the Energy Department. Regulatory capabilities are limited, but that is consistent with a limited set of rules to administer, and a limited number of occasions when they could be administered anyway in a small system—outsourcing would be a better option. Functioning is efficient in spite of small size; and
- ***Skills and experience in renewable energy***—MICUH's staff is familiar with the main concepts, technologies, barriers and opportunities regarding renewables in Anguilla. Most have self-trained on the topic of renewable energy (attending several workshops and conferences, doing research and taking online courses, and discussing with experts), building on solid academic credentials.

AREO

AREO has been effective in securing financial resources in spite of limited options, and has overall adequate human resources and skills regarding renewable energy:

- ***Availability of financial resources***—AREO is funded by grant resources. The Anguilla National Trust (a registered non-profit organization) channels the grant money to AREO. In 2008, AREO received its first two and a half years of funding from the Overseas Territories Environmental Programme (OTEP). Currently, AREO is being funded by CDKN with DFID resources, and has developed an effective connection with them. Since the grants are typically for short periods, AREO needs to periodically identify and apply for different grants. When AREO cannot access to grant resources, it becomes a volunteer organization. AREO faces the same limitations of MICUH in terms of options for securing funding for Anguilla;
- ***Availability of human resources***—AREO consists of one full time member, who is responsible for management and implementation of all of its activities. The Anguilla National Trust provides administrative support. One public relations specialist also supports AREO. AREO reports on its progress and results to the different donor organization that fund it. Functioning is efficient in spite of small size; and
- ***Skills and experience in renewable energy***—AREO's full time staff member has no formal educational training in renewable energy, but has developed sound skills and understanding on the job during the past five years and built a broad international network in the renewable energy sector through conferencing,

research, and public outreach activities. As a result, AREO can also serve as an information clearinghouse and facilitator between private companies interested in renewable energy, international technical assistance and funding organizations, and the Government.

ANGLEC

ANGLEC is a financially viable company, has adequate human resources, and has a good basis upon which build skills for renewable energy:

- ***Availability of financial resources***—ANGLEC is a commercially viable company, thanks to direct fuel cost-pass through and despite very infrequent adjustment of base rates. However, ANGLEC is not a cash-rich utility. ANGLEC management states that the company has been able to finance new required investments by paying out lower returns and no large dividends to shareholders, improving the efficiency of its plants, and increases in sales. Lack of base rate reviews constrains the ability to make new investments, particularly highly capital-intensive ones in renewable energy. ANGLEC management states that the company aims to operate as a private entity, but a socially responsible one—even limiting increases in the fuel surcharge, absorbing part of that cost (as a result, actual tariffs—although high—are lower than what they could be according to the law). ANGLEC's cash position is constrained due to an expansion in capacity to meet increased demand prior to the global economic crisis, and is now gradually recovering in spite of lower than usual collection rates and customer disconnections (some of which have been reintegrated—see footnote 2 on page 4);

- ***Availability of human resources***—ANGLEC has adequate human resources. It has about seventy staff, divided into Administration, Transmission and Distribution (T&D), and Generation areas. Management comprises eight people. The Administration area comprises the General Manager, the Chief Financial Officer, the Human Resource Manager, Accountant, and the IT Manger. The Generation area comprises the Systems Control Engineer, the Generation Superintendent, and the Maintenance, Operations, and Electrical Supervisors. The T&D area comprises the Network Operations Engineer, the T&D Superintendent, the Technical Services Engineer, the Customer Service Engineer, and three supervisors. Decisions go through the management team, which tables them with the Board, which in turn adopts them; and

- ***Skills and experience in renewable energy***—ANGLEC has no formal renewable energy expertise, but can pick up distributed scale projects quickly thanks to its general qualifications. For example, it hired a contractor to install the hospital's system, but is now operating and maintaining it. For general technical assistance, ANGLEC states that it would rely on the Caribbean Electric Utility Service Corporation (CARILEC) or PV Power in the UK. For utility scale renewable energy plants, ANGLEC envisions either contracting a specialized company to Design, Build, Operate, and Maintain (DBOM), design and build with just a few days' training, or buying from an IPP. The O&M component of a DBOM contract could also be limited in time for simpler plant such as solar PV, and be handed off to ANGLEC after a few months or less; any waste-based technology may require a longer time.

Electrical Inspector's Office

The Government's Electrical Inspector office, which is part of the Planning Department, does not have the expertise or resources to inspect distributed renewable energy systems on buildings to make sure they comply with reliability and safety technical requirements—in particular, it could not handle inspecting an increased amount of renewable systems, or enforcing a new set of safety and operating standards for renewables.

6.3.4 Technical skills—minor barriers

There are a few qualified installers of distributed renewable energy systems, but no certification to inform people about who they are. Most retailers of renewable energy systems do not have the capability to install them. Several solar water heating systems were poorly installed in the past, causing malfunctioning and slowing down uptake of this very cost-effective technology.

The Building Code is in draft form. Prepared in 1994, it provides insufficient guidance for proper installation of renewable energy systems—and no mandatory predisposition for installation of viable equipment such as solar water heaters.

At utility scale, most skills can be contracted given the limited amount of transactions, and transferred to ANGLEC.

6.3.5 Information and awareness—barriers for solar, wind, and waste energy

There is limited information about the actual technical, economic, and financial viability of renewable energy options in Anguilla. For solar PV, limited information is not a problem given Anguilla's situation in the Caribbean—but wind and waste need more site-specific assessments. ANEC has proposed preliminary plans for 'Zero Energy' Development Zone in Corito that could include wind, solar, and waste-based energy installations. A wind data analysis by Mistaya Engineering Inc. for Green Island Power, LLC provides some resource data on Corito, and the East part of the island, suggesting high capacity factors. Information on waste volumes and weight is regularly collected (including a breakdown by origin), but no specific information on the waste's composition to allow assessing the viability of specific technologies.

There is also limited awareness regarding the installation, importation, and benefits of renewable energy systems in Anguilla. As noted, customers are little aware of costs and benefits of solar water heaters, and arguably even less of more complex systems such as solar PV. Many customers are not aware of the duty free concession for importing solar water heaters that has existed for the last twenty years, or that for other renewable energy equipment as recommended in the National Energy Strategy and as upheld in practice for the past few years. (Also, consumers must apply for duty free concessions on a case by case basis using a long procedure.) There are no training programs at the community college level to increase awareness or capacity on renewables, nor any technical schools or city and guilds vocational programs in Anguilla.

7 Recommendations to Integrate Renewable Energy

Anguilla can use renewables for saving on fuel costs for power generation—and it should do so as soon as possible, given the energy crisis that its households and businesses face. Table 7.1 summarizes our recommendations.

Table 7.1: Recommendations for Integrating Renewable Energy Technologies

	Utility Scale Renewables	Distributed Scale Renewables
Commercial barrier		
Lack of comm. viability	**No barrier**—no measure	**No barrier**—no measure
Legal and regulatory barriers		
Lack of clear rights to use a resource	**No barrier**—no measure	**No barrier**—no measure
Lack of right to access and develop a site	**No barrier**—no measure	**Now**—mandate solar water heaters for new buildings in draft Building Code
Inability to sell electricity generated	**Now**—adopt ANGLEC corporate rules to directly develop, procure under DBOM, or contract IPPs under ANGLEC's licence; publish request for EOIs for the solar PV tender, and include O&M in RFP **Later**—consider creating autonomous licensing regime for IPPs	**Now**—adopt ANGLEC corporate rules to create SOC; amend Electricity Act by extending licence exemption to the sale of excess renewable electricity to public supplier; issue a pilot SOC with a limited cap and with a pilot disaggregated tariff
Economic regulatory distortions	**Later**—commission COSS; amend Electricity (Rates and Charges) Regulations with disaggregated tariff structure; determine best option for regulator to administer rules	
	Later—amend ANGLEC's licence and Electricity Supply Regulations adding cost recovery principles	**Later**—issue a revised SOC with a revised cap
Other barriers		
Limited financing	**No barrier**—no measure	Use this report to secure low-cost financing, guarantees, and grants for solar projects (water heating, PV); set up consumer financing initiative
Limited availability of equipment	**No barrier**—no measure	
Limited institutional capabilities	Secure funding for further activities, such as a cost of service study or broader power sector reform	Secure funding for further activities; strengthen capacity of Electrical Inspector's Office to deal with SOC
Limited technical skills	Include O&M when procuring a specialized contractor	Check electric wireman's licence and plumbers' licence
Limited information and awareness	Assess quantity and quality of wind and waste resources	Consider adopting external certification for solar installers (water heating, PV)

Notes: DBOM = Design, Build, Operate, and Maintain; O&M = Operations and Maintenance; IPP = Independent Power Producer; COSS = Cost of Service Study; RFP = Request for Proposals; EOI = Expression of Interest; SOC = Standard Offer Contract

The table shows recommendations that should be followed **now**, and others that may be followed **later**—but as soon as possible.

Where no barrier exists, we recommend no measure (cells shaded in lighter grey in the table):

- All economically viable technologies (both at utility, and at distributed scale) are also commercially viable, so nothing additional should be done to increase their commercial viability. In particular, this means that technologies that are already commercially viable do not need to be subsidized. Current duty exemptions might be left as they are if desired; however, they should not be increased, because it would not be economically justified—lost revenue from exempted duties could be better used to solve actual barriers, such as limited access to financing;
- There are no barriers to the right of using solar, wind, and waste resources for generating electricity, so nothing more is needed;
- There is nothing in the rules that blocks the right to access and develop a site for utility scale renewable energy generation. New procedures in the Physical Planning Bill and new details provided in the Environmental Protection Bill may improve the current situation, streamlining the process and guiding the authorities' broad discretion under existing rules; and
- There are no particular barriers to financing utility scale renewable energy, or obtaining the equipment at a reasonable cost. The flexibility in the existing licensing regime that allows ANGLEC to contract an IPP under its public supplier's licence may help let others finance renewable energy projects, if needed.

In the remainder of this section, we recommend how to solve actual barriers identified:

- We start by recommending **measures that should be taken now** for realizing Anguilla's immediate renewable energy potential, with the strictly necessary changes and additions to the existing rules (7.1);
- Then, we recommend **further legal and regulatory measures than may be taken later**—but still as soon as possible (7.2); and
- Finally, we recommend **other measures to solve barriers not related to the legal and regulatory framework** (7.3).

7.1 Measures for Realizing Anguilla's Immediate Renewable Energy Potential

Anguilla can and should take immediate steps to develop renewable energy—in particular at utility scale, which represents the most cost-effective option; but also at distributed scale.

For both utility and distributed scale projects, we recommend that ANGLEC adopt corporate rules to develop, procure, or contract renewable energy and renewable energy capacity (7.1.1).

For utility scale renewables, ANGLEC should:

- Issue a request for expressions of interest for the solar PV plant it intends to procure (7.1.2); and
- Add a brief period of operations and maintenance (O&M) in the draft Request for Proposals solar PV (7.1.3).

For distributed scale renewables:

- The Government should amend the Electricity Act to extend the exemption from a licence to also cover the sale of excess electricity to a public supplier (7.1.4);
- ANGLEC should develop a pilot Standard Offer Contract (SOC) with a pilot disaggregated tariff (7.1.5); and
- The Government should mandate solar water heating for new facilities (7.1.6).

7.1.1 Utility and distributed scale renewables: ANGLEC to adopt corporate rules

The Government wants renewables to reduce electricity costs in the long term, and to contribute as much as possible to satisfying current and projected demand. Utility scale solar PV represents the most immediate opportunity for doing both things—and since the Government is the majority shareholder of ANGLEC, and controls ANGLEC's Board of Directors, it can achieve its own goals by making sure that ANGLEC develops a solar PV plant (and any other renewables) in the best possible way. Distributed scale solar PV can also make its contribution. Customers who supply excess electricity at an economically viable cost with solar PV should be compensated for the higher fossil fuel costs that they offset.

This solution should not disappoint those who wish that an independent regulator force ANGLEC to do something—an independent regulator is a tool for a Government to ensure good quality of a public service at a reasonable cost in the interest of the country, when the Government does not own or directly control the public service company. Currently, the Government owns the majority of ANGLEC and controls its Board, and there is no independent regulator, nor any real electricity regulatory framework in Anguilla for a regulator to administer. It would be unwise to go about setting up an entire framework and someone to administer it before implementing renewables that may be done in a relatively quicker and easier way, and that could benefit the country right away.

Appendix J contains a draft of the rules that we recommend ANGLEC adopt. Below we explain how we recommend adopting the rules in a binding way; what the rules should contain for utility scale renewables; what the options are for doing utility scale renewables; and what the rules should contain for distributed scale renewables.

How to adopt the corporate rules in a binding way—by amending ANGLEC's by-laws

We recommend that the rules be adopted by amendment to ANGLEC's by-laws. As such, they would bind the company, shareholders, directors—and by extension, officers who manage ANGLEC on behalf of the directors. The procedure for amending the by-laws is set out in the Companies Act in section 63:

> *By-law powers*
>
> *63. (1) Unless the articles, a by-law, or any unanimous shareholder agreement otherwise provides, the directors of a company may by resolution make, amend, or repeal any by-laws for the regulation of the business or affairs of the company.*
>
> *(2) The directors of a company shall submit a by-law, or any amendment or repeal of a by-law made under subsection (1) to the shareholders of the company at the next meeting of shareholders after the making, amendment or repeal of the by-law, and the shareholders may, by ordinary resolution, confirm, amend or reject the by-law, amendment or repeal.*

(3) A by-law, or any amendment or repeal of a by-law, is effective from the date of the resolution of the directors making, amending or repealing the by-law until—

(a) the by-law, amendment or repeal is confirmed, amended or rejected by the shareholders under subsection (2); or

(b) the by-law, amendment or repeal ceases to be effective under subsection (4);

and, if the by-law, amendment or repeal is confirmed or amended by the shareholders, it continues in effect in the form in which it was confirmed or amended.

(4) When a by-law, or an amendment or repeal of a by-law is not submitted to the shareholders as required by subsection (2), or is rejected by the shareholders, the by-law, amendment or repeal ceases to be effective, and no subsequent resolution of the directors to make, amend or repeal a by-law having substantially the same purpose or effect is effective until the resolution is confirmed, with or without amendment, by the shareholders.

(5) A shareholder who is entitled to vote at an annual meeting of shareholders may make a proposal to make, amend or repeal a by-law.

ANGLEC has expressed its preference for the rules to be adopted as a policy, instead of by amending the by-laws. We understand that this preference is for rules that would allow ANGLEC more flexibility to operate, without variations that are necessary in certain circumstances but that could constitute a contravention of the rules, which would expose management and officers to liability from minority shareholders or other persons.

It is a reasonable concern—but what matters to address it is not how the rules are promulgated (whether through by-laws or policy), since a policy of the company must also be complied with. Instead, what matters is the formulation of the rules. To ensure more flexibility,

- ***One option is to have true policy where all that is stated are basic objectives***. Such a policy would represent non-binding, flexible rules; but it would not provide the kind of detailed guidance needed. Importantly, we recommend that rules provide detailed guidance because as such they could, later in the regulatory process, represent one definition of what costs are 'reasonably incurred' and may be recovered through tariffs (see section 7.2.2).
- ***A better option is to introduce more flexibility in the rules***, by introducing the power for the directors to obtain approval for deviations from the rules prior to or after the deviation. The updated rules contained in Appendix J contain such flexibility in the recommended amendment of the by-laws' paragraph 4.1:

In managing the business and affairs of the company, the directors, and any person to whom their powers are delegated under paragraph 4.10 or otherwise, shall comply with the Corporate Rules for Renewable Energy set out in the Schedule.

In the management of the business and affairs of the company, the Corporate Rules for Renewable Energy set out in the Schedule have effect, subject to any variation by the directors—or any person to whom their powers are delegated under paragraph 4.10 or otherwise—that is previously authorized, or subsequently ratified, by ordinary resolution of the shareholders.

What the rules should contain for utility scale renewables—a best practice process

After a preamble explaining the importance of renewable energy for Anguilla, and principles of efficiency and transparency that ANGLEC commits to, the rules would establish a best practice process to develop, procure, or contract new renewable energy generation capacity:

- A **demand forecast**—ANGLEC management would prepare this;
- A **least cost generation plan with full consideration of renewable energy options** (including those at distributed scale) alongside conventional ones—ANGLEC management would prepare this;
- A **consultation with the public**—one such as under our assignment would also work, since ANGLEC participates and an independent assessment of candidate renewable energy options is presented;
- An **approval of the least cost generation plan**—the Board of Directors would sign off on this;
- An identificat**ion of the best option to design, build, operate, maintain, and finance** new renewable energy generation capacity—ANGLEC management would have to assess three possible options (see Table 7.2 for an explanation and comparison of these three options) and select from them the one that is most likely to deliver power reliably and at least cost:
    1. Fully developed by ANGLEC;
    2. Procured to a specialized contractor under a Design, Build, Operate, and Maintain (DBOM) contract; or
    3. Contracted to an Independent Power Producer (IPP).
- A **transparent and competitive procurement process when the best option identified involves third parties** (that is, either procurement under a DBOM contract, or contracting an IPP). The process would provide clear eligibility and evaluation criteria, and include a prequalification phase (publishing of a request for expressions of interest) before issuing a full request for proposals to shortlisted bidders, for limiting the amount of proposals to be reviewed to just those of most qualified bidders. The Board of Directors would sign off on bidding documents and any contract awards, while the rest would be delegated to management to do.

This process would also be subject to regular reruns, with updated demand forecasts and least cost generation plans, and public consultations at each update.

What are the options to do utility scale renewable energy under the rules?

Table 7.2 explains what entity would design, build, operate, maintain, and finance a project under each of the three options that ANGLEC would have to assess, and from which it should select the best one to deliver least cost power reliably.

Below we explain each option's advantages and disadvantages in greater detail.

Table 7.2: Options for Implementing New Utility Scale Renewable Energy Projects

Option	Design	Build	Operate	Maintain	Finance	Summary Assessment
Fully developed by ANGLEC	ANGLEC/ contractor	ANGLEC/ contractor	ANGLEC	ANGLEC	ANGLEC	**Pros**: relatively easy and quick; low cost of capital **Cons**: ANGLEC financial constraints, and limited ability to operate/maintain
Procured under DBOM contract	Contractor	Contractor	Contractor (may transfer to ANGLEC after initial period)	Contractor (may transfer to ANGLEC after initial period)	ANGLEC	**Pros**: relatively easy and quick, efficient, low cost of capital, allows capability transfer to ANGLEC **Cons**: ANGLEC financial constraint
Contracted to an IPP	IPP	IPP	IPP	IPP	IPP	**Pros**: not subject to ANGLEC financial constraints, no need for new licensing regime **Cons**: relatively complex and long, likely higher cost of capital

The **fully utility-integrated option** would have ANGLEC design, build, operate, and maintain the plant (with the option to hire a contract for design and build) just like it does for conventional plant.

- ***Advantages***. This option would have an easier and quicker implementation process, which would largely be internal to ANGLEC; it would also allow using ANGLEC's relatively low cost of capital; and
- ***Disadvantages***. On the other hand, ANGLEC's capacity to raise the financing may be constrained, and its capability to design, build, and especially operate and maintain the plant once it's built may be limited.

The **DBOM contract option** would be a form of public-private partnership—a way to share operational and financing responsibilities for providing the electricity service. This option would represent an intermediate option between the other two.

- ***Advantages***. This option would leave it to a specialized contractor to do what it can do best (precisely the activities identified by the acronym D, B, O, and M). It would also be relatively quick and easy to implement, and enjoy ANGLEC's relatively low cost of finance. Further, it would allow the contractor to train ANGLEC for a certain period (shorter or longer, depending on the technology) on O&M, making sure there is an adequate skills transfer before a potential hand-off to the owner that financed the plant; and
- ***Disadvantages***. We see no disadvantages to this option, apart from being subject to any financing constraint of ANGLEC's.

The **IPP option** would be fully developed by a third party that would sell all electricity to ANGLEC under a power purchase agreement (PPA), which would in turn re-sell it to customers.

- ***Advantages***. This option would let third parties do technologies that the utility is unwilling or unable to do, such as more complex ones involving waste. It would also be a way to alleviate ANGLEC's financial burden, transferring it to a third party. Further, the IPP could operate under ANGLEC's licence, with no need to create and administer a third party licensing regime; and
- ***Disadvantages***. This option would be longer and more complex to implement, as it would involve preparing and negotiating a PPA, and enforce grid interconnection standards on the IPP. It may even end up being more expensive depending on an IPP's cost of finance, and on the need to attract specialized labor from abroad to settle in Anguilla for a long period. Finally, it may be difficult to implement in practice, since most qualified bidders may be more interested in a DBOM contract (or just a design and build contract) so that they may pursue other business opportunities as soon as they complete one.

What the rules should contain for distributed scale renewables—arrangements for a well-designed Standard Offer Contract

For distributed scale renewable energy, ANGLEC would:

- Identify the **technically and economically viable cap** for eligible distributed generation to contribute to the energy mix—this could be set at a lower amount initially, and then expanded as much as the grid can progressively handle, for example thanks to additional backup and standby capacity;
- Create a **grid and distributed generation code** setting out rules for interconnecting distributed renewable energy generation to the grid, as well as limits on the maximum unit size and total capacity, if required—this would ensure that interconnecting customers' systems is easy and safe, that individual systems are set up primarily for own use, and that the system can handle all distributed systems together;
- Create a **Standard Offer Contract (SOC)** under which ANGLEC would buy excess power from eligible customers:
  - At a **fair rate set at actual avoided fuel cost** (that is, considering ANGLEC's cost of generation that is offset by distributed generation under realistic dispatching conditions). This would mean implementing a net billing arrangement, and not a net metering arrangement. As we explain in more detail below, we believe that actual fuel cost would be a good and relatively easy way to calculate avoided cost;
  - For a **term no less than a system's useful lifetime** (usually 20 years)—this would be necessary to provide certainty to customers who decide to invest in a distributed renewable energy system.
- Try to secure under its public supplier's licence **any changes to tariffs and conditions of supply** necessary to promote the maximum possible development of economically efficient distributed renewable energy generation.

What a well-designed SOC looks like is likely to be a controversial matter, in Anguilla like in most places. Different actors—the utility, customers as individuals, sellers and installers of systems—are likely to have a different opinion depending on their interest. The best way to think about this matter is from the perspective of the country as a whole (all customers collectively), as appropriate for an assignment contracted by the Government, to pursue the interest of the entire population instead of any particular ones.

Why a complex package of several items? A SOC (in some countries called a feed-in tariff) is technically a standing offer to purchase power from small scale systems at some predetermined (but not necessarily fixed) price, for a predetermined period of time, and subject to certain technical requirements. It is a set of standardized tools for implementing projects that transaction costs would make it impracticable to implement on an individual basis. All details are sorted out upfront in a standard way—more time and effort upfront for an apparently complex package, but less time and effort for customers to sign up one after another once the package is ready.

Why a cap on individual and overall eligibility? 'Distributed generation' is defined by its connection to the distribution network. Therefore, it needs to be of a certain size consistent with the voltage of the distribution network, and consistent with the systems being developed primarily for self-generation. Individual caps could be set by customer type (in Anguilla, levels of consumption), for example a maximum of 50kW for residential customers, and 150kW for small non-residential ones, and perhaps more for larger non-residential ones.

Capping total eligibility to an amount that the system can handle allows preserving the quality, stability, and reliability of service. A total cap can increase once the system is upgraded—but the two things should happen in the right order, in the interest of quality of service (for which the utility is responsible): first the system is upgraded, then the total cap may increase. The limit could be established as a percentage of peak demand on a first come, first served basis. An initial cap would be set at a lower level, then reset once it is evaluated, and once the effects on the Company's finances and operations are analyzed.

Why a grid code? A system operator may be legitimately concerned that interconnecting renewables (especially intermittent ones) may affect the quality of service. If this concern is not solved, the result may be that even viable options are not allowed to connect to the grid. Instead, a standard grid code or interconnection agreement would allow anyone (especially installers hired by customers) to know in advance what needs to be done to comply. It would include technical and operating standards, but only those that are necessary to ensure safety, reliability, and stability of service.

Why net billing at avoided fuel cost, and not net metering? Net metering spins a customer's meter backwards when it sells excess electricity, causing the utility to supply some of the electricity it sells to its customers at retail price (higher value) instead of at cost (lower value). This means that, if a supplier is to remain financially viable, it must be allowed to recover those higher costs; ultimately a supplier will recover those costs from customers, increasing their bills. The result is to raise electricity costs and tariffs to the country as a whole, with eligible SOC customers subsidized by other customers. Net metering is easier to implement and provides an incentive to individual customers. However (even if eligible system size is limited) it raises people's bills, which is contrary to the priority objective for Anguilla to integrate renewable energy. The incentive to individual customers (in addition to being at the expense of others) is also an unnecessary one in Anguilla, where solar PV is already commercially viable (it saves on the tariffs).

Net billing measures and bills separately the flow of electricity that a customer buys (at the retail rate) from the electricity that a customer sells (at the SOC rate, to be set at avoided cost). This arrangement ensures that the country as a whole pays no more than it should for its electricity, while customers that contribute to the energy mix with least-cost power get a fair price for it (no more than what it would cost the utility to supply, and not less either), and can capture the entire value of their investment. It is a little more complex to implement—but not too complex, as we further explain below. In particular, it is consistent with Anguilla's priority objective for renewable energy integration.

Which avoided cost should be used, and what does 'realistic dispatch conditions' mean? Non-firm generation, such as wind or (to a lesser extent, given correspondence to the load curve of a system like Anguilla's) solar PV, cannot offset fixed costs of investing in firm generation that can provide backup and standby. It can offset variable costs, which are those that fluctuate depending on how much electricity is generated (mostly fuel; as well as variable O&M costs such as lube).

The actual avoided cost encountered by a utility over an extended period of time will vary from year to year depending on what plant is available for dispatch. However, if a utility operates economically, it should be dispatching the most efficient units first, then the next most efficient, and so on (as described in section B.2.4, ANGLEC's high speed units, the least efficient, provide only about 2 percent of generation).

As more distributed renewable energy is interconnected, utilities may worry that running units at a lower regime may make them far less efficient. This concern has some merit, but should not affect the result if the avoided cost is calculated taking into account realistic dispatch conditions. At all time, all units except the marginal one should generally be optimally loaded, so the quantity of power generation by a non-optimally loaded unit should be rather small. Fuel consumption of the engines are usually specified by the manufacturer for about 80 percent loading. In our experience, one can expect a variation in fuel efficiency that causes about 2 percent lower efficiency at full power, and between 2 and 5 percent lower efficiency at about fifty percent load, depending on the manufacturer. The extent of the variation is usually dependent on the type of fuel injection and turbocharging technology used. Figure 7.1 below shows typical results for a Wartsila engine.

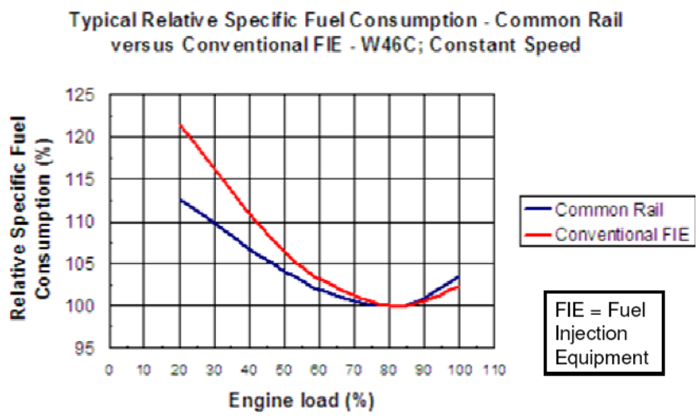
Avoided cost should certainly be quantified—but the quantification should not be very difficult (fuel cost incurred per kilowatt hours generated over a certain period), and the increase in fuel cost calculated as a result should not be large and not hurt customers. Also, in the longer term there would be mechanisms to ensure recovery of these costs (more on this below, section 7.2.2).

We recommend to give consumers two options in terms of which avoided cost they may pick:

- The **short-run avoided fuel cost**, to be updated on an periodical basis (for example annually) based on actual value. This would be calculated based on realistic dispatch conditions that take into account the machines' fuel efficiency curves, which that the company would review annually. Customers may choose this option if they think that future actual costs will be higher; or

- The **current estimate of long-run avoided fuel cost**. This would be calculated based on realistic dispatch conditions and a likely generation expansion plan. Customers may choose this option if they think that future actual costs will be lower.

Figure 7.1: Relative Fuel Consumption of a Wartsila Engine at Different Loads



Source: P. Hakkinene, *Diesel engines*, https://noppa.aalto.fi/noppa/kurssi/kul-24.4410/materiaali/Kul-24_4410_chapter_3.pdf

OK, but wouldn't net metering at the retail tariff still be better than net billing at avoided fuel cost? The question of net billing versus net metering is probably the one that came up more frequently, and more passionately, during our visits to Anguilla. It is a very important question that deserves extra attention—in the table below we answer to the more detailed arguments that are typically brought in favor of net metering.

Table 7.3: Key Questions and Answers on the Net Metering vs. Net Billing Debate

Argument in favor of net metering	Answer
Solar PV should be given a financial incentive like in every successful implementation of it worldwide. Net billing at avoided cost provides no incentive for solar PV; only net metering can provide the incentive needed. Without sufficient financial incentive, the SOC will not be successful	**The best financial incentive for doing solar PV in Anguilla is that it is, in itself, a commercially viable investment there**—it already saves on customers' bills, just as things are, and has good returns (see Box 7.2). This is a great result in a country where electricity costs are so high, and where about a fifth of the population lives below the poverty line. Financial incentives in successful examples worldwide have been given in rich countries where solar PV is not commercially viable. **This is not to say that solar PV faces no financial barrier. In fact, it does** in terms of access to good loan terms for systems that have a relatively high upfront cost. So, there is a case for a financial incentive—but instead of making other Anguillan customers pay for it (as would happen with net metering), it should be taxpayers of developed countries paying (as would happen if the subsidy were given through a low-cost consumer finance instrument for distributed renewables funded by a bilateral or multilateral donor).

	Net metering alone would not be a sufficient financial incentive, because all it would do would be to make an already commercially viable technology even more viable for those who can already afford it. It would not, by itself, address the real barrier—access to finance, which (as recommended in section 7.3) should be overcome with other instruments (concessional loans, guarantees, or a dedicated consumer finance facility).
The matter of how 'avoided cost' is established will be subject to mistrust and suspicion, and can be easily manipulated. It is best avoided altogether by a net metering mechanism	In fact, a **SOC at actual avoided fuel cost would increase transparency** rather than hinder it, and help convince customers that they are getting a fair price. Currently customers do not even know what the fuel cost portion of the tariff is, or how it is calculated—the proposed solution strongly argues that fuel cost (EC$ per kWh) should be the avoided cost used. Fuel cost is not at all hard or opaque for the utility to determine, and it should be published on a regular basis.
Net metering creates more certainty, while net billing creates more uncertainty	**Net billing and net metering actually provide similar certainty**, since both the retail tariff and avoided fuel cost vary directly with the utility's varying cost of diesel—only, the retail tariff varies at a range that is higher than that of the cost of fuel alone. Instead, the key to greater certainty is the term granted for the SOC, which (as recommended) should be as long as the system's lifetime (20 years). A shorter term does create uncertainty, and is the key reason behind the limited success of other regional programs.
Since the amount of solar PV eligible for the SOC would be limited, any negative effect of net metering incentives would be minuscule	This may be true in the short term, but this assignment aims to **create a legal and regulatory framework that is valid in the long term** when the amount of distributed renewable generation is likely to increase. A net billing arrangement at avoided cost, with gradually increasing caps as soon as technically and economically feasible, is a better and more sustainable solution.
Nowhere (particularly in the Caribbean) is net billing successful—not even in Jamaica, which has offered a 15% premium over avoided cost	It does look like no Caribbean country has got distributed generation right for now—**Anguilla could well be the first country to get it right the first time around**. As summarized in Box 7.1, Grenada started with net metering, but switched to a buy-all/sell-all arrangement at avoided cost since net metering was costing the company too much (the utility cannot pass extra costs on to customers); Barbados's net billing arrangement has had limited success, mostly due to a very short term that makes the arrangement highly uncertain; applications in Jamaica, on the other hand, have been picking up.
Net metering is fair because customers are paid for the power they generate exactly what they pay to the utility for the power it generates	Many customers argue that if they sell electricity to ANGLEC, they should get the same rate that ANGLEC charges them—but actually the proposed solution would be a powerful way to show that the SOC would do

precisely that. **The rate paid to customers for solar PV-generated electricity would be the same paid by customers for diesel-generated electricity: the fuel surcharge**, which is a direct pass-through for power generation on which the utility makes no profit.

In summary:

- **Net metering** at the retail tariff would be better from the perspective of individual customers, and would be easier to implement. However, it would make the country as a whole worse off, as it would make all customers pay so that solar PV (which is already a viable investment) would be even more viable for customers who can afford it; and
- **Net billing** at avoided fuel cost would be better from the perspective of the country; it would be a bit more difficult to implement—but not that difficult, and more transparent and fair.

Box 7.1: Experience with Distributed Generation in the Caribbean

Grenada. In February of 2007, Grenada Electricity Services Ltd. (GRENLEC) issued a Phase I feed-in tariff (FIT). This FIT was a net metering scheme for renewable energy systems up to 10kW that capped total nameplate capacity total at 300kW (roughly 1% of GRENLEC's peak demand). The FIT's total installed cacity reached 272kW as of March 2012, with the remaining 18kW expected to be installed by September 2012. The Phase I FIT costs ANGLEC approximately ECD500,000 per year—these costs cannot be passed onto the consumer because GRENLEC operates under a price cap system; in addition, GRENLEC cannot charge a separate rate to recover the costs of providing backup power and the use of its wires under the current tariff structure. Given the cost created by this program, in January 2011 GRENLEC launched a modified Phase II FIT (individual cap 100kW per system, total cap 500kW). One hundred percent of the electricity generated by customer-owned renewable energy is metered and purchased by GRENLEC at about ECD0.5 per kWh. Selling all electricity to customers at retail rate and buying customers' excess electricity at avoided cost enables GRENLEC to recover its fixed costs.[18]

Barbados. Barbados Light & Power (BL&P) offers a Renewable Energy Rider for distributed renewable energy under a net billing arrangement at avoided cost. The maximum system size is 5kW for residential customers, and 50kW for commercial customers. The Rider is available on a first-come first-serve basis up to a maximum of 200 systems, or a combined installed capacity of 1.6MW, whichever comes first. Electricity purchased is supplied to the grid at 1.8 times the Fuel Clause Adjustment or 31.5 Barbados cents per kWh (a 'floor'), whichever is greater.[19] Currently, the Rider counts 13 participants (10 residential and 3 non-residential) for a total capacity of 92.4kW. Ten additional commercial customers have applied for systems of 100-150kW—the regulator recently gave BL&P permission to add a limited number of commercial systems up to a maximum of 150kW on a buy all/sell all basis that would allow BL&P to recover its fixed costs.

[18] Communication with management of WRB Enterprises and GRENLEC, 27-29 March 2012.

[19] The Barbados Light & Power Company Limited. "Renewable Energy Rider". http://www.blpc.com.bb/bus_energyrider.cfm (accessed May 31, 2012).

Uptake to date has been slow mainly because of the uncertainty about the continuation of the renewable energy rider. BL&P is currently reviewing the RER, aiming to set up a new arrangement by July 2012.[20]

Jamaica also recently started implementing a net billing system for distributed renewable energy generation, based on avoided cost plus a 15% premium. The Government announced its plans to implement net billing at the end of 2011; implementation was delayed for some time, mainly due to the need to approve the technical requirements for the interconnection. As of May 2012, the regulator has received 10 applications. The renewable energy generation is expected to be paid about US$0.18-0.25 per kilowatt hour based on current market prices (avoided cost + 15% renewable energy premium).[21]

Why a long term? A SOC at avoided cost should not mean uncertainty. Customers in other Caribbean countries where a short-term, avoided cost arrangement is being offered—such as Barbados, whose Renewable Energy Rider is at avoided cost, but for a limited term—are not buying in, and with good reason. Customers need to know that they will be fairly remunerated for what they provide for the long term, not just for a few years—arguably, providers of financing need to know the same.

A long term will also reduce transaction costs for the utility that buys electricity, to avoid renewing or reissuing interconnection agreements once they have expired after too short of a period.

Why change the tariff too? Supply of energy (sale of electricity measured in kilowatt hours) should be the separate tariff component that eligible SOC customers may avoid paying (at least to some extent), because their systems offset the variable (mostly fuel) cost of supplying that energy. However, their systems do not avoid the cost of being connected to a distribution system, or having backup and standby capacity when the sun is not shining or the wind is not blowing. For this, tariff structures should charge separately for supply of energy, distribution, and backup and stand-by capacity. Otherwise, by implementing renewable distributed generation customers may be enjoying services they do not pay for, and force other customers to bear those costs.

Disaggregating a tariff structure needs to be done right—in section 7.1.5 we explain what could be done in the immediate term, while in section 7.2.4 we recommend what to do in the longer term.

[20] Castalia exchange exchanges with Stephen Worme at BL&P 2 April 2012.

[21] Jamaica Observer. "Net billing to be implemented this month". http://www.jamaicaobserver.com/news/Net-billing-to-be-implemented-this-month_11394396#ixzz1wTnksR5Q (accessed May 31, 2012).

Box 7.2: Solar PV with Net billing at Avoided Fuel Cost from a Customer's Perspective in Anguilla

A typical 2kW thin-film PV system with a turnkey cost of about US$8,000 could generate net savings amounting to a net present value (NPV) of about US$3,801 over a period of 20 years, assuming: (i) a capital cost of US$4,000 per kW; (ii) an annual O&M cost of US$60 per kW, (iii) a loan to finance 60 percent of the capital cost over a period of five years at an interest rate of nine percent per annum; and (iv) 50 percent of the solar PV output consumed by a customer, with the remainder 50 percent being sold to ANGLEC at an avoided cost of grid power generation of US$0.28 per kWh. The payback time of the solar PV project to the customer would be eight years, and the solar PV system would yield an Internal Rate of Return (IRR) of 17 percent. If the interest rate on the loan were 6 percent (a concessional rate such as one that could be obtained through donor funding), the net present value of the solar PV project for would increase to US$4,169, IRR would increase to 19 percent, and the payback time would be 7 years.

7.1.2 Utility scale: ANGLEC immediately to publish request for expressions of interest for solar PV

ANGLEC's initiative to procure a 2MW solar PV plant is an excellent idea, and should not be delayed.

Consistent with the best practice process described in the rules, we recommend that ANGLEC publish as soon as possible a request for expressions of interest. This will allow a broad range of qualified bidders to learn about the opportunity and prepare competitive offers adequately. It would also allow limiting the number of full proposals that should be evaluated, since it would allow selecting a short list of bidders.

7.1.3 Utility scale: ANGLEC to add O&M in the solar PV Request for Proposals

ANGLEC's draft RFP to procure the design and build of a 2MW solar PV plant looks sound. We just recommend that ANGLEC consider adding an O&M component (even a short one, given the relative simplicity of operating and maintaining a solar PV plant compared to other technologies), turning it into a DBOM contract; and once the corporate rules for renewable energy are adopted, that it check that the RFP complies with them.

7.1.4 Distributed scale: amend Electricity Act to extend exemption from licence also to the sale of excess electricity

We recommend amending the Electricity Act, Part 2, Section 2, subsection 2 by adding the following text in bold (Appendix section K.1 contains this same amendment):

> *(2) Subsection (1) shall not apply to the use of any electrical plant which—*
>
> *(a) is powered only by wind and which is used by any person for the purpose only of supplying electricity to his own premises****, or selling excess electricity to a public supplier on terms agreed with the public supplier****;*
>
> *(b) is used only for the photovoltaic generation of electricity by any person for the purpose only of supplying electricity to his own premises****, or selling excess electricity to a public supplier on terms agreed with the public supplier****;*

This amendment would overcome the barrier of inability to sell renewable electricity at distributed scale. Unlike solar PV, small scale wind is not economically viable—but as long as the rate it gets under a SOC is no more than avoided cost, making it eligible for the SOC would not harm other customers.

7.1.5 Distributed scale: ANGLEC to develop pilot Standard Offer Contract (SOC) with pilot disaggregated tariff

Anguilla's distributed renewable generation potential is likely to be high, and should be implemented as soon as feasible—but a gradual approach would be wise to start. It would allow assessing operational and financial implications, test customer interest, and provide time to prepare for broader uptake.

As explained above, implementing grid-connected distributed renewables requires two things that must come together:

- **A well-designed SOC**; and
- **A disaggregation of the tariff structure**.

The calculation of avoided cost (both short and long term) may take relatively less time, but accurately disaggregating the tariff would require a Cost of Service Study (COSS). A COSS would estimate what it actually costs to supply different services to different customers. A COSS will be useful, but will take some time to procure and carry out—and additional funding.

Anguilla should not wait for all of this to happen, and should start piloting a SOC as soon as possible, with a limited cap. A pilot disaggregated tariff could estimated, and be offered by ANGLEC as part of the 'SOC' package. This can be done with no changes to laws or regulations, simply pursuant to sections 4.1 of both ANGLEC's public supplier's licence and Schedule I of the Electricity Supply Regulations:

> *(4.1) (…) if, having due regard to the nature and circumstances of a supply of electricity to any consumer or potential consumer, the Licensee considers that the terms and conditions of affording such a supply under the provisions of this Licence are inappropriate, any or all of such terms and conditions may be amended by agreement in writing between the Licensee and such consumer or potential consumer: Provided further that details of any such amendment shall be notified to the Governor in writing and published in the Gazette.*

The cap on the pilot SOC would limit the effect of any error to a negligible value.

7.1.6 Distributed scale: mandate solar water heating for new facilities

For new buildings, the Government should mandate that when a water heater is installed, it be a solar water heater, and one compliant with a Caribbean certification such as one used in Barbados, Saint Lucia, or Jamaica. The mandate could be included in the draft Building Code. An effect of this mandate would be that new buildings must be constructed with the necessary space and plumbing for installing solar water heating systems. This would affect builders, who however would recover costs from sales just as they do with any other requirement of the draft Building Code.

As an alternative, this could be a simple step in the permitting process. There is a precedent for this in Anguilla—new buildings are not granted a permit unless they come with an underground water tank to collect rainwater.

We make a few recommendations for existing buildings in section 7.3.

7.2 Additional Legal and Regulatory Measures for Later

With the measures recommended in section 7.1, Anguilla could implement in a relatively short period a significant part of its potential—especially at utility scale, which enjoys the least costs. As soon as those immediate measures are set off, there are six other things that Anguilla should do:

- Consider whether to create an autonomous licensing regime for IPPs (7.2.1)—we actually recommend not doing that;
- Amend ANGLEC's licence and Electricity Supply Regulations by adding tariff setting principles on recovery of sustainable energy costs (7.2.2)—this would absorb the immediate term reform in ANGLEC corporate rules in a longer-term, broader reform for the power sector;
- Commission a Cost of Service Study (7.2.3)—as the basis for a better tariff structure that works for promoting distributed renewables, and as a key way to identify opportunities for cost savings other than renewables;
- Amend the Electricity (Rates and Charges) Regulations with a disaggregated tariff structure (7.2.4)—charging separately for energy, distribution, and capacity; and potentially including a special component for recovering all clean energy investments;
- Issue a revised SOC (7.2.5)—with an increased total cap, and based on the experience with the pilot;
- Determine the best option for a regulator to administer rules (7.2.6)—selecting it from different domestic and regional options.

We describe each of these recommended measures below.

7.2.1 Utility scale: consider whether to create an autonomous licensing regime for IPPs

During our first trip to Anguilla, ANGLEC management stated that it would be keen for a third type of licence, one for IPPs, to be created; the Government also proved interested. This licence would have to be created by amending the Electricity Act, E35. The licence would be for the sale of all electricity generated to ANGLEC: if such a licence were created, we would recommend also clarifying that wheeling of electricity (IPPs using ANGLEC's grid to sell directly to large customers) is prohibited. Wheeling would be unnecessary and too costly to administer in a small system with few or no large customers, and potentially harmful for Anguilla's small grid.

Given discussions we had with ANGLEC and the Government, we recommend that both consider this option—but for discarding it. We do not recommend creating a third type of IPP licence and the third party licensing regime that comes with it. It would complete Anguilla's licensing framework, but it would be unnecessary, time-consuming, costly, and difficult to administer. ANGLEC can already implement utility scale renewable energy projects in cooperation with private third parties through the DBOM model, or by assigning rights to an IPP under its own licence. Legal changes required would be many, and drafting them would cost high legal fees. Also, administering a new licence regime is something that Anguilla does not have the institutional capabilities to do now—and that may be difficult to administer even if it Anguilla developed those capabilities.

7.2.2 Utility scale: amend ANGLEC's licence and Electricity Supply Regulations by adding tariff setting principles on recovery of sustainable energy costs

The corporate rules that we recommend ANGLEC adopt (Appendix J) cover how to correctly plan and develop renewable energy investments—but don't fully ensure that ANGLEC can actually recover those investments, and make an allowed return on them. Anguilla's rate review process is rudimentary and has been virtually non-existent, with little detail as to what steps it should involve and what information should be provided, no provision for it to happen at regular intervals, and limited or no regulatory capacity to handle it anyway.

Setting up a sound rate review process to solve these problems, and setting up the entity to administer it, are matters that go well beyond renewable energy integration alone—they are matters of broader power sector reform that need to be dealt with for any type of investment (renewable, but also conventional generation, and other non-generation investments too). As such, they do not belong to the scope of this assignment. Creating a rate review process only for renewables would fall into a vacuum of rules, regulatory capacity, and regulatory activity.

That said, once a broader reform of Anguilla's power sector regulation takes place there would be two very different approaches any person or entity exercising the regulatory function could take to encourage renewables:

- The most obvious would be to simply order the utility to invest in particular projects that the regulator (broadly intended) considers beneficial; and
- The other is to provide incentives for the utility to make the right decisions itself based on the power of the regulator to allow or disallow the costs that the electric utility may pass on to consumers through electricity tariffs.

We recommend the latter strategy, because it promotes economic efficiency for the benefit of customers without interfering with the utility's day-to-day business. This would be done by inducing the electric utility to either (i) develop least cost renewable energy plant itself, or (ii) procure or contract least cost electricity from third parties—specialized contractors under a DBOM arrangement, or IPPs, respectively. Given an approved tariff level that only covers least cost plant selected from a range that includes renewables, the utility would have to invest in (or purchase from) least cost renewable energy plant if it wants to be financially viable.

The way to induce the utility to do things right would be to offer it a 'safe haven'—state that as long as it follows the best-practice way to do renewables at utility and distributed scale (as established in the recommended rules for ANGLEC), it would recover the cost of investing or purchasing from least cost renewables. Costs incurred in accordance to due process and rules would be identified as 'approved renewable energy costs', and considered *prima facie* to be used and useful and to have been prudently incurred—and as such approved for recovery through tariffs.

This could be achieved by adding the following definition in section 1.1 of both ANGLEC's public supplier's licence and Schedule I of the Electricity Supply Regulations:

> *'Approved Renewable Energy Costs' are:*

- *renewable power generation investments that are made by the public supplier, and operating and maintenance expenses, depreciation, and any taxes of those investments that are incurred by the public supplier,*
- *utility scale renewable power purchase costs that are incurred by the public supplier, as a consequence of purchasing renewable power from third parties, and*
- *distributed scale renewable power purchase costs that are incurred by the service provider, as a consequence of purchasing renewable power from its consumers*

in accordance with the Schedule of ANGLEC's by-laws ('Corporate Rules for Renewable Energy').

And by adding in section 4.4 of both ANGLEC's pubblic supplier's licence and Schedule I of the Electricity Supply Regulations the following statement:

The Minister or the Arbitrator shall consider that Approved Renewable Energy Costs are reasonably incurred.

Appendix section K.2 contains these same amendments. The definition of 'Approved Renewable Energy Costs' could also be expanded to include investments in energy efficiency (both on the supply side, for ANGLEC; and on the demand side, for ANGLEC's customers) that ANGLEC may make—in that case, the adjective could be changed from 'Renewable' to 'Sustainable'. These costs, too could then be recovered through tariffs, and the utility could make an allowed return on them benefitting customers and itself.

7.2.3 Utility and distributed scale: commission a Cost of Service Study

As noted above, Anguilla should commission a COSS to assess what it actually costs to supply different services to different customers (and ideally, by time of day for larger customers). The COSS would provide the necessary information for changing the tariff structure to a disaggregated one and setting the value of the various components (as recommended below). It would also be critical to identify ways other than renewables to reduce costs—particularly reducing generation operating costs, which as shown in section B.2.4 are among the highest in the region, and reducing losses.

7.2.4 Utility and distributed scale: amend the Electricity (Rates and Charges) Regulations with a disaggregated tariff structure

The Electricity (Rates and Charges) Regulations state what the tariff components are (Schedule I, section 2.(1)), how much they amount to, and—in the case of the fuel surcharge—how they are calculated. They were developed as a result of a rate adjustment that was done in accordance the Electricity Supply Regulations and ANGLEC's licence.

However, these Regulations and the licence do not state that a base rate and a fuel surcharge must be the only tariff components. In other words, they do not mandate which components there should be—there could be other and different tariff components.

Therefore, there could be a rate adjustment under which a disaggregated tariff structure is approved, resulting in new Electricity (Rates and Charges) Regulations being made to reflect this approved new disaggregated tariff structure.

Such a tariff structure (which could be defined as 'sustainable tariff structure') would be disaggregated and cost-reflective, charging consumers separately for:

- Supply of energy, measured in kilowatt hours sold (energy charge);
- Connection to the distribution system (connection charge); and
- Provision of generating capacity (capacity charge).

Cost of fuel should be included fully in just one component (fuel surcharge), and not split between a base charge and the fuel surcharge.

We also recommend publishing the fuel surcharge (in EC$ per kWh) monthly, for transparency—current ANGLEC bills do not do so, and the way that the fuel surcharge is calculated and included in tariffs makes it even more difficult to appreciate.

The 'sustainable energy tariff structure' may also:

- Reduce cross-subsidies between consumer classes—to the extent that is consistent with the Government's policy objectives of affordability (the Government could maintain a lifeline tariff for the lowest-consuming customers, but at least it would be clear how much this costs and what the effect is on other customers); and
- Charge consumers on a variable basis, depending on the time of day, so far as this is practical and cost-benefit justified.

Finally, we recommend that ANGLEC apply, within a rate review, for the creation of a special, separate tariff component that could be called 'Renewable Energy Recovery Clause'. All Approved Renewable Energy Costs, as defined above (see section 7.2.2) could be recovered through this tariff component—which, ideally, would require a rate review just for being set up the first time, but that then could be adjusted without one, as soon as approved investments are operating and benefit customers. Customers would see the 'Renewable Energy Recovery Clause' as a separate item on their bill, and know what it is for—especially, they would know that to it correspond reductions in the fuel surcharge. This same tariff component could also be used for energy efficiency investments, of course (and in this case be called 'Sustainable Energy Recovery Clause', and approved costs 'Approved Sustainable Energy Costs').

7.2.5 Distributed scale: issue a revised Standard Offer Contract

Based on the experience of the pilot SOC, and once a COSS allows a general revision of all customers' tariff structure, ANGLEC should issue a revised SOC with an increased cap, and updated rates based on avoided cost, and still with a term equal to the systems' lifetime. Customers that had signed up for the pilot might be given the option to migrate under the new regime, and to have their term reset.

7.2.6 Utility and distributed scale: determine the best option for a regulator to administer rules

There would be three options for a regulator to administer the rules of a reformed regulatory framework (including new rules for renewables, as well as broader rules for the power sector). Each option has advantages and disadvantages:

- **Maintain the current situation, and appoint an Electricity Commissioner**—this would be a quick solution, and would require no amendments of laws or regulations. However, this solution might not be very effective since the Minister would be unlikely to have the necessary skills, and the Electricity Commissioner's powers would be subject to the current limitations. It may also be a costly solution if a skilled Electricity Commissioner were hired to perform limited functions infrequently; or

- **Assign regulatory functions to the Public Utilities Commission (PUC)—** this would require changes to the Electricity Act, ANGLEC's public supplier's licence, and the PUC Act. The PUC could be a well-functioning regulator, but would need to hire new staff with power sector expertise (currently the PUC only regulates Anguilla's telecommunications sector). Therefore, it may end up being a costly solution too; or
- **Assign regulatory functions to the Eastern Caribbean Electricity Regulatory Authority (ECERA), once it is set up**—the ECERA could be a good option for an effective body at reduced cost, since the cost would be pooled among several countries. However, the ECERA may take many more years to be set up, and international agreements between countries of the Organization of Eastern Caribbean States (OECS) in addition to changes to domestic laws and regulations.

7.3 Other Measures

For problems of limited financing and limited availability of equipment, we recommend **using this report to secure low-cost financing and other financial resources for distributed solar systems—both solar water heaters and solar PV**. A consumer financing facility, even if limited, could help address the problem of a high upfront cost (in a context of limited loans) much better than duty exemptions. Two main options would be possible:

- Financing could be sought from the UK Government and its agencies, arguing that a widespread program for funding solar water heaters would generate CO_2 emissions reductions at a relatively low cost; and
- ANGLEC could be allowed to fund the cost of purchasing and installing the systems, and recover these costs through their tariffs.

Concessional loans (that is, loans with better-than-market terms, such as a lower rate or a grace period), loan guarantees, and grants for project preparations would be the main financial tools possible.

To help solve limited institutional capabilities, we recommend:

- **For distributed scale renewables, that the Government strengthen the capabilities of the Electrical Inspector's Office** (human resources, financial resources, and skills) so that it may (i) handle an increased number of inspections under the SOC, and (ii) enforce new operating and safety standards; and
- **For utility and distributed scale renewables, that the Government and ANGLEC secure funding for further studies and reforms**—such as a COSS, or broader power sector reform matters.

To help increase skills for renewables in the country, we recommend:

- **For utility scale renewables, including an O&M component (even short) when procuring a specialized contractor**; and

- **For distributed scale renewables, checking whether requirements for a wireman's and plumber's licence are appropriate for small PV and wind systems, and for solar water heating**, respectively. In particular, distributed scale renewable systems can pose a danger because they continue to generate electricity when the power supply from the grid has been cut off. This creates two types of concerns:
  - Live work problems: solar PV panel arrays and wind turbines may not 'switch off' if the sun or wind is acting on them, causing potential danger in a facility during an emergency where emergency workers need to switch off the power supply, and
  - Protection of electricity network workers: safety issues can arise if a solar PV or wind system is feeding electricity back into a de-energized supply grid. This poses a risk to electrical workers working on the network.

To help enhance information and awareness, we recommend:

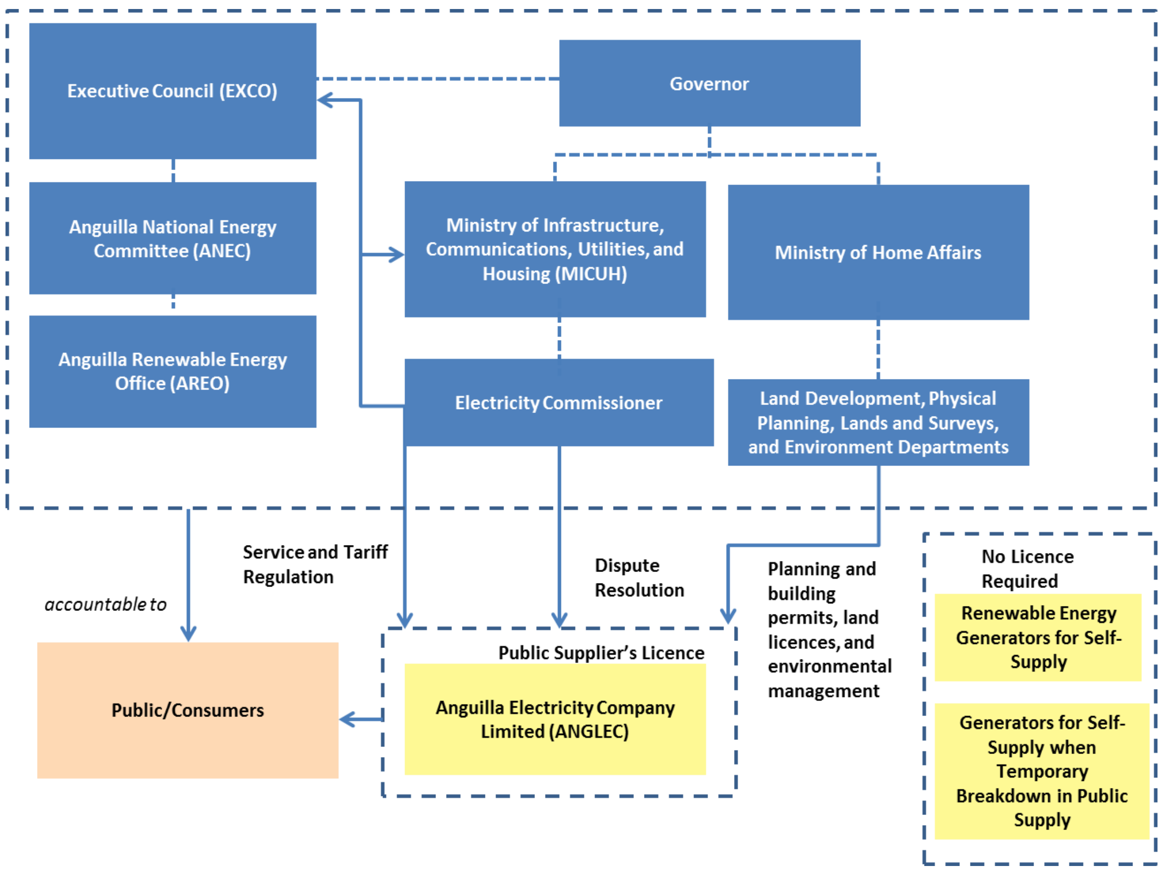
- **For utility scale renewables, further assessing the quantity and quality of wind and waste resources**. Wind might be even cheaper than solar PV (although much more difficult to develop, operate, and maintain). Waste is very little, but for a small island like Anguilla solving the waste management problem is worth an extra try—some of the smallest biogas units could be useful;
- **For distributed scale renewables, consider adopting external certifications for installers of solar water heaters and solar PV systems**, to solve any information asymmetry between installers and customers.

Appendix A: Institutional Outline of the Power Sector

The main actors in Anguilla's power sector are: (i) the Government, which sets policy, regulates the sector, and owns the majority of the Anguilla Electricity Company Limited (ANGLEC); (ii) ANGLEC itself, the vertically integrated public electricity supplier that produces, transmits, and distributes electricity; and finally (iii) non-profit organizations that promote the transition to renewable energy supply.

Figure A.1 shows the actors in Anguilla's power sector. We describe each of them below.

Figure A.1: Power Sector Governance in Anguilla



A.1 Government entities

The **Governor** is the representative of the Queen and the Constitutional Head of State in Anguilla. The constitution gives the Governor certain responsibilities, including oversight for external affairs, defense, internal security, and international financial services or any directly related aspect of finance. He is also the presiding officer of the Executive Council (see below).[22] The Governor is responsible for all public and civil service in Anguilla. The Electricity Act gives the Governor the powers to: grant, renew, and revoke all licences for electricity provision; take action to acquire land for public electricity supply under the Land

[22] HM Governor's Office. http://anguilla.fco.gov.uk/en/about-us (last accessed April 5, 2012).

Acquisition Act; grant tax exemptions for public suppliers of electricity; impose an environmental levy;[23] appoint the Electricity Commissioner and the Government Electrical Inspector; direct the Electricity Commissioner and require the Electricity Commissioner to request information from the public supplier that it may reasonably require; direct the Electricity Commissioner or other appointed person to assume control of and exercise of the public supplier's licence if the public supplier is failing; and make regulations under the Electricity Supply Act to make it effective.[24]

The **Executive Council (EXCO)** is a body consisting of the Governor, who presides it; the Deputy Governor; four ministers of the Crown—the Chief Minister and three line Ministers (currently the Minister of Infrastructure, the Minister of Home Affairs, and the Minister of Social Development); and the Attorney General.

It is important to note that EXCO deliberates on policy documents, laws, and regulation based on the principle of collective responsibility—the relevant Minister tables a matter, and EXCO deliberates by consensus.[25] EXCO is responsible for:

- Formally approving Cabinet decisions, adopting policy directives from the Governor, and adopting Government policies (for example, it adopted the National Energy Policy; if it is to become effective, it will have to adopt the National Climate Change Policy);
- Approving Bills before they go to the House of Assembly for final approval;
- Approving Regulations, which do not have to go to the House of Assembly for final approval; and
- Approving electricity rates and rate adjustments.

The **Ministry of Infrastructure, Communications, Utilities and Housing (MICUH)** is responsible for energy. MICUH is in charge of setting energy policy, regulating the electricity sector, and implementing the Government's policy objectives. The Minister responsible for energy is in charge of tabling electricity Bills and Regulations with EXCO.

The **Electricity Commissioner** ('the Commissioner') is appointed by the Governor; none is currently appointed. The Commissioner is situated within MICUH, but reports to the Governor. The Commissioner plays an ombudsman role, responsible for settling disputes between the public supplier of electricity and customers. The Commissioner is in charge of requesting and collecting information from the public supplier of electricity on accidents, assuming control of and exercising the public supplier's licence if directed to do so by the Governor (if the pubic supplier is failing), consenting to the public supplier of electricity's connection of circuits, easements, and being informed about compensation for losses or damage resulting from works carried out by public supplier when laying lines across land or roads. The Commissioner can also set maximum rates in his sole discretion at which electricity supplied by a public supplier (ANGLEC) may be resold by persons to whom the electricity is supplied (consumers). However, the Governor approves normal electricity rates

[23] Electricity Act, s.32(2): 'the Governor may, by regulation, impose an environment levy based on a percentage of the total income from electricity supplied by a public supplier or on such other basis as he may determine'.

[24] Electricity Act. December, 2004.

[25] Guide to the Operation of the Executive Council. 2002. Section 3.

through regulations, and rate adjustments are approved by the Minister responsible for energy.

The **Ministry of Home Affairs** is responsible for lands, physical planning, and environment policy and regulation in Anguilla. Within the Ministry of Home Affairs,

- The **Land Development Control Committee (LDCC)** is responsible for reviewing and approving applications for new development (including utility scale renewable energy projects) on land, and issuing planning permits;
- The **Department of Physical Planning, Department of Lands and Surveys** is responsible for managing the registered lands system, and reviewing and approving land licence applications; and
- The **Department of Environment** is responsible for preparing environment policy (such as the Climate Change Policy) and environmental legislation (such as the draft Environmental Protection Bill); and for carrying out national environmental management.

The majority of the planning and permitting processes for large renewable energy projects fall under the Ministry of Home Affairs.

For smaller renewable energy projects, the **Ministry of Works** is responsible for monitoring and enforcing building policies in accordance with a draft Building Code. The Ministry's building board provides the necessary building permits. Distributed scale renewable energy systems, unless they are large enough to classify as a development project (see section E.4), would not need to submit an application or apply for any of these licences or permits.

A.2 Electricity service providers

The **Anguilla Electricity Company Limited (ANGLEC)** is an investor-owned electric utility with an exclusive public supplier's licence to produce, transmit, and distribute electricity in Anguilla for fifty years, ending in 2041. The Government and Government Social Security have a majority shareholding (a combined 56 percent of ANGLEC's shares); the remaining 44 percent is held by the National Bank of Anguilla, the Caribbean Commercial Banks, other local companies, and the general public.

ANGLEC's total number of customers is 7,250 as of April 2012,[26] which accounts for nearly 100 percent of total demand (with the exception of a few distributed renewable energy systems). An average domestic customer consumes about 300 kWh/month, and total average customer consumption is 850 kWh/month (domestic and commercial customers).

Total revenues for 2010 increased to EC$69.23 million (US$25.6 million), a 10.7% increase over the previous year due to growth in demand and the opening of a new resort on the island. Gross operating profit decreased by 32.1% to EC$11.29 million (US$4.18 million) in 2010, and Net Profit for the year was EC$5.98 million (US$2.21 million), a 42.7% decrease in profits due mainly to the higher absorption of fuel costs by ANGLEC in 2010. Long-term liabilities were EC$29.6 million (US$10.96 million) (borrowings and contributions for construction), and current liabilities were EC$10.4 million (US$3.85 million) (borrowings were EC$4 million (US$1.48 million) of this amount)[27].

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[26] Conversation with ANGLEC management, 22 April 2012.

[27] ANGLEC. "ANGLEC: Giving Power to the People". Annual Report 2010.

No one holds a private supplier's license in Anguilla. However, there are some customers who generate electricity using renewable energy for self-supply, and that generate electricity with backup diesel generators for their own consumption when the national electricity system is down (no licence is required for these activities, as explained in section E.1.1).

A.3 Non-profit organizations

The **Anguilla National Energy Committee (ANEC)** is a volunteer organization that comprises a diverse group of professionals that are working together to advance Anguilla's climate change and environmental sustainability agenda. ANEC's members are: a representative from MICUH, ANGLEC's General Manager, a representative of the Anguilla Renewable Energy Office, the Director of the Department of Environment, a former Permanent Secretary for Economic Development, the Chief Financial Officer of the National Bank, builders, renewable energy system owners, and the Anguilla National Trust (which provides administrative and office support). ANEC drafted Anguilla's National Energy Policy, held the public consultations on the Energy Policy, and brought it to EXCO for its consideration (see section D.1).

The **Anguilla Renewable Energy Office (AREO)** is the active arm of ANEC. AREO is a Non-Governmental Organization (NGO) that was part of the consultative group that contributed to and reviewed Anguilla's draft Climate Change Policy (see section D.2). AREO was founded in 2008 to promote a transition to renewable energy on Anguilla. AREO works with both public and private entities involved in the energy sector. It also works with donors and funding organizations to support renewable energy development in Anguilla. In addition, AREO does public outreach and facilitates stakeholder consultations.

Appendix B: Electricity Demand and Supply in Anguilla

In this appendix we analyze electricity demand (section B.1) and supply (section B.2) in Anguilla.

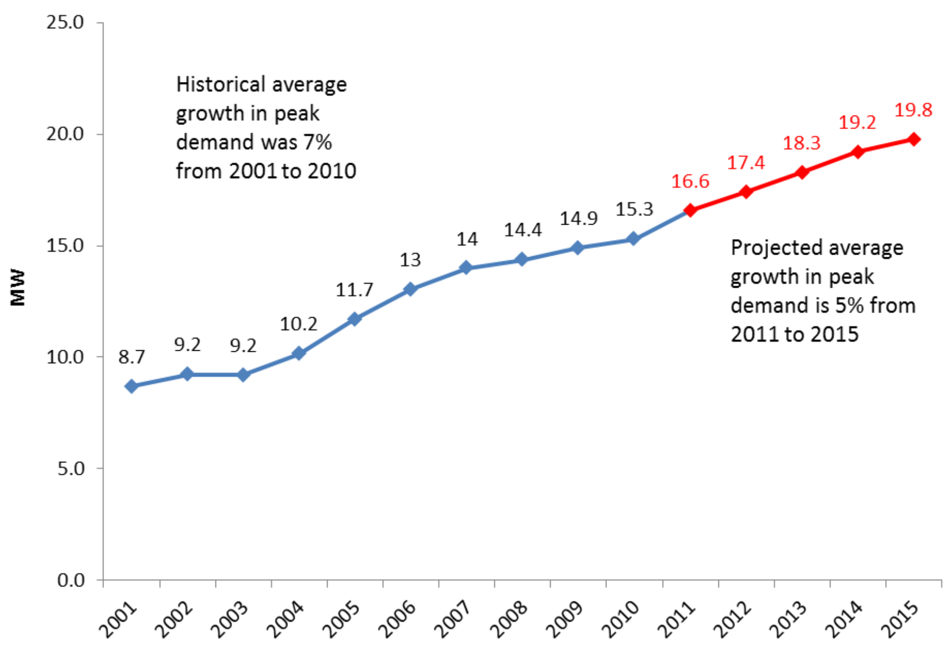
B.1 Electricity Demand in Anguilla

Below we analyze peak demand in ANGLEC's service area, ANGLEC's load factor, and ANGLEC's electricity sales.

B.1.1 Peak Demand

Demand for power has grown consistently since 2003. As shown in Figure B.1 below, peak demand for electricity was 15.3MW in December 2010, compared to 14.9MW for the same period in 2009.[28] This increase is due to demand growth throughout all sectors, and the opening of a major resort in Anguilla at the end of 2009. Average historical growth in peak demand was 7 percent from 2001 to 2010. ANGLEC's load forecast for the period December 2011 through December 2015 expects that peak demand will increase on average by 5 percent per year, from about 16.6MW in 2011 to 19.8MW at the end of 2015,[29] as shown in the figure.

Figure B.1: ANGLEC Peak Demand (2006-2010)



Source: Based on ANGLEC's Annual Reports for 2010, 2006, and 2005

[28] Anguilla Electricity Company Limited. "Anglec: Giving Power to the People." Annual Report 2010.

[29] Anguilla Electricity Company Limited. "2013 Corito Power Station Expansion Justification". 2011. As many utilities commonly do, ANGLEC carries out demand forecasts and expansion plans every five years. Demand trends post-2015 are uncertain, but is likely to be mostly driven by the tourism economy (even one additional hotel has a large effect on demand for a country like Anguilla).

Given the current economic situation, ANGLEC is considering reducing its peak demand growth projection down to 1 percent per year for the next five years. In that case, ANGLEC expects that it could extend the commercial operation of existing plant, or use new utility and distributed scale renewable energy to meet demand. However, with Anguilla's small electricity system, one new commercial project (such as another large hotel) can easily change the load forecast.

B.1.2 Load factor

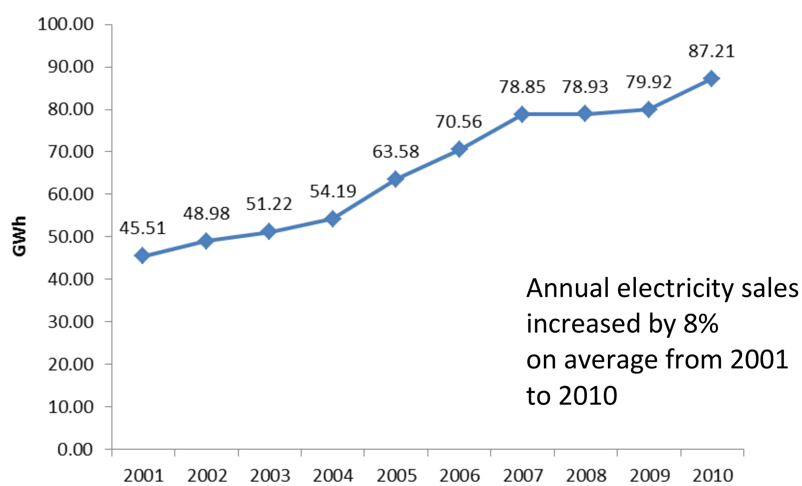
The system load factor—defined as the ratio of the average load to peak load during a specified time interval, typically a year—was approximately 92 percent in 2010. From 2000 to 2010 the average load factor was 90 percent, which means that the majority of the time the company operated at 10 percent below the yearly peak.[30] A higher system load factor indicates a steadier load, with less need for generation capacity per unit of power consumed. Anguilla's high load factor ranks well in comparison to other similar countries in the Caribbean, which had load factors below 80 percent in 2009.

The load factor could be improved even more by encouraging customers to shift their electricity consumption from peak time to off-peak time. By successfully displacing more demand to off-peak times, generation costs as well as customer bills could decrease. This could be done through more demand-reflective tariffs that charge people more for consuming at peak compared to off-peak times, and through awareness campaigns.

B.1.3 Electricity Sales

Figure B.2 shows the trends in total annual electricity sales from 2001 to 2010. During this period, total electricity sales grew steadily at an average 8 percent per year, from about 46GWh in 2001 to 87GWh in 2010, fueled by economic growth across all sectors and the boost in the tourism industry during that period.

Figure B.2: ANGLEC Total Electricity Sales (2001-2010)



Source: Based on Roach, Mariscia S. "Anglec's Load Forecast 2012-2010." Anguilla Electricity Company Limited, 2011.

[30] Roach, Mariscia S. "Anglec's Load Forecast 2012-2010." Anguilla Electricity Company Limited, 2011.

B.2 Electricity Supply in Anguilla

Below we review ANGLEC's plant mix, reserve capacity margin, expansion planning, electricity generation costs, fuel efficiency, constraints and opportunities for fuel supply, and system losses.

B.2.1 Plant Mix

ANGLEC generates electricity running medium speed and high speed diesel units. It has eleven generators manufactured by Caterpillar, Mirrlees, and Wartsila. All units run on Diesel No. 2 fuel.[31] The table below gives basic information about ANGLEC's generating units.

In the past, ANGLEC's generating capacity included both high and medium speed diesel generators, with a large portion of its generation coming from less efficient high speed diesel units. In recent years, however, the commissioning of additional medium speed units, including the 2008 commissioning of a new Wartsila 5.1MW medium speed diesel generator has effectively allowed putting the two remaining high speed units in reserve 98 percent of the time. Total installed capacity in 2010 was 33.1MW. As of 2012, ANGLEC has 9 medium speed generators in operation; and two high speed units that remain on standby as backup capacity.[32]

Table B.1: ANGLEC Generating Units in Service

Generating Unit	Type	Installed Capacity (MW)	Commercial Operation Date	Expected Retirement Date
0	High speed	1.6	2006	2021
2	Medium speed	1.4	1986	2014
3	Medium speed	1.4	1987	2015
6	High speed	1.2	1999	2016
4	Medium speed	3.8	1988	2016
10	Medium speed	3.8	1998	2018
11	Medium speed	3.8	2000	2020
12	Medium speed	3.1	2000	2020
13	Medium Speed	3.9	2005	2025
14	Medium speed	3.9	2005	2025
15	Medium speed	5.1	2008	2028

Source: ANGLEC Expansion Strategy and discussions with ANGLEC Management

B.2.2 Reserve capacity margin

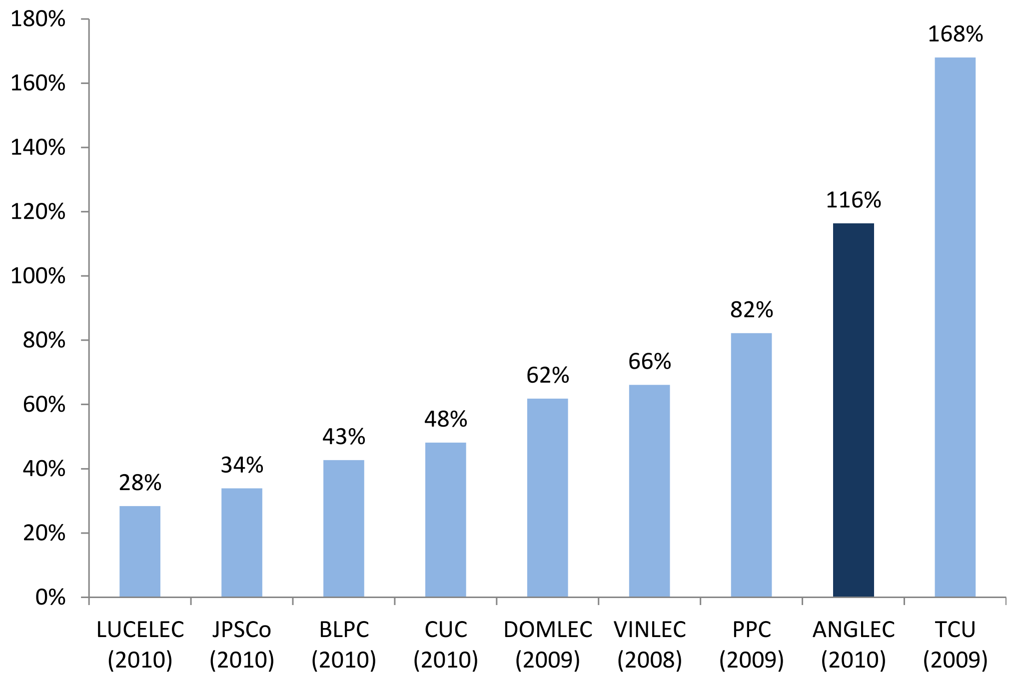
Generation capacity is built to meet peak demand, plus a reserve margin. A standard measure of the ability of generation capacity to meet peak demand is the reserve capacity margin. The reserve capacity margin is calculated as the difference between generation capacity less peak demand, divided by generation capacity. A reserve capacity margin of zero

[31] Information provided by ANGLEC Management, January 15, 2012.

[32] Information provided by ANGLEC Management, January 15, 2012

means the country's generating capacity is exactly equal to the country's peak demand. Most electricity systems target a reserve capacity margin of at least 15 percent to ensure that the system can withstand unplanned outages during periods of peak demand—although in island countries they are typically higher due to these systems' isolation, need to mitigate risks from extreme weather events (for example, hurricanes), and small size. In addition, in a very small island system, the addition of one new generator can boost the reserve capacity margin significantly.

Figure B.3: ANGLEC's Reserve Margin Compared to Other Caribbean Utilities (2010)



Source: Utilities' Annual Reports, 2010

At the end of 2010, ANGLEC had a reserve capacity margin of 116 percent, well above that of most other Caribbean countries as shown in Figure B.3. Peak demand that year was 15.3MW, significantly below the generating capacity of 33.1MW. Even excluding high speed diesel units, ANGLEC's reserve capacity margin would stand at about 98 percent.[33]

ANGLEC uses a N-2 standard for its reserve capacity margin (that is, requiring backup capacity for the two largest generating units on the system) plus an additional 15 percent capacity in the event that the remaining generators are functioning poorly.[34] The equation below illustrates the way that ANGLEC calculates its required reserve capacity:

$$\begin{aligned} \text{Required Reserve Capacity} = \; & \text{Capacity or Largest Generator} \\ & + \text{Capacity of Second Largest Generator} \\ & + .15(\text{Capacity of Remaining Generators}) \end{aligned}$$

[33] Information provided by ANGLEC Management, January-March 2012.

[34] ANGLEC. "2013 Corito Power Station Expansion Justification." 2009

For ANGLEC, N-2 security would require 9MW of reserve capacity. Adding 15 percent to account for potential poor functioning of remaining generators, ANGLEC's target reserve capacity would require 12.6MW. The current 14.8MW of reserve capacity is above target reserve capacity—although ANGLEC estimates that with projected peak demand growth and the need to retire units #2 and # 3 in the medium term (2012-2015)—which have a combined capacity of 2.8MW—it may soon fall below its target reserve capacity margin.[35]

B.2.3 Expansion Planning

At current demand growth rates, the reserve capacity margin will require additional generating capacity to accommodate consumption growth in ANGLEC's service area for the next five years, as well as continued decommissioning of the two older units. For this reason, ANGLEC's expansion plan calls for to add one additional Wartsila 5.1MW medium speed diesel unit. This will provide ANGLEC with significant excess capacity. ANGLEC, however, continues to revise its demand forecasts, considering the effects of the economic downturn and the potential of adding renewable energy capacity instead of firm capacity.[36]

Each year ANGLEC prepares a five year load forecast based on planning, economic, and financial data. ANGLEC prepares its expansion plan, based on its load forecast, and installs new capacity as needed before large development projects come online. To determine if it has enough capacity, ANGLEC evaluates whether or not its firm capacity may meet its target reserve capacity under the load forecast. When the firm capacity does not provide enough capacity to meet demand with sufficient reserve capacity, ANGLEC invests in new plants. The timeframe for getting a new unit to commercial operation can be up to two and a half years given the planning and approval process, and construction time.

In addition, ANGLEC has stated that its acquisition of the Wartsila unit will improve efficiency (these units' heat rate—energy consumed per kilowatt hour produced—is better than the other units that ANGLEC operates) and allow it to meet increasing demand. This suggests that the utility will consider replacing older units with more cost-effective generation to improve efficiency—in addition to when meeting the target reserve capacity margin calls for it—provided it sees the right incentive for doing so.[37]

ANGLEC does not need ministry approval to add capacity, just internal approval by its Board.

B.2.4 Electricity Generation Costs

ANGLEC's generation operating costs (defined as the sum of all fuel and generation-related operating expenditures, divided by gross generation) are relatively high. Figure B.4 compares ANGLEC's generation operating cost against those of other Caribbean utilities. High generation operating costs are common in the Caribbean due to the small size of generating units (which limits the efficiency compared to larger units) and high cost of imported fuel (often made even higher by relatively uncompetitive fuel procurement).[38] ANGLEC's generation operating costs are higher than those in Barbados, Grenada, Dominica, the

[35] ANGLEC. "2013 Corito Power Station Expansion Justification." 2009

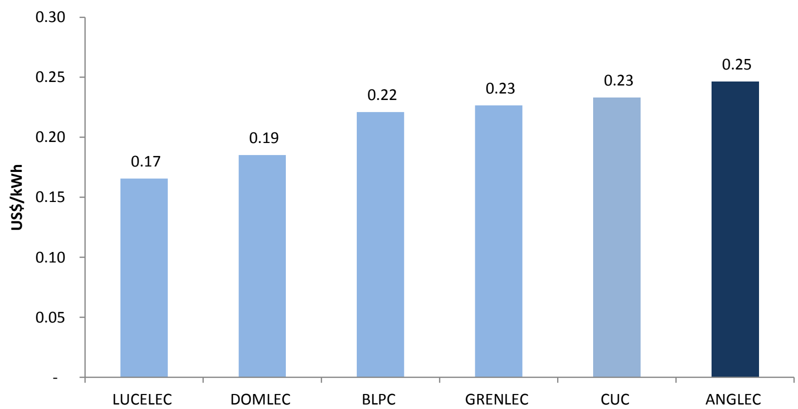
[36] Information provided by ANGLEC Management, January-March 2012

[37] ANGLEC. "2013 Corito Power Station Expansion Justification." 2009

[38] Information provided by ANGLEC Management, January-March 2012. Improving fuel procurement is outside the scope of this assignment, but ways to do so could be identified by a cost of service study.

Cayman Islands, or Saint Lucia. As we recommend in section 7.2.3, commissioning a cost of service study would allow identifying ways to reduce generation operating costs.

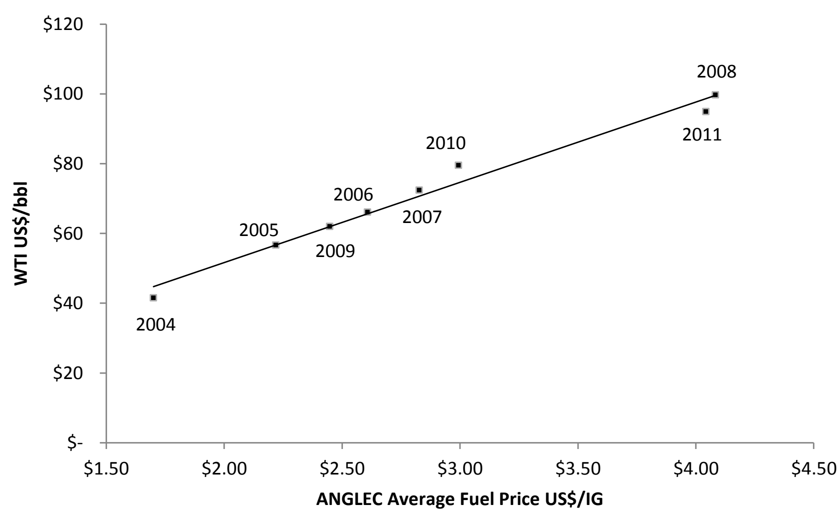
Figure B.4: ANGLEC's Generation Operating Cost compared to other Caribbean Utilities (2010)



Source: Utilities' Annual Reports, 2010

Figure B.5 shows the correlation between the average price of fuel paid by ANGLEC compared to the average price of West Texas Intermediate (WTI) crude oil.

Figure B.5: ANGLEC's Average Price of Fuel (US$/IG) and WTI Crude (US$/bbl)



Source: ANGLEC Annual Reports, information from ANGLEC Management, CME Group

In 2008—the most recent year where WTI crude oil averaged US$100 per barrel[39]—ANGLEC paid an average of about US$4 per imperial gallon (IG) for diesel.[40] In 2010,

[39] U.S. West Texas Intermediate and Gulf Coast No 2 Diesel Low Sulfur Spot Price FOB, US Energy Information Administration, *Spot Prices for Crude Oil and Petroleum Products*, http://www.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm

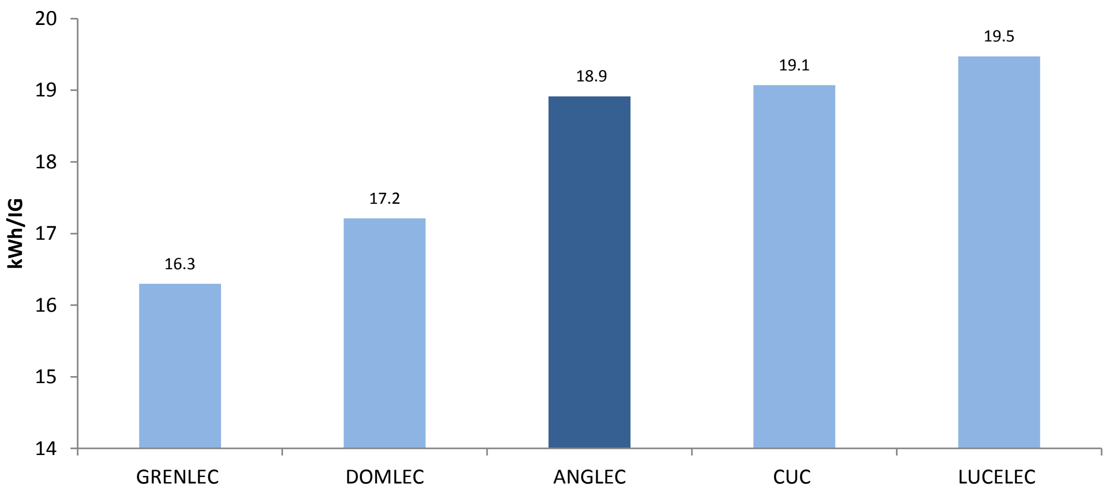
[40] The price is derived from dividing ANGLEC's fuel cost for the year by the number of gallons that it used in its operations in that year

ANGLEC's average fuel price was about US$3 per IG, and WTI averaged about US$80 per barrel. In 2011, ANGLEC's average fuel price was about US$4 per IG, with WTI average at about US$95 per barrel.[41]

B.2.5 Fuel efficiency

Figure B.6 compares fuel efficiency—gross kWh generated per IG of fuel consumed, considering diesel plants only—across various Caribbean countries. ANGLEC's relative efficiency is shown by its middle ranking even when compared to some larger systems such as Saint Lucia (76MW installed capacity, 56MW peak demand). To ensure an accurate comparison, Dominica's figures are based only on its diesel plants, excluding hydro-based generation.

Figure B.6: ANGLEC's Fuel Efficiency compared to other Caribbean Utilities (2010)



Source: Source: Utilities' Annual Reports, 2010 (diesel-based generation only considered)

B.2.6 Opportunities and constraints for fuel supply

Fuel supply in Anguilla is characterized more by constraints than opportunities. Fuel is provided in small barges due to lack of deep seawater ports. This increases the frequency and costs of supply, and limits the competitiveness of procurement.[42] The use of cheaper fuels such as heavy fuel oil is limited by the size of the plants used for ANGLEC's market (low speed diesel plants in Barbados, for example, are about 12.5MW each—245 percent larger than ANGLEC's largest unit); the lighter Diesel No. 2 remains the most convenient option for fossil fuel-based generation. Finally, Anguilla lies far from ongoing initiatives for increased energy integration in the Caribbean, such as the planned East Caribbean Gas Pipeline from Trinidad and Tobago.[43] A submarine connection to Nevis could be considered

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[41] U.S. West Texas Intermediate and Gulf Coast No 2 Diesel Low Sulfur Spot Price FOB, US Energy Information Administration, *Spot Prices for Crude Oil and Petroleum Products*, http://www.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm and http://www.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EER_EPD2DL_PF4_RGC_DPG&f=D

[42] Information provided by ANGLEC Management, January 15, 2012

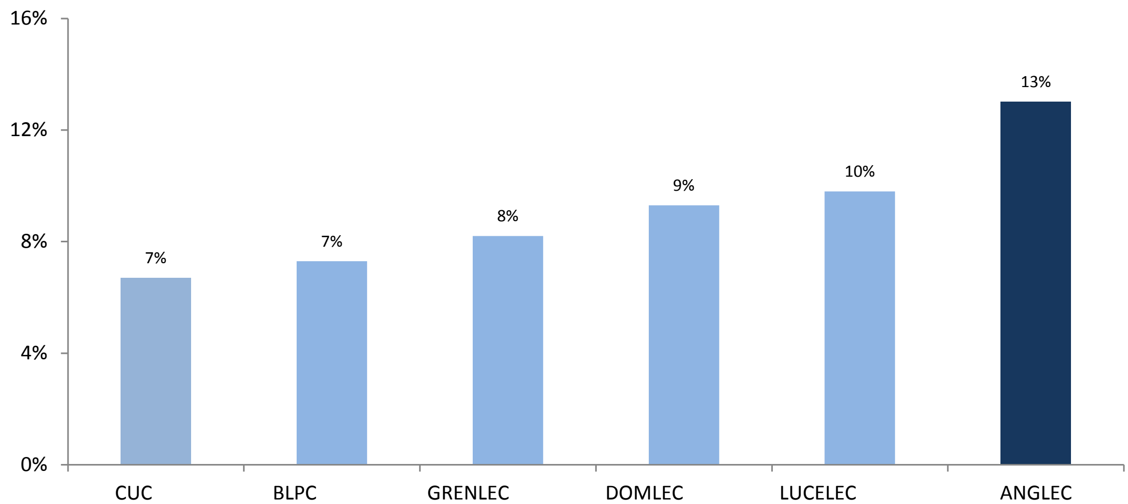
[43] Unlike other OECS countries, Anguilla is not considered for the Eastern Caribbean Gas Pipeline by the latest publications available on the topic: World Bank, Energy Sector Management Assistance Programme (2006). *OECS Energy Issues and Options*; and World Bank (2010). *Caribbean Regional Electricity Generation, Interconnection, and Fuels Supply Strategy*.

assuming that sufficient geothermal capacity is developed on Nevis to be exported to countries other than St. Kitts, but geothermal development in Nevis has been much slower than expected.[44]

B.2.7 System losses

System losses are equal to net energy generated minus energy consumed by customers—they account for losses of electricity during transmission and distribution, as well as theft and under-billing. Electricity systems in industrialized countries typically have system losses below 10 percent. ANGLEC's system losses in 2010 (13 percent) were relatively high compared to those of other Caribbean utilities, as shown in Figure B.7. ANGLEC management estimates that current losses are about 12 percent (10 percent for transmission and distribution losses, and 2 percent for commercial losses). Again as recommended in section 7.2.3, a cost of service study could identify opportunities to reduce losses.

Figure B.7: ANGLEC's System Losses compared to other Caribbean Utilities (2010)



Source: Utilities' Annual Reports, 2010

[44] This possibility is mentioned in the National Energy Policy, part II, page 14. As of today, however, geothermal development in Nevis has stalled—three slim holes were drilled in 2008 confirming good temperatures for a project of up to 35MW, but little progress has been made since (R. Bertani (2012). *Geothermal power generation in the world 2005-2010 update report*, in Geothermics 41 (2012) 1-29).

Appendix C: Electricity Tariffs in Anguilla

In this appendix, we review ANGLEC's tariff categories and components.

C.1 Tariff Categories

ANGLEC does not have specified tariff categories. In fact, its base rates are based only on monthly consumption level for residential and non-residential customers alike. However, in practice they roughly correspond to different customer segments:

- The first base rate equates to a 'lifeline tariff'[45] to ensure that the poorest in Anguilla can have access to a small amount of electricity. The first 40kWh are sold as a block for EC$22. It is not possible to purchase an amount of electricity lower than 40kWh for a fraction of the price;
- The second base rate applies mainly to residential and small commercial customers;
- The third base rate applies to medium-large commercial operations with greater electricity needs (for example, hotels); and
- The fourth base rate applies to ANGLEC's largest commercial customers (very large hotels, for example). There are no industrial customers.

C.2 Tariff Components

Tariffs charged by ANGLEC to its customers comprise a base rate per kWh, which includes a fixed portion of fuel costs; a fuel surcharge per kWh that depends on the cost per gallon of fuel oil; and an environmental levy.

- The **base rate** portion of the electricity tariff is intended to cover the operating expenses of the utility, and provide a return on assets for ANGLEC. It is set by the Government through regulation. According to ANGLEC's Electricity (Rates and Charges) Regulations, 2004 ANGLEC's base rates in Eastern Caribbean Dollars are as follows:

  "Where consumption per month—

  – *does not exceed 40 units (kilowatt hours): US$8.30*

  – *exceeds 40 units but does not exceed 25,000 units (kilowatt hours): US$0.24 cents per unit*

  – *exceeds 25,000 units (kilowatt hours) but does not exceed 100,000 units (kilowatt hours): US$0.23 cents per unit*

  – *exceeds 100,000 units (kilowatt hours): US$0.15 cents per unit, plus an additional fixed charge of US$7,735."*

- The **fuel surcharge** portion of the electricity tariff is designed to recover expenses incurred by the utility due to variations in the cost of fuel with respect to the fixed reference of US$1.35 per gallon. If and when the cost per gallon of fuel imported differs from US$1.35 per gallon, the fuel surcharge (positive or

45 A pricing strategy designed to provide minimal amounts of electricity at low prices to households. Under a lifeline tariff, the first block of electricity used is provided for free or for a nominal price, with higher blocks carrying increasing prices.

negative) is added to the base rate to adjust the overall rate. The fuel surcharge for ANGLEC's service area is calculated by adding or subtracting US$0.004 per unit for every US$0.04 per gallon increase or decrease in the price of fuel oil over or below US$1.35 per gallon; and

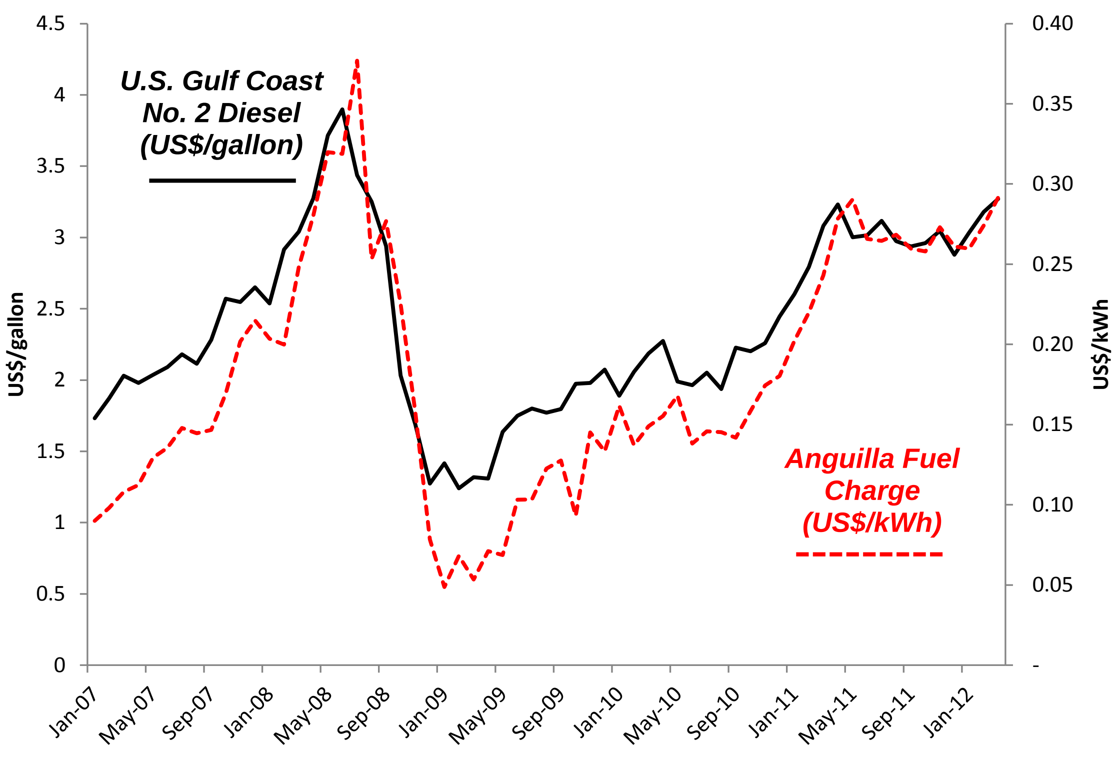
- The **environmental levy** is an additional seven percent (on the sum of the base rate and fuel surcharge) mandated by the Government to be used to pay for sanitation services unrelated to electricity. The levy is assessed to both the base rate and the fuel surcharge and then added to the total tariff.

In addition, the customer is charged a meter rental fee of EC$1.88 per month.

C.3 Volatility of fuel surcharges based on the price of oil

Because all of ANGLEC's generators operate on Diesel fuel, the fuel surcharge portion of the tariff tracks the price of Diesel No.2. This is illustrated in Figure C.1, which shows the direct correlation between the price of Diesel No. 2 and the fuel surcharge in ANGLEC's service area between 2007 and March 2012. The oil price spike of 2008 is well visible.

Figure C.1: Volatility of Fuel surcharge and Gulf Coast Prices of Diesel No.2, 2007-2012



Source: ANGLEC (fuel surcharge) and US Energy Information Administration (Diesel prices)

Appendix D: Analysis of Anguilla's National Energy Policy and Draft Climate Change Policy

In this Appendix we analyze Anguilla's National Energy Policy and draft Climate Change Policy, and the implications for electricity regulation.

D.1 National Energy Policy

ANEC drafted the National Energy Policy (NEP), and EXCO adopted it in December 2009.

The current administration has upheld the NEP adopted by the previous administration (for example, it is upholding the proposed tax incentives for renewable energy technologies), and is working on implementing it. However, the Government is considering updating and expanding, and re-tabling a revised version with EXCO.

Given the NEP's primary focus is to provide reliable and quality supply of electricity at an equitable price, its first goal is to:

> *1. Ensure universal access to an affordable electricity supply for all Anguillans, particularly those below the poverty line for whom basic access is still in doubt.*[46]

The NEP also includes sustainable energy policy goals to be achieved in the medium to long term, acknowledging that a transition to renewable energy will take time, and highlighting that this transition should be achieved "without compromising the reliability and quality of electricity supplies to customers of the Utility by over-accelerating the process of change."[47]

The NEP proposes a new mandate for assuring sustainability, which includes the following goals related to renewable energy:

> *2. Reduce dependence on fossil fuels for power generation and transportation.*
>
> *3. Use locally available renewable resources such as wind and solar power to the greatest extent possible to meet both existing and increasing demand for power generation.*
>
> *6. Support ANGLEC's prudent and viable transition from primarily diesel-based to primarily renewably-based power generation.*
>
> *7. Create a legislative framework for customer-generated renewable power.*[48]

Meeting these goals may require revising legislation and developing new rules that enable renewable energy integration. The Government recognizes this fact, and states as two of the key energy policy goals of the NEP:

> *1. Policies, legislation, regulations, standards and incentives that promote energy efficiency, foster the use of renewable energy resources, and facilitate the transition to and adoption of renewable energy technologies.*
>
> *2. Integration of sustainable energy strategies into national sustainable development planning and programming.*[49]

[46] The Government of Anguilla. "The Anguilla National Energy Policy: 2010-2020." Office of the Chief Minister, 2009.

[47] The Government of Anguilla. "The Anguilla National Energy Policy: 2010-2020." Office of the Chief Minister, 2009.

[48] The Government of Anguilla. "The Anguilla National Energy Policy: 2010-2020." Office of the Chief Minister, 2009.

The NEP also includes a number of relevant policy recommendations, such as to identify the potential and viability of renewable energy in Anguilla, update legislation to encourage the utilization of renewable energy, mandate Environmental Impact Assessments (EIAs) for new energy projects (this would happen if the Bill for Environmental Protection, 2009 is passed and becomes an Act), implement appropriate pricing policies, and facilitate sustainable energy supply network by providing sufficient incentives to encourage private sector investments. The NEP also proposes further strategies for promoting renewables, such as providing tax incentives for the use of renewable energy technologies.

There are no specific targets for renewables in the NEP.

D.2 Draft Climate Change Policy

The Department of Environment of the Ministry of Home Affairs prepared the draft Climate Change Policy CCP based on a series of national consultations conducted from 2008 to 2010. This process was funded by DFID as part of the regional Enhancing Capacity for Adaptation to Climate Change in the Caribbean UK Overseas Territories (ECACC) Project. Anguilla's Climate Change Policy has not been adopted by EXCO.

The draft CPP complements and supports the NEP. The draft CCP's policy statement is to ensure that by filling policy, legislative, and institutional gaps, and cooperating between the Government and stakeholders, the country will be able to manage climate change impacts and transition to a climate resilient, energy efficient, and low carbon economy.[50]

The two policy goals that are relevant to renewable energy integration are:

> *8. Achieve energy independence and the ability of Anguilla to meet its vital energy needs with reliable, affordable and renewable energy resources, through the pursuit of a balanced and advantageous transition toward control of our energy future, built upon a solid and ever growing foundation of our own free, abundant, clean, and renewable energy resources - (the wind and the sun).*
>
> *10. Create a more competitive and environmentally responsible private sector by implementing "no regrets" measures that will protect the environment, promote low carbon energy efficient development while enhancing the resilience of natural ecosystems to climate change impacts.*[51]

We would recommend that goal number 8 be rephrased as 'achieve *greater* energy independence' or 'pursue energy security'. Using renewables may improve energy security, since it may increase reliability and resilience. A better diversified portfolio benefits the country by increasing the likelihood that electricity is available when needed, and decreasing the share of electricity supply that is subject to external shocks. However, Anguilla should not pursue energy independence at any cost—only if the energy security benefits exceed the economic costs. Achieving energy independence at any cost could prove impossible given that Anguilla's renewable energy options cannot provide firm power with today's commercially viable technologies; may jeopardize the NEP's main goal to "ensure universal

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[49] The Government of Anguilla. "The Anguilla National Energy Policy: 2010-2020." Office of the Chief Minister, 2009.

[50] Government of Anguilla. "Transforming to a Climate-Resilient, Energy Efficient and Low Carbon Economy-Anguilla's Climate Change Policy". 2011.

[51] Government of Anguilla. "Transforming to a Climate-Resilient, Energy Efficient and Low Carbon Economy-Anguilla's Climate Change Policy". 2011.

access to an affordable electricity supply for all Anguillans"; and would be counter to the Government's priority policy objective of enabling renewable energy integration to reduce costs, while increasing energy security and enhancing environmental sustainability.

The draft CCP also includes directives to ensure implementation of the goals, and objectives within the next five years to facilitate the transition to a climate resilient, energy efficient, and low carbon economy. There are several policy directives for energy security that would support implementation of the draft CCP. These policy directives include: (i) implementing the energy policy, (ii) implementing the recommendations of the energy policy to meet new energy demand using renewable energy sources, and (iii) enacting and enforcing the draft Environmental Protection Bill. These policy directives are appropriate ways to enable implementation of the draft CCP.

There are no specific targets for renewables in the draft CCP.

Appendix E: Analysis of Anguilla's Relevant Laws and Regulations

E.1 Control of Supply of Electricity

Legal rules control the supply of electricity in Anguilla at two levels:

1. Rules regulating the supply of electricity generally through a licensing regime established under the Electricity Act, E035; and
2. Rules contained in the corporate instruments of ANGLEC to which it is subject as a company registered under the Company Act, C065 of the Revised Laws of Anguilla.

Below we discuss those rules that are relevant to renewable energy integration (E.1.1. Licensing; and E.1.2 Corporate Instruments).

E.1.1 Licensing

The licensing regime rules of the Electricity Act, E035 are set out in the Act itself; in Regulations made under the Act, namely the Electricity Supply Regulations E035 and the Electricity (Rates and Charges) Regulations E35-2 as amended by the Electricity (Rates and Charges) (Amendment) Regulations 2009; and in licences issued under the Act. The rules contained in a licence are statutory—that is to say, they are mandated under statute, in particular, regulation 2 of the Electricity Supply Regulations. However, the Governor is given the discretion to determine certain terms, for example, the term of the licence and the area of supply.

Below we examine the rules in the Act and Regulations separately from those in ANGLEC's licence, which is the only licence issued to date.

Electricity Act and Regulations

The Electricity Act, E035 prohibits persons from using any electrical plant—including renewable energy plant—to supply any premises with electricity, unless the supply is authorized by a licence issued by the Governor, or the Act exempts the supply from the requirement for a licence.[52] If a person supplies electricity in violation of this prohibition he commits an offence and may be made to pay a fine of up to $5,000 or be imprisoned for up to 6 months.[53]

The Act empowers the Governor to issue only two types of licences: a public supplier's licence to supply electricity to any part of Anguilla, and a private supplier's licence to supply electricity to the person's own premises. It does not contemplate a licence to supply electricity on a commercial basis to a public supplier who has a public supplier's licence.

The Act exempts from the requirement for a licence any electrical plant that:

> *(a) is powered only by wind and which is used by any person for the purpose only of supplying electricity to his own premises;*

[52] Section 2.

[53] Section 4.

(b) is used only for the photovoltaic generation of electricity by any person for the purpose only of supplying electricity to his own premises;

(c) is installed in any vehicle, vessel or aircraft for the purpose only of supplying electricity to that vehicle, vessel or aircraft;

(d) is used only for the purpose of supplying electricity at such times as there is a temporary breakdown in the supply of electricity under a public supplier's licence;

(e) is such electrical plant as mentioned in paragraph (d) at such times as the plant is being used only for the purpose of servicing or testing the plant;

(f) is used only in connection with the carrying on of any constructional or repair work, or any excavation, in any case where it is not reasonably practicable to use electricity supplied under a public supplier's licence; or

(g) is electrical plant of any class or description as may be prescribed by the Governor by regulation for the purposes of this subsection.

The Act deals comprehensively with the application and issue of the licence, but contains limited provisions as to the terms and conditions to which a licence is subject.

In the case of the private supplier's licence, the Act has only one condition apart from the requirement that the electric plant be used only to generate for one's own consumption: the electric plant must not be used in a manner likely to constitute a nuisance, or cause injury to, any other person. Failure to comply may result in the revocation of the licence by the Electricity Commissioner. The Act leaves all other terms to be set in the licence. No private supplier's licence has to date been issued, but the Electricity Supply Regulations E035 sets out (in four short paragraphs in Schedule 2) what must be included if and when such a licence is issued: the term, which can be no more than 5 years; and the notice and procedure for terminating, revoking, and renewing the licence.

In respect of the public supplier's licence, the Act imposes more conditions, but again the details and additional conditions are left to be established by Regulations, and in the licence. These terms and conditions relate to standards of service, tariffs, and land rights. These terms and conditions are more extensive than those of the private supplier's licence, as explained below.

As to the exercise of regulatory functions over the electricity sector, the Act gives the Governor the responsibility for the issue of licences. However, his discretion is limited as to the terms and conditions subject to which the licensee operates—the terms and conditions of licences are prescribed in the Electricity Supply Regulations E035. The regulatory function of monitoring and enforcement of these licence conditions is performed by the Electricity Commissioner (a post established by the Electricity Act, E035), the Governor, and the High Court. Enforcement involves warning notices and may escalate to heavy fines and revocation of the licence if the warning notices are not heeded. Despite the useful enforcement procedures, the enforcement aspect of the regulatory function is also limited because the standards to be enforced are set in terms that only seek to ensure that the public supplier meets overall objectives. (See the public supplier's broad service standards in section E.2, and the broad criteria for tariff adjustments in section E.3.)

ANGLEC's Licence

On 28 March 1991, the Governor issued an exclusive public supplier's licence to ANGLEC to supply electricity to the whole of Anguilla for a period of 50 years[54] (unless revoked or terminated under section 6 of the Act), starting on 1 April 1991 (the same day that the Electricity Act, E035 came into force). The licence states that it is issued 'in consideration of' the performance of ANGLEC's obligations under the licence.

Generally, the licence confirms that its provisions are subject to the Act. The important features for the purpose of understanding the legal and regulatory framework for electricity are the assignment rights it gives to ANGLEC, and the provisions relating to service standards and tariffs. Here we discuss the assignment rights—we explain the service standards below in section E.2, and tariffs in section E.3.

Assignment rights

Under clause 11, ANGLEC can transfer or assign 'the licence or the benefit of the whole or any part of it' if it has the prior written consent of the Governor. This provides ANGLEC with a legal basis, once it has prior approval:[55]

- To hand over everything to another utility, or
- To give an independent power producer (IPP) the right to produce power under ANGLEC's licence, which power ANGLEC could repurchase in accordance with the terms of a power purchase agreement between ANGLEC and the IPP (the IPP would be using an electric plant under a licence—ANGLEC's licence—and so may be considered to satisfy the requirements of section 2 without a further licence in its own name), or
- To hand over distribution once the reselling rates comply with the rates set by the Electric Commissioner under section 30 of the Electricity Supply Act, E035, or
- To enter into a contract under which it keeps possession of the electric plant, but permits another entity to operate the electric plant in its name.

Despite any power of ANGLEC under clause 11 to allow others to produce power on its behalf from which it can later purchase, ANGLEC cannot purchase power from the holder of a private licence or a person exempted from the requirement of a licence because the private licence holder and the exempted person is prohibited from using their plant for a purpose other than producing electricity for their own use.

E.1.2 Corporate Instruments

The corporate instruments of a company are the instruments that govern the affairs of the company. The key instrument that regulates who has the power to make decisions and how they are made is ANGLEC's by-laws. Under the by-laws, the business affairs are managed by

[54] The Anguilla Electricity Ordinance 1991. *Public Supplier's Licence issued to Anguilla Electricity Company Limited by the Government of Anguilla*. March 28th, 1991.

[55]

Table 7.2 presents the various licence options for utility scale renewables, followed by a discussion of advantages and disadvantages of each option..

directors, who are appointed by ANGLEC's shareholders. As the holder of a majority of shares (as noted above, directly and through Government Social Security the Government holds 56 percent of the shares), the Government exercises considerable control over the appointment of ANGLEC'S directors, and the policies implemented by the company.

The directors exercise their powers by decisions taken by majority at meetings. Outside of meetings, a resolution signed by all directors entitled to vote at a meeting has the same effect as a decision taken at a meeting. The Managing Director and other officers of ANGLEC perform their duties under the authority and control of the directors, who are empowered to delegate its powers to committees of directors or officers of the company.

Under paragraph 4.11 of the by-laws, the directors may impose on the officers any terms and conditions or any restrictions that they think fit in respect of the powers entrusted to the officers. This means that—in addition to the terms and conditions in the Act, Regulations, and licence—ANGLEC is subject to any internal terms and conditions imposed by the directors on officers charged with actually carrying out the statutory duties of ANGLEC as a public supplier. This is an important provision for our recommendations (section 7.1.1).

E.2 Service Standards

The Act, Regulations, and licence set service standards with which the public supplier must comply. The Act contains only a few: the maximum power to be supplied, street lighting obligations of the public supplier, and the use and maintenance of meters. The Electricity Supply Regulations E035 contain detailed standards respecting the voltage at which electricity is to be supplied, and set out in Schedule 1, one main standard that must be included in a public supplier's licence, and which is included in ANGLEC's licence:

> '[*ANGLEC*] *shall operate, control, manage, and maintain the system for the generation, transmission, distribution and supply of electricity to the public … with a view to providing a regular, sufficient and continuous supply of electricity'*.

Having regard to ANGLEC's assignment rights discussed above (E.1.1), any or all of these activities may be carried out by a person to whom ANGLEC assigns the relevant rights under its licence.

The Act, Regulations, and ANGLEC's licence do not control how ANGLEC must meet this overall objective. In other words, they do not have restrictions concerning what electric plant can be used, when, to what extent, and how, the capacity of the plant can be increased (for example requiring that expansion is least cost or that renewable energy options are considered in preparing expansion plans). They do not create an obligation on ANGLEC to get approval of its generation expansion plans. To recover its cost of generation expansion and maintenance through tariffs, all ANGLEC must show is that the costs were reasonable (see section E.3). Expansion and maintenance is therefore a business decision to be taken in accordance with ANGLEC's corporate instruments, subject only to an overall requirement that the supply be regular, sufficient, and continuous; and costs reasonable.

E.3 Tariff Regulation

The Electricity Act, E035 contemplates two types of tariffs: (i) a tariff of rates for the charges that a public supplier can charge a customer; and (ii) a tariff at which a person to whom the public supplier supplies electricity can resell the electricity.

In respect of the rates for reselling, the Act empowers the Electricity Commissioner to set maximum rates in his sole discretion. In respect of the rates for selling to a consumer, a more complex framework is set up. The Act empowers the Governor to establish a tariff of rates in regulations. Some tariff rules are also contained in the licence. These rules in the regulations and licence require that the tariff have a specific structure, establish specific rates, and set out a procedure for changing the value of the tariff. We explain the tariff structure and rates in section E.3.1; and the procedure for changing tariffs rates in section E.3.2.

E.3.1 Tariff structure and rates

The current tariff structure and rates are governed by ANGLEC's public supplier's licence, the content of which is mandated by the Electricity Supply Regulations, E035 and the Electricity (Rates and Charges) Regulations, E35-2 as amended by the Electricity (Rates and Charges) (Amendment) Regulations, 2009. The licence entitles ANGLEC to charge a base rate and fuel adjustment surcharge. The 'Rates and Charges' regulations establish the values of the rate and surcharge: the base rates vary according to usage, and the fuel surcharge is EC$0.01 per unit for every 10 cents per gallon increase in the price of fuel oil over EC$3.64 per gallon.

E.3.2 Rate Adjustment Procedure

The rate adjustment procedure is governed by the public supplier's licence, the content of which is mandated by the Electricity Supply Regulations, E035.

The responsibility for initiating the procedure is placed on ANGLEC. If the company wants a rate adjustment it must serve a serve a notice on the Minister with responsibility for electricity, requesting a rate change of a specified amount, to commence on a future date (not less than 90 days from the date of the notice) stated in the notice. Together with the notice, ANGLEC must submit its most recent audited accounts; and its estimate for the 5 following financial years. ANGLEC must publish the notice for the information of the general public. If the Minister does not approve the notice within 30 days, ANGLEC may apply for the matter to be determined by an arbitrator chosen by the parties, or, if they cannot agree, by the Governor. If adjustment is agreed, it is given effect through new electricity (rates and charges) regulations, which would repeal the existing ones.

As required by the Electricity Supply Regulations, E035, ANGLEC's licence sets criteria to provide guidance for Minister and the Arbitrator in the exercise of their discretion as to whether, and to what extent, rates should be adjusted. In deciding whether to approve a rate adjustment requested by ANGLEC, they must ensure that the rates are at least sufficient to enable ANGLEC:

- To meet all expenses reasonably incurred in the production of such revenues, including (without limitation) depreciation of assets, provision for bad debts and interest on indebtedness;
- To repay its indebtedness;
- To provide for the cost of replacement of its capital assets;
- To provide a reasonable proportion of the capital costs of expanding its undertaking to meet any demand for an increased service to the public; and
- To provide an annual return on its Ordinary Shareholders' Equity at a rate not less than 12 per cent per year (this rate enables ANGLEC to raise the capital that

it needs to make the necessary investment in plant to meet its obligation of providing a reliable service).

If the Minister or the Arbitrator requires information other than the audited accounts and the five-year forecast for the purpose assessing ANGLEC, having regard to the criteria above, they may request this information. Although the Electricity Act, 035, and the licence do not expressly give this power, the Interpretation and General Clauses Act, I025 establishes that if a duty is given to an authority, the authority has the power to do all things that are necessary to enable it to perform its duty:

Construction of enabling words

> *38. Where in any law power is given to any person to do or enforce the doing of any act or thing, all such powers shall be understood to be also given as are reasonably necessary to enable the person to do or enforce the doing of the act or thing.*

The last time the rate adjustment procedure was invoked was after Hurricane Luis had caused considerable damage to ANGLEC's equipment and apparatus. By letter addressed to the Minister of Public Works, ANGLEC requested a ten percent rate increase from EC$0.60 by EC$0.66. It submitted audited financial statements with its request. In a letter from the Chief Minister in January, 1996, ANGLEC's application was rejected. It was indicated that the rejection was agreed upon in EXCO. ANGLEC brought the matter to arbitration. The Arbitrator was selected by agreement between ANGLEC and the Government. The Arbitrator awarded half the increase sought.

E.4 Land rights

Renewable electricity generation requires land on which the wind turbines, solar systems, or other projects (such as waste-based renewable energy projects) can be located, including the right to access this land over the land of others. Also necessary is the right to develop the land as a power plant. Thirdly, it is necessary to obtain rights to place poles and other apparatus on the land of others. Below we describe the legal framework for acquiring land (E.4.1), including the right to access it over the land of others; for obtaining the right to develop land (E.4.2); and for obtaining rights over the land of others to place poles and other apparatus (E.4.3).

E.4.1 Land acquisition

While the extent of land necessary for utility scale and distributed scale operations may differ, both operations require the same type of land rights for their operations. Generally an interest in land must be secured through outright purchase, or the lease of the land. If access to this land must be obtained by passing over the land of another, easements are necessary.

If waste-based renewable energy projects use gas from waste on the property of another, a servitude different from an easement—a *profit-à-prendre*—may also be required to entitle the developer to take the gas produced on the land of another.

For solar systems, one may opt to obtain not ownership or a lease, but a contractual licence to place solar panels on the property of another containing terms that restrict the licensor's right to revoke it.

All these rights are governed by land law. Anguilla's land law comprises the English common law of real property as codified, amended, and supplemented by Anguillan legislation.

The Common Law (Declaration of Application) Act, C60 declares that the English common law is in force in Anguilla. The English common law of real property establishes the interests that can be held in land and rules for how these interests can be created and transferred. The Registered Land Act, R30 simplified these rules and introduced more certainty in land transactions. The Government Lands Regulation Act, G010, enables special rules to be established to govern land held by the Government, but no such special rules have been made. However, the Land Acquisition Act, L010 gives the Government special powers to compulsorily acquire land held by anyone. Also relevant is the Aliens Landholding Regulation Act, A055, which imposes restrictions on non-Anguillans to hold and transfer interests in land.[56]

The effect of these laws is that land and easements can be acquired by private treaty between the developer and the landowner (whether private or Government), or by compulsory acquisition by the Government and transferred to the developer. The Electricity Act, E035 comprehensively deals with how and when compulsory acquisition, as opposed to private treaty, can be used. It states in section 10:

> *10. (1) When a public supplier needs land for the purpose of generating, transmitting, distributing or supplying electricity, the supplier shall endeavour to acquire such land by private treaty*
>
> *(2) Where the public supplier fails to acquire such land by private treaty and where the Governor in Council considers that such land is necessary for the purpose of generating, transmitting, distributing or supplying electricity, the Governor in Council may, at the request of the public supplier, cause necessary action to be taken to acquire such land in accordance with the provisions of the Land Acquisition Act and, upon such acquisition, to transfer the land to the public supplier on payment of the full cost of acquisition to the Government by the supplier*
>
> *(3) Acquisition of any land for the purpose of subsection (2) shall be deemed to be for a public purpose within the meaning of the Land Acquisition Act.*

Land is not defined in the Land Acquisition Act, L010 or in the Electricity Act, E035. The Interpretation and General Clauses Act, I25 dictates that land has the following meaning when used in an Act, if the Act does not contain a definition:

> *"land" includes all tenements or hereditaments, and also all messuages, houses, buildings, or other constructions, whether the property of Her Majesty, Her heirs or successors, or of any corporation, or of any private individual, except where there are words to exclude houses and other buildings;*

The legal principle established by the authorities is that:

> *When power is given by statute to acquire land compulsorily, the whole interest must be acquired notwithstanding the definition of 'land' in the empowering enactment as including easements or rights over land, unless special provision is made, and there is no power to require and acquire an easement, right or lease only…If the land acquired has attached to it the benefit of a right of way or other easement with respect to other land, that benefit will pass to the acquiring authority on the conveyance of the land acquired.*[57]

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[56] There are other statutes affecting land rights but which are not important for current purposes: the **Small Tenements Act, S40** regulating the rights of persons of property leased for little or no rent; the **Law of Property (Miscellaneous Provisions) Act, L025** which deals with the powers of others to execute of hold land documents on behalf of others.

[57] Halsbury's Laws of England, Compulsory Acquisition of Land, Vol.18 (2009) 5th Edition, para. 532.

Therefore, section 10 of the Electricity Act, E035 and the Land Acquisition Act, L010 entitle the Government to compulsorily acquire the full rights of the registered proprietor over land. It is also clear that any existing easements over other land not being acquired, which exist for the benefit of the land acquired, will pass with the conveyance to the Government, and then to the electricity supplier when the property is transferred.

However, whether the Government can acquire only a lease in the land being acquired, or create additional easements in land not being acquired that do not already exist for the benefit of the land being acquired, depends on the construction of the Electricity Act, E035 and the Land Acquisition Act, L010. The Government can acquire such lease or easements if these Acts can be interpreted as making special provision for this. Our review of these Acts reveals that there is nothing in them (except perhaps section 24 of the Land Acquisition Act, L010) from which such special provision can be inferred. On the contrary there is much from which it can be inferred that only acquisition of full title is contemplated. Indeed, section 2(3) of the Land Acquisition Act, L010 expressly declares that once the required notices are placed in the Gazette, 'the land shall vest absolutely in the Crown.' Under the Land Registration Act, a person with absolute title has absolute ownership. Absolute title is in not consistent with a lease or an easement.

E.4.2 Land development

Unless a renewable energy developer has the prior written permission of the development authority (the Land Development Control Committee) or the development is exempted under the Land Development Control Regulations, L015, the developer will not be able to set up a renewable energy electric plant if setting up that plant amounts to developing the land within the meaning of the Land Development (Control) Act, L015.[58] Development is defined as follows:

> *"development", in relation to any land, includes any building or rebuilding operations, engineering operations, mining operations (including the removal of sand) in, on, over or under any land, the making of any material change in the use of any building or land, the subdivision of any land, the laying out of roads, the filling of ravines or swamps, or any other preparatory work which indicates an intention thereby to change or alter the existing nature or character of any land and "develop" shall be construed accordingly;*

Exempted developments under the Land Development Control Regulations, L015 include:

> *Class 1. Any enlargement, improvement or other alteration of a dwelling house subject to the conditions—*
>
> *(a) that the external cubic content of the original house is not exceeded by one-tenth or 50 cubic metres, whichever is the greater;*
>
> *(b) that the height of such enlargement or improvement or other alteration does not exceed the highest part of the roof of the original house; and*
>
> *(c) that such enlargement or improvement or other alteration does not extend beyond the furthest point of any wall of the house abutting a road;*

[58] There is a draft Physical Planning Bill which, if passed will repeal and replace this Act. While this Act may introduce changes to the procedure, the definition of develop and conditions of approval, this comment is equally valid in respect of this draft legislation.

Under the Act, therefore, the installation on a dwelling house of apparatus for the generation of solar power may fall within the exempted developments prescribed by the Land Development Control Regulations, L015 (the Land Development Control Committee also stated this during our meeting). In contrast, the setting up of wind, waste-to-energy plants and solar plants (except those that fall within the exception cited above) would need approval.

To protect the environment, development applications are likely to involve environmental impact assessments. Although this is not an explicit requirement under the Act, it is facilitated by the broad powers in the Regulations to request additional information before approving applications for developments. There is draft legislation, the Physical Planning Bill, which proposes to make environmental impact assessments mandatory for 'power plants'. Other draft legislation, the Environmental Protection Bill, proposes to provide a framework for the Minister responsible for the environment, and committees established under the Bill, to review activities—including electricity supply activities—proposed in Anguilla for their potential impact on the environment, and require environmental impact assessment reports where this is deemed necessary (such reports are mandatory for certain specified activities—but power generation is not listed as such).

E.4.3 Statutory rights

In addition to easements, which in theory are rights of a landowner to have certain rights over the land of his neighbour for the benefit of his land, the landowner needs statutory rights—that is, rights over any land of others even though the land is not neighbouring land, to erect poles or install wires or other apparatus necessary for the supply of electricity. The Electricity Act, E035 confers such statutory rights on a public supplier in section 9(2), which states:

> *'For the purpose of a public supplier's licence, a public supplier may from time to time cause standards, poles and towers together with fixtures and fittings to be erected, and electric lines to be laid and carried through, across, over or under any road or through, over or under any land whatsoever, enclosed or otherwise'*

In addition to this, the Schedule of the Act sets out some details respecting those rights and the procedure that must be followed by the public supplier to take advantage of these rights.

Apart from conferring these statutory rights on the public supplier, the law of Anguilla, in particular the Registered Land Act, R30, section 28(h) and (i), expressly declares that the rights of all owners of registered land in Anguilla are subject to these statutory rights. It gives these rights the status of 'overriding interests.'

Table E.1: Summary of Land Rights

	Utility Scale Renewables	Distributed Scale Renewables	Existing Legislation	Conclusion
Land acquisition	Requires purchase, or lease of the land, servitude if on another's property (waste projects), or contractual licence (to place solar panels on another's	Requires purchase, or lease of the land, or contractual licence (to place solar panels on another's property)	All land acquisition rights governed by existing land laws and Electricity Act	Land and easements can be acquired by private treaty between the developer and the landowner, or by compulsory acquisition by the

	Utility Scale Renewables	Distributed Scale Renewables	Existing Legislation	Conclusion
	property), or compulsory acquisition of land by Government			Government and transferred to the developer
Land development	Developer needs permission from Land Development Control Committee to set up a utility scale renewable energy project	Exempted from permits if renewable system does not exceed a certain size defined in the land development control regulations	Land development governed by Land Development Control Regulations. Environmental impact assessment can also be requested in an *ad hoc* manner	Land development control legislation governs land development, but environmental legislation would strengthen environmental management
Statutory rights	Need rights over any land (even if not neighboring land), to erect poles or install wires or other apparatus necessary for the supply of electricity	Not required	Electricity Act confers statutory rights to ANGLEC, Registered Land Act provides that rights of all registered land owners are also subject to these statutory rights	Electricity Act and Registered Land Act provide the necessary statutory rights needed for utility scale projects, and not needed for distributed scale renewables

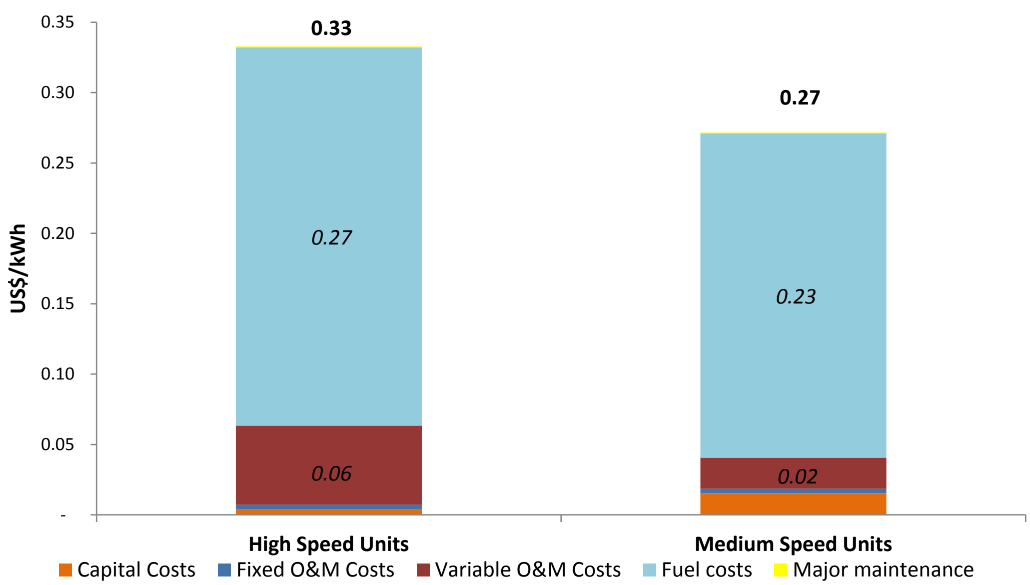
Appendix F: Estimated Conventional Generation Costs and Electricity Tariffs for Assessing Renewables

In this appendix we estimate conventional generation costs and electricity tariffs for assessing the economic and commercial viability of renewable energy in Anguilla. It is important to note that the numbers we estimate are not historical values, but theoretical ones for purposes of analysis, given a certain assumption on the cost of diesel fuel (as we explain below, we conduct our estimate assuming that diesel costs US$4 per gallon).

F.1 Estimated Conventional Generation Costs

For our analysis of the viability of renewable energy technologies in section 5, we calculate a benchmark generation cost of ANGLEC's conventional plant. Figure F.1 shows an estimate of the all-in cost (or long run marginal cost, LRMC) of the two types of generators currently operated by ANGLEC (high and medium speed diesel plants) based on a Diesel No.2 price of US$4.00 per IG.

Figure F.1: Estimated All-in Costs of Generation of ANGLEC's Plants with Diesel US$4.00/IG



Source: Castalia estimate based on data on current plants provided by ANGLEC.

Note: Figures based on assumed Diesel fuel costs of US$4.00 per gallon.

We use a figure of US$4.00 per IG because we need to use some estimate of future oil prices, and a good source for these is a futures oil contract. As of April 2012, WTI crude oil futures are trading at about US$102 per barrel for December 2013, about US$98 per barrel for December 2014, and about US$95 for December 2015.[59] Based on the correlation shown in the past between ANGLEC's average fuel prices and WTI oil, US$4 per barrel is a

[59] CME Group. "Light Sweet Crude Oil Futures." Accessed April 16, 2012 at: http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude.html

reasonable estimate for the period in which Anguilla may consider renewable energy options—as soon as possible, given the current situation commonly described as a crisis.

The figure shows that, at a fuel price of US$4.00 per IG, the all-in cost of generation of high speed units is about US$0.33 per kWh, while that of medium speed units is US$0.27 per kWh. The fuel-only portion of the all-in cost is US$0.27 and US$0.23 per kWh, respectively.[60]

This estimate is based on the following assumptions:[61]

- Capital costs: US$1.2 million per MW for medium speed units, and US$250,000 per MW for medium speed units;
- Weighted Average Cost of Capital (WACC) = 10 percent (real); (WACC = Cost of Equity * Share of Equity + Cost of Debt * Share of Debt, that is 0.12 * 0.64 + 0.065 * 0.36 = 0.10, as provided by ANGLEC);
- Annual inflation in Anguilla: 8.7 percent;[62]
- Tax rate: 0 percent;
- Availability: 87 percent for high speed units, and 95 percent for medium speed units;
- Fuel efficiency: averages for figures between 13.5 and 15.5kWh per IG for high speed units, and between 16.5 and 17.9kWh per IG for medium speed units;
- Operations and maintenance (O&M) costs: fixed O&M US$27 per kW per year; variable O&M US$56 per kW per year and US$22 per kW per year for high speed and medium speed units, respectively;
- Lifetime: 15 years for high speed units, 20 years for medium speed units;
- Major maintenance in years 3, 6, and 9 for high speed units, and years 5, 10, and 15 for medium speed units; and
- Diesel fuel price: US$4.00 per gallon.

F.2 Estimated Tariffs

The table below shows the tariff per kWh for each category established by the base rates when the fuel surcharge—based on the assumption of a diesel price of US$4.00/IG—is added. As agreed with the Government, we show values in United States Dollars so that we may use the values below for assessing the commercial viability of distributed renewable energy technologies.[63]

[60] The price differential of US$0.06 per kWh depends on high speed units' shorter lifetime (25 percent less than medium speed units), lower fuel efficiency, and lower availability, in spite of their lower capital costs.

[61] Meeting with ANGLEC management, Anguilla, 17 February 2012. Remote follow-up by telephone and e-mail, February 2012-April 2012.

[62] Central Statistical Office, Anguilla. 2010 Inflation Rate (period average %). Consumer Price Index Monthly and Annual Data as of January 2012. Eastern Caribbean Bank. http://www.eccb-centralbank.org/Statistics/index.asp#monstats (last accessed 28 March 2012). The inflation assumption translates into a capital recovery factor of 13.15 percent per year for high speed units; and 11.75 percent per year for medium speed units.

[63] Conversion of Eastern Caribbean Dollars $3.64 per gallon to US Dollars (12 March 2012), http://www.xe.com/

Table F.1: Estimated Total Tariffs with Fuel at US$4 per IG (US$ per kWh)

Tariff	Base Rate (a)	Fuel surcharge assuming oil at US$4/IG (b)	Total (a+b+c)
Tariff One (1-40 kWh)	0.21	0.26	0.47
Tariff Two (41-2,500 kWh)	0.24	0.26	0.50
Tariff Three (2,501 - 100,000 kWh)	0.23	0.26	0.50
Tariff Four (> 100,000 kWh)	0.16 (excluding fixed charge)	0.26	0.45 (excluding fixed charge)

Notes: (1) The total tariff does not include the Meter Rental Fee; (2) A Fuel Price of US$4.00 per IG is used for calculating the fuel surcharge; the fuel charge was EC$0.45 or US$0.17 for March 2012; (3) The fixed charge for base rate four is not accounted for.

Appendix G: Renewable Energy Technologies

Below we review the current state and future prospects of 'screened in' renewable energy technologies in Anguilla. We start each section by briefly introducing a technology. Then, we describe the current state of development of each technology in Anguilla. Next, we assess the primary resource that each technology uses. After that, we analyze the technology in greater detail, and identify the type and scale that would be appropriate for Anguilla. Following that, we discuss costs for each technology. Finally, we make a few conclusions about the future potential of the technology in Anguilla.

G.1 Solar Photovoltaic Energy

Anguilla is very well endowed with sunlight, which represents the primary energy resource for solar photovoltaic (PV) systems. Because sunlight is intermittent, solar PV systems—a mature and internationally widespread technology—provide non-firm power, mostly as small or commercial systems distributed on the grid. Capital costs of solar PV systems are expected to fall further, following a downward trend that has brought their generation costs to competitive levels in Anguilla's high electricity price environment. Conversion efficiency of PV panels is also expected to further improve; expected improvements in batteries for backup are more uncertain.

Current state of development in Anguilla

There are no utility scale solar PV plants in Anguilla, and penetration of smaller systems is relatively limited. With the abundance of irradiation that Anguilla receives, many large and medium consumers of electricity—in particular, hotels—have been showing increased interest in systems designed for self-generation. In addition, ANGLEC has created a draft request for proposals for up to 2MW of solar PV installed capacity.[64]

Primary resource

No solar radiation map exists for Anguilla. However, a solar radiation map developed in 2010 for Bahamas[65]—estimating an average between 5 and 6kWh per square meter per day—may be used that as a proxy for Anguilla. These are very similar to radiation values estimated for Barbados and other Caribbean countries, which allows using estimates from other countries for output from various PV panel types (as well as for solar water heaters).

Technology for solar PV energy

Solar PV technology transforms solar radiation into electricity. The basic component of a PV system is the PV cell, a semiconductor device that converts solar radiation into direct-current electricity. ('Conversion efficiency' is the ratio between the electrical power produced by a solar PV cell and the amount of incident solar energy received per second.) PV cells are interconnected to form a PV panel (or module). PV panels combined with a set of additional application-dependent system components (such as inverters, batteries, electrical components, and mounting systems) form a PV system. PV systems can be used individually, or grouped together in arrays.

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[64] ANGLEC. "Request for Proposal: Photovoltaic Generating Plan." January, 2012

[65] Fichtner, *Direct normal solar irradiation on The Bahamas*, based on National Renewable Energy Laboratory (NREL), 2010.

There are currently two types of commercial PV modules: wafer-based crystalline silicon (c-Si, which currently represent about 85 to 90 percent of the global annual market[66]) and thin films. Other technologies, such as advanced thin films, organic cells, and more novel concepts, are being developed, but are not commercially available. The efficiency of solar cells has increased considerably over the past few years, and is expected to increase further, especially for newer types of cells.

There are two categories of wafer-based crystalline silicon modules:

- Monocrystalline modules are made from a single large silicon crystal cut from ingots. This is the most efficient (up to 15 to 20 percent efficiency or more)[67], but also the most expensive type of solar PV panel
- Polycrystalline modules are cast in ingots of silicon that contain several small silicon crystals. This is the most common type of panel currently available on the market, and is somewhat less efficient (down to 13 to 15 percent efficiency)

Thin film panels are more economical to produce, but less efficient (efficiency ranges from 6 to 12 percent). They include amorphous silicon (a-Si) and micromorph silicon; cadmium-telluride (CdTe); and Copper-Indium-Diselenide (CIS) and Copper-Indium-Gallium-Diselenide (CIGS).

Mounting systems for the panels can be fixed, or integrate a tracking system. Tracking systems tilt panels (along one or two axes) towards the sun to increase exposure to radiation. Tracking systems are a mature technology, and increase the overall efficiency of a panel by over 20 percent (depending on panel type). However, they are more fragile and expensive than fixed mounting systems, and are less cost-benefit justified where the solar resource is good; they are also used to a limited extent in areas prone to hurricanes such as Anguilla.

Other technical issues and opportunities

The potential for increasing the use of utility scale PV in Anguilla may be constrained by the country's limited land mass, and fragmented ownership of mostly privately held land. PV systems require between 2.5 and 4 acres of land per MW.[68] Small and medium systems are more likely to be installed on residential and commercial rooftops. However, the constraint in availability of land will only be relevant in the medium to long term, when the cost of solar PV may be low enough to justify the more extensive installation of larger scale systems.

Costs of solar PV energy

The solar industry has made great progress over the past few years in reducing the costs of PV systems, and further reductions in cost are expected in the coming years. The cost of solar modules decreased from around US$27.0 per Watt in 1982 to approximately US$3-4 per Watt in 2012, depending on scale and panel type.[69] According to some estimates,[70] the

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[66] International Energy Agency. Technology Roadmap: Solar Photovoltaic Energy (2010).

[67] Conversion efficiencies based on International Energy Agency. Technology Roadmap: Solar Photovoltaic Energy.

[68] NREL. "PV FAQs: How Much Land will PV need to supply our electricity." 2004 and conversation with Salomon Energy on 4/10/2012

[69] Solar Buzz (2010). Photovoltaic Industry Statistics: Costs (http://www.solarbuzz.com/StatsCosts.htm); conversation with Salomon Energy, April 15,2012.

[70] Energy Information Administration, *Annual Energy Outlook 2010*.

cost of PV systems could drop below US$2.5 per Watt by 2035, driven by expected falling prices of polysilicon (however, a shortage in polysilicon supply in 2008 led to a price hike that could happen again).

Commercial size systems (about 60kW) installed in Anguilla can have an installed cost of about US$3,500-4,500 per kW with polycrystalline panels, depending on the site.[71] Smaller systems of just a few kilowatts, such as that installed at the hospital, are more expensive (about US$4,500 per kW).[72] Past estimates for systems to be installed at hotels are much higher (about US$6,000 per kW)[73]. According to some estimates, installing a battery for full backup could add between US$1,500 and US$2,800 per kW installed,[74] depending on battery quality and type; the cost of installed batteries for a hybrid system in Anguilla[75] are reportedly as low as an additional US$1,000 per kW, but not for full backup. An unsolicited offer for a multi-megawatt solar PV project had a preliminary estimate of installed cost as low as US$2.1 million per MW.[76] More conservative estimates for high-quality utility scale solar PV would be in the order of US$3.0-3.2 million per MW installed for monocrystalline panels—these would have sealed panels, and would be backed by a long term guarantee.[77]

Installed capacity	Unit Capital Cost (US$/kW)	O&M Costs (US$/kW/yr)	Capacity Factor (%)	Annual output (GWh/year)	Lifetime (years)	LRMC (US$/kWh)
Solar PV (polycrystalline, fixed, commercial)						
60kW	3,500	50	21%	0.0108	20	0.24
Solar PV (thin film, fixed, small)						
2kW	4,000	60	21%	0.0036	20	0.28
Solar PV (thin-film, fixed, small, with battery)						
2kW	6,800	60	21%	0.036	20	0.45
Solar PV (monocrystalline, fixed, utility)						
2MW	3,100	60	23%	6.042	20	0.22

Source: Estimates based on information provided by Comet Systems, ANGLEC, Siemens, Salomon Energy.

Note: discount rate of 9% for distributed scale; 11% for utility scale.

The cost of generating electricity with quality solar PV is still relatively high compared to other energy sources—but can be economically and commercially viable in Anguilla. Based on information referenced above and using a discount rate of 9 percent, small and commercial systems at distributed scale in Anguilla—assuming an output of 1,800kWh per

[71] Conversation with Comet Systems, February 2012;

[72] Conversation with ANGLEC, February 2012.

[73] Jadoo Power, estimate for Royale Caribbean Resort.

[74] Conversation with Salomon Energy, 20 April 2012.

[75] Anguilla, February 2012. U.S. Solar Battery: US$250 to $260 per battery (12 batteries); Gold-Cart Battery: US$150 per battery (8 batteries), for a total of 20 batteries for backup power at night (for a hybrid 4kW Solar PV / 200 watt wind system)

[76] Conversation with ANGLEC, April 2012.

[77] Conversation with Siemens and Salomon Energy, 11 April 2012.

kW per year (corresponding to a capacity factor of about 21 percent, that is about 1,840 hours on 8,760 hours per year)—could have an estimated LRMCs between US$0.24 per kWh (for larger, polycrystalline systems of about 60kW), US$0.28 per kWh (for smaller, thin-film systems of about 2kW for domestic use), and US$0.45 per kWh (for smaller, thin film systems that have battery storage capability). For utility scale systems with monocrystalline panels, assuming a higher capacity factor of up to 23 percent and a discount rate of 11 percent, the LRMC could be about US$0.22 per kWh.

Conclusions on solar PV energy in Anguilla

Very good availability of the primary resource; continuously improving technology; relatively easy design, installation, and O&M; and decreasing capital costs all contribute to a positive outlook for solar PV in Anguilla in the medium to long term, both at utility and at distributed scale.

G.2 Solar Water Heaters

As noted, Anguilla enjoys a very good availability and quality of solar radiation. Unlike solar PV, capital costs of solar thermal energy systems used to heat water—a relatively simple and very mature technology—are already low, making this an even more viable renewable energy option for the country.

Current state of development in Anguilla

Penetration of solar hot water systems in the residential and commercial sector of Anguilla is limited, and knowledge of how to install them is too. Some of the systems sold are imported from Australia, while others are manufactured in Barbados and Saint Lucia.

Technology for solar water heating

The main components of a solar water heater system are the storage tank, and the solar collector. There are two main types of solar collectors utilized for low grade thermal applications:

- **Flat plate panels** are the most common type of solar collectors. A flat plate collector is an insulated box with a glazed cover, an absorber, and copper pipes. The solar radiation passes through the glazed cover and heats the absorber. The circulation water in the pipes captures the thermal energy. The water can move by natural convection to an elevated tank, or be actively pumped through the collector. The intercept efficiency[78] for flat plate collectors may be as high as 80 percent, but decreases rapidly with the increased difference between the temperature of the heated fluid and the ambient temperature; and
- **Evacuated glass tube collectors** use shallow glass tubes to reduce the heat loss to the surrounding environment. The absorber is located inside the tube and is heated by the sun radiation passing through the glass. The intercept efficiency of an evacuated tube collector is slightly lower than a flat plate collector. However, the efficiency of the collector is less impacted when the temperature difference between the heated fluid and the surrounding environment increases, therefore maintaining a higher efficiency even with a higher operating temperature. This

[78] Intercept efficiency is defined as the efficiency of the collector in converting solar energy to heat when the average temperature of the panel is equal to the ambient temperature. At intercept efficiency, there are no losses or gains from the environment.

makes evacuated tube collectors better suited to providing process heating in the temperature range from 80 to 90°C.

In terms of scale, solar water heater systems range from a domestic system for one family storage tank capacity of 50 to 80 gallons and capacity of 1 to 2kW, to a commercial system with storage tank capacity of 1800 to 2600 gallons and capacity of 70 or 100kW. Scale corresponds to the sector—smaller systems are used in the residential sector, while larger ones are used in the commercial and industrial sectors. Commercial applications include in particular hotels and restaurants; industrial applications vary greatly—ranging from processing of poultry to horticulture (although this is less likely in warm climates).

Transfer of heat to a hot water system may be done through a 'solar fluid' flowing through a tube attached to the absorber plate (or through heat pipes integrated in the solar plates) to fluid contained in a manifold at the top of the collector, which in turn is connected to the storage cylinder by a heat exchanger. The 'solar fluid' may contain a non-toxic anti-freeze solution.

Costs of solar water heaters

The cost of a solar water heaters depends not only on the installed capacity of the collector (Watts thermal), but also on the capacity of the storage tank—and especially installation, making it very difficult to provide general pricing estimates. Aspects such as whether or not a building has plumbing pipes going up to the roof or not; the pitch of a roof; roofing material; and options for ground mounting all critically affect cost.[79] Since this is a mature technology, capital costs are unlikely to fall to a significant extent. However, a study by the International Energy Agency suggests that costs decrease by 20 percent when the total capacity of domestic solar water heaters doubles within a given country.[80]

Installed capacity	Unit Capital Cost (US$/kW)	O&M Costs (US$/kW/yr)	Capacity Factor (%)	Annual output (GWh/year)	Lifetime (years)	LRMC (US$/kWh)
Solar Water Heater (flat plate, commercial)[81]						
70kW	1,100	24	19%	0.115	20	0.09
Solar Water Heater (flat plate, small)						
2kW	1,600	20	17%	0.003	20	0.13

Source: Estimate based on data provided by Solar Dynamics for Barbados and information gathered in Anguilla.

Note: discount rate of 9%.

For our assessment, we used cost figures collected from solar water heater retailers in Anguilla (including Solar Dynamics, whose systems are being imported).[82] Figures gathered

[79] AREO conversation with Comet Systems, 12 April 2012.

[80] International Energy Agency (2009). Renewable Energy Essentials: Solar Heating and Cooling.

[81] To calculate the cost of a 70 kW system—which is a combination of smaller units) we calculated that it would require twelve of Solar Dynamic's 160 Gallon, 5.7 kW systems. These are the largest systems that they sell. The cost, therefore, reflects the cost of twelve of those units, sold in Barbados with installation for US$5,190, plus the 20 percent markup added for additional cost in Anguilla.

[82] Conversation with Landmark Realty Ltd, 12 January 2011. Conversations with Keene Enterprises (retailer), Solarhart systems, http://www.solahart.com.au/

on the systems' efficiency confirm those for installation in Barbados, but need a 20 percent markup on installed cost to account for a more limited market in Anguilla. Estimated generation costs for residential and commercial solar hot water systems are as low as US$0.13 and US$0.09 per kWh, respectively.[83] A local installer referenced a 150 liter system for a 3 bedroom house, with installation included, for around USD$1,500, which is a competitive price.[84] Output per kW (thermal) installed can be assumed to be the same based on a similar solar radiation shown for Bahamas, as discussed in section G.1.

Conclusions on solar water heaters Anguilla

Solar thermal energy for water heating is among the most cost-effective renewable energy technologies available. Adopting regional standards for solar water heater systems may be useful to ensure that systems sold on the market comply with a minimum level of efficiency that is appropriate for Anguilla—and that sub-standard systems are not imported in the country.

G.3 Wind Energy

Wind energy is a mature technology that provides non-firm energy at both utility scale and distributed scale. Potential in Anguilla looks promising, although information about the resource is limited; land is limited too. In spite of lower costs, wind looks like a less immediate opportunity than solar, which is easier to design, install, operate (with a much lower intermittency—and actually a very predictable load), and maintain. Detailed wind resource studies are needed to confirm preliminary estimates, and land availability would need to be assured for a period equivalent to plant lifetime for actual projects to be developed successfully.

Current state of development in Anguilla

There is no utility scale wind energy plant in Anguilla. An initial wind data analysis was done by Mistaya Engineering Inc. for Green Island Power, LLC that provides wind resource data on Corito and the East Part of the Island that shows good wind potential. However, it does not provide any economic or financial information; measurements were taken for a short period of time, and results are uncertain.[85] Based on this wind data analysis, the Government has proposed including wind turbines as part of its planned "Corito 'Zero Energy' Development Zone."[86] However, the development is still in the planning stages, and preliminary estimates on wind energy benefits at Corito need to be confirmed before the government may decide whether to go ahead with the plan.

Primary resource

The speed and consistency of wind resources are the primary concern for developing wind generation. These two factors directly affect the capacity factor of a wind plant. With highly variable wind, capacity factors and output are reduced increasing the long run marginal cost of the machine. Also, short term wind variability (that is, within a given minute or hour) decreases the reliability of wind plant causing more backup conventional generation to be needed.

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[83] Meetings with retail distributors during our field visit to Anguilla, November 2010.

[84] Information from Comet System, referenced by AREO, 12 April 2012.

[85] Lambert, Tony. "Anguilla Wind Data Analysis." Mistaya Engineering Inc., 2008

[86] Anguilla National Energy Committee. "Corito 'Zero Energy' Development Zone." 2009

The offshore wind industry has grown substantially in recent years. Wind resource assessments show that offshore locations typically offer better capacity factors (up to 7 percent more than for on-shore farms[87]). Before actual development of offshore wind could be considered, offshore wind resources of Anguilla should be assessed in detail, including a bathymetric survey (a study on the sea surface and depth). This would represent an important first step, as it is one of the two main components of an offshore wind resource assessment (the second one being wind measurements).

Technology for wind energy

Wind turbines capture with their blades the kinetic energy in surface winds, and use the mechanical power generated by the rotation of the blades to turn a generator, thereby converting kinetic power into electrical energy. Wind turbines are an established, widespread technology that has recently increased its penetration worldwide (159GW installed worldwide by end-2009 according to the World Wind Association; a tenfold increase since 1997). Grid systems that have high penetration of wind energy include Denmark (over 19 percent of electricity generation), Spain and Portugal (over 11 percent), and Germany and the Republic of Ireland (over 6 percent).

In terms of types of technology, wind turbines come in three-blade or two-blade configurations—three-blade turbines capture more wind energy, but two-blade turbines are more suited to high wind speeds (and their higher rotational speed produces louder noise).

In terms of scale, larger turbines (from 1MW to 5MW) yield more power at relatively lower capital cost, and are preferred whenever it is possible to carry and install them—also because there are high fixed costs for developing a wind farm that must be sustained, regardless of installed capacity.

In terms of location where the technology can be installed, wind turbines can be installed onshore or offshore—the key technological aspect involved in offshore developments concerns the foundations, which are best placed in shallow waters (up to 20 meters) and close to shore (up to 20 kilometers).[88]

Other technical issues and opportunities for developing wind energy in Anguilla

There is limited ability to integrate intermittent power supply in the electricity system of Anguilla. The share of intermittent generation that a grid can handle depends on the response time of available stand-by and load-following generating units—diesel units typically have rapid response times. Additional diesel backup would be needed for developing wind farms beyond 15 percent of peak capacity, which is an approximate estimate ANGLEC mentioned for grid-integrated intermittent capacity (about 0.5MW for each additional MW of wind), and this would carry a high cost.[89]

There is also limited availability of land for installing onshore wind farms in Anguilla. This limits the possibility of installing larger and more cost-effective turbines (3 to 5MW), and requires using turbines of 1MW or less instead. Limited availability of land also constrains the choice of sites with a good wind resource and adequate accessibility. Reportedly, some

[87] European Wind Energy Association, *Oceans of Opportunity*, September 2009.

[88] European Wind Energy Association, *Oceans of Opportunity*, September 2009.

[89] Conversations with ANGLEC. January-April, 2012

are also concerned about the visual impacts and noise of wind farms, and the negative impact this could have on the high-end tourism industry in Anguilla.

Emerging technologies for energy storage and offshore wind forecasting devices should be considered in the medium term for increasing the share of grid-connected wind energy in Anguilla. Provided the cost of these technologies decreases over the next few years, they represent an interesting potential alternative to a strategy that only relies on additional rapid-response thermal capacity. The effect of energy storage technologies is to increase the effective capacity factor of a wind farm, ensuring better grid stability. Offshore wind forecasting devices provide early warning about changes in expected wind energy output—allowing ramping up of rapid response plants if wind decreases, or ramping down generation from wind in the event of storms (wind speeds of over 25 meters per second are too high for turbines to withstand).

Finally, interruptible loads (customers that pay a special tariff accepting that service to them may be interrupted at certain times) may help stabilize the effects on the grid of intermittency. Interruptible loads are not uncommon in Anguilla, but are handled on a case-by-case, as-needed basis.

Costs of wind energy

Capital costs of wind energy vary greatly depending on the technology, the site, and the scale of a wind project.

'Class 1' turbines (such as those produced by Vestas), designed to withhold extreme gusts of 250 kilometers per hour, and average annual wind speeds of 10 meters per second, have installed capital costs of about US$1,800 per kW;[90] lowerable or tiltable turbines (such as those produced by Vergnet[91]), designed to lower or tilt down the nacelle and blades in case of hurricanes, cost more (up to US$3,000-US$3,500 per kW). Only a detailed study for a specific site can price accurately the capital and O&M costs.

The future costs of wind energy depend on technology and market factors. Supply bottlenecks led to a steady increase in turbine prices, which peaked in 2008 for delivery in 2009. However, an easing of turbine demand in 2009, mainly due to financing issues coupled with an expanding supply chain, led to a global oversupply in 2010. Oversupply in the global wind market has meant that prices for contracts signed in late 2008 and 2009 for delivery in the first half of 2010 fell by 18 percent. The Energy Information Administration (EIA) expects capital costs of onshore wind to decrease by as much as 19.6 percent by 2035, and those of offshore wind to decrease even more (32.4 percent)[92].

Installed capacity	Unit Capital Cost (US$/kW)	O&M Costs (US$/kW/yr)	Capacity Factor (%)	Annual output (GWh/year)	Lifetime (years)	LRMC (US$/kWh)
Wind Energy (850kW 'Class 1' turbines)						
3.4MW	1,800	50	35%	10.4	20	0.09

[90]Vestas, http://www.vestas.com/en/wind-power-plants/procurement/turbine-overview.aspx#/vestas-univers, http://www.vestas.com/en/wind-power-plants/wind-project-planning/siting/wind-classes.aspx#/vestas-univers (last accessed 20 December 2010).

[91] Vergnet Wind, http://www.vergnet.fr (last accessed 21 December 2010).

[92] United States Energy Information Agency, *Assumptions to the Annual Energy Outlook 2010*, 2010

Installed capacity	Unit Capital Cost (US$/kW)	O&M Costs (US$/kW/yr)	Capacity Factor (%)	Annual output (GWh/year)	Lifetime (years)	LRMC (US$/kWh)
Wind Energy (275kW lowerable or tiltable turbines)						
3.02MW	3,150	98.5	35%	9.27	20	0.16
Wind Energy (10kW distributed turbines)						
10kW	6,000	110	25%	0.02	20	0.35

Source: Capital and O&M Costs, lifetime: based on information provided by Vestas (Class 1 turbines) and Vergnet (lowerable/tiltable turbines), and information from a 10MW wind farm proposed by BL&P in Barbados. Capacity factor: conservative estimate based on a preliminary assessment by Mistaya Engineering of 39-44 percent in Corito and East End.

Note: discount rate of 9% for distributed scale; 11% for utility scale.

The estimated LRMC for the utility scale wind farm on Anguilla is US$0.09 per kWh, based on a 850kW 'Class 1' turbine with a capacity factor of 35 percent. This is a conservative estimate we adopt for our analysis lacking a detailed estimate—Anguilla's preliminary estimate is for capacity factors between 39 and 44 percent for a 800kW turbine produced by Enercon;[93] very high capacity factors, however, are not uncommon in this region. Lowerable or tiltable turbines would have a higher LRMC with the same capacity factor—about US$0.16 per kWh. LRMCs of distributed scale turbines, assuming a lower 25 percent capacity factor (since it may be assumed that the best sites would be those for utility scale wind), would be US$0.35 per kWh for a 10kW turbine.

Conclusions on wind energy in Anguilla

Wind energy represents an interesting potential for Anguilla, but a less immediate one than solar which, in spite of higher costs, is easier to design, install, operate (with a much lower intermittency—and actually a very predictable load), and maintain. In any case, detailed information is needed to assess how much of Anguilla's wind potential is technically feasible and commercially viable. In particular, the country would benefit from detailed assessments for onshore potential, and potentially for offshore potential. Assessing offshore wind could be especially important, because it might address a key limitation to developing wind energy in small island countries—limited availability of land.

Finally, the scope for developing wind energy could increase significantly if energy storage and wind forecasting solutions become technically and commercially viable.

An initial limit of 15 percent peak capacity might be a reasonable and safe first step for integrating wind energy in Anguilla's grid until better information on the resource is collected (and experience in managing wind farms is gained), and proves that it is technically and economically feasible to go beyond this limit.

G.4 Waste-Based Energy

Waste-based energy technologies use waste collected by sanitation authorities to produce energy. Technologies belong to two broad categories: landfill gas to energy, and waste to energy.

[93] Lambert, Tony. "Anguilla Wind Data Analysis." Mistaya Engineering Inc., 2008

Landfill gas to energy harvests the gas created by the action of microorganisms within a landfill after the materials have already been deposited in the landfill. Landfill gas is then combined with various types of technologies (most of them mature) for converting gas to energy. It can be done at both utility scale and distributed scale.

Waste to energy technologies actually use the waste as fuel, before it is put into the landfill. This has the benefit of reducing waste that goes into the landfill.

Current state of development in Anguilla

There is no landfill gas to energy project or waste to energy project operating in Anguilla. Despite the lack of projects, initial stakeholder consultations showed that there is much interest in using waste as a resource. It is likely that the limited waste stream in Anguilla may sufficient to support only a very small waste-based energy project, if any.

Primary resource

Anguilla generated an average of 35 tons per day (TPD) of municipal solid waste (MSW) from 2007 to 2011.[94] This tonnage fluctuates significantly throughout the year due to tourist seasons. The amount of waste produced per day includes 15.6 tons per day of household waste, 8.5 tons per day of green waste, 7.6 tons of commercial waste, and 3.3 tons of industrial waste.[95] Currently, all of the waste is dumped in Corito, as no markets exist on the island for recycling or composting these materials, and the quantity is too small to attract a transporter with the exception of metal, due to its high market value (Anguilla, however, does not receive revenue from the sale of metals). A small amount of the waste is crushed at the landfill and used for roadways, but the crusher that is available is frequently broken, and replacement parts are difficult to obtain.[96] The table shows waste production between 2007 and 2011.

Table G1: Corito Landfill Disposal Data in Metric Tons (2007-2011)

Year	Household	Green	Commercial	Waste	Total
2007	5,287.65	3,486.89	2,069.03	1,516.84	12,360.41
2008	5,037.98	4,000.76	3,852.11	1,763.85	14,654.70
2009	4,911.18	2,027.22	3,204.73	846.90	10,990.03
2010	6,031.24	3,645.13	2,706.23	1,059.77	13,442.36
2011	7,246.65	2,462.03	2,121.72	747.10	12,577.50

Source: Anguilla's Statistics Unit

Key resource factors affecting the viability of waste-based energy projects include the quantity of waste, and its characteristics. Alkalinity, and internal temperature—in addition to moisture content, and composition of the waste—determine the quality of the landfill gas. The fraction of organic waste and moisture content of the waste determine the Net Calorific

[94] 2011 Figures are calculated by using the first four months (the only months for which data is available) as an approximation of the waste levels for the next eight months

[95] Anguilla Statistics Unit. "Environmental & Climate." Accessed 4/10/2012 at: http://www.gov.ai/statistics/ENVIR_CLIMATE_TAB_10.htm

[96] Clinton Foundation, Anguilla Work Plan-Renewable Energy.

Value (NCV) of the waste for waste to energy—a higher moisture content of the waste decreases its NCV. In order to accurately assess the potential for landfill gas generation and the NCV of Anguilla's waste, a detailed study of the waste should be carried out.

Technology for Waste-Based Energy

Technologies for landfill gas to energy and waste to energy are proven and commercial. Currently, waste to energy is used in more than 25 countries.[97] Several different technologies can be used for converting producing waste-based energy. Most processes produce electricity directly through combustion, while others produce combustible fuels such as methane, methanol, ethanol, or synthetic fuels.

The key technologies include the following:

- **For Landfill gas to energy:**
  - **Internal combustion engines** are the most commonly used option for landfill gas energy conversion projects. They have comparatively low capital costs, a high efficiency, and a high degree of standardization;
  - **Gas turbines** are most economical for capacities of over 3MW. However, they typically have parasitic energy losses of 17 percent of gross output compared to internal combustion turbines (which have parasitic losses of seven percent). The turndown performance of gas-fed turbines is poor compared to internal combustion engines, and difficulties may occur when they are operated at less than a full load. Other problems include combustion chamber melting, corrosion, and accumulation of deposits on turbine blades; and
  - **Fuel cells** may become attractive in the future because of their higher energy efficiency, negligible emissions impact, lower maintenance costs, and suitability for all landfill sizes (although previous studies have suggested that fuel cells would be more competitive in small to medium projects[98]). At present, however, fuel cells remain uncompetitive with conventional applications, due to economic and technical disadvantages.
- **For Waste to energy:**
  - **Anaerobic digestion** (biogas) consists of a series of processes in which microorganisms break down biodegradable material in the absence of oxygen; it is used for industrial or domestic purposes to manage waste and/or to release energy. The technical expertise required to maintain industrial scale anaerobic digesters coupled with high capital costs and low process efficiencies has limited the level of its industrial application as a waste treatment technology;
  - **Incineration** (the combustion of organic material) with energy recovery is the most commonly used waste to energy generation technology. Modern incinerators have decreased emissions of fine particulate, heavy metals, trace dioxin and acid gas emissions;

[97] Gamma Energy Ltd. http://www.gammaenergy.mu/index.php?item=16&lang=1

[98] United States Department of Energy (1997). *Renewable Energy Annual 1996. Chapter 10 – Growth in the Landfill Gas Industry,* http://www.p2pays.org/ref/11/10589/chap10.html

– **Pyrolysis** is a thermo-chemical decomposition of organic material at elevated temperatures in the absence of oxygen. Pyrolysis is useful for producing combustible fuels: charcoal, biochar, or biofuel; and

– **Plasma arc gasification** is an experimental technology that uses an electric current that passes through a gas (air) to create plasma, a collection of free-moving electrons and ions. When plasma gas passes over waste, it causes rapid decomposition of the waste into its primary chemical constituents which is normally a mixture of predominantly carbon monoxide and hydrogen gas, known as syngas. (The extreme heat causes the inorganic portion of the waste to become a liquefied slag, which is cooled and forms a vitrified solid upon exiting the chamber.) The syngas can be combusted in a second stage in order to produce process heat and electricity.

The scale of waste-based energy plants depends on the type of technology used. Incineration technology requires a very large amount of waste to be viable. Commercial-scale plants using pyrolysis and gasification would typically be in the order of 20,000 to 250,000 tpa[99]. Pyrolysis to charcoal and energy plants range from 20,000 to 50,000 tpa, with an energy output of 1MW to 2MW. Anaerobic digesters, however, can have a capacity as small as 100kW , and run on a waste stream not too much higher than Anguilla's—however, the smaller the unit, the higher the cost.

Landfill to gas energy engines range from small scale (about 300kW) to utility scale (3-5MW, and above for gas turbines). Utility scale engines require at the least 150,000 tpa for the reciprocating internal combustion engines—according to some industry estimates (confidential source), a 850kW plant would require a cumulative amount of one million tons of waste to operate with a 95 percent capacity factor. As a comparison, Anguilla's cumulative amount of waste produced over the past ten years was less than 100,000 tons. Smaller units of about 270-300kW would require about one third of that amount (approximately 300,000 tons in total), which is still more than Anguilla can produce. Gas turbine and fuel cell engines are larger and require significantly more tonnage still.

Costs of Waste-Based Energy

Internal combustion turbines, incinerators, and gas turbines are mature technologies, and their costs are unlikely to decrease significantly in the future. Anaerobic digesters, pyrolysis, plasma arc gasification, and fuel cell technology, however, are not yet fully mature technologies, and their costs are likely to decrease with further technology developments and experience or learning effects.[100]

Municipal solid waste to energy plants come in many different sizes and varieties. Costs can vary from technology to technology. Variables such as capacity, the amount of up-front sorting required, emission testing and monitoring technologies, operator training, and ash management also have an impact on the project costs. Incinerators require control measures for stack emissions and flue gas cleaning equipment (such as acid scrubbing plant, carbon injection system, electrostatic precipitators or fabric 'type' filters, depending on the type of

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[99] Last S., *Pyrolysis and Gasification*, Mechanical Biological Treatment Website, 2008, http://www.mbt.landfill-site.com/Pyrolysis Gasification/pyrolysis gasification.html, last accessed 29 September 2010.

[100] Schoots K., Kramer G.J., van der Zwaan B. (2010). *Technology Learning for Fuel Cells: An Assessment of Past and Potential Cost Reductions*. Energy Policy Vol. 38, Issue 6, pp. 2887-2897

control system employed). Cleaning processes can form a significant proportion of the overall capital costs of a waste to energy plant—estimated between 30 and 60 percent in the United Kingdom, depending on the waste mix and technology.[101] Regulations concerning the design and operation of incinerator plants also mean that the capital costs and operating costs for waste to energy incinerators can be high.

Although reciprocating engine gas and diesel generators are based on the same type of technology, the capital costs for internal combustion and gas generators are higher than those of diesel generators (including generators that are currently operating in Anguilla), but typically lower than other renewable energy technologies. The capital cost of internal combustion engines is about US$4,000 per kW.[102] Because landfill gas is free, and the operations and maintenance costs for gas engines are low (usually about US$0.03 per kWh), landfill gas to energy is generally more competitive than other renewable energy technologies, and competitive with conventional generation given their fuel expenses.

Landfill gas to energy project costs include costs for gas collection and flaring, electricity generation, and direct use. Each project involves the purchase and installation of equipment (capital costs) and the expense of operating and maintaining the project (O&M costs). The viability of a landfill gas to energy project depends primarily on the price and efficiency of the generator used, and the quality and quantity of the landfill gas resource.

Waste to energy plant capital expenditure can range widely, depending on the technology, and waste stream composition and quantity. Incineration technology is mature, and has limited scope for additional 'learning' effects. It is unlikely to benefit from a significant decline in cost (unless the cost of materials, inputs or labor used to make incinerators decrease). Newer types of waste to energy technologies, however, may benefit from learning effects that could lead to a decline in capital costs. Biogas costs are influenced by factors such as climate, organic content in the waste, and digester type; all-in cost for a biogas system with a digester can range from US$4,000 to US$8,000 per kW installed (confidential source). The digester is typically 70 to 80 percent of the project cost.

Installed capacity	Unit Capital Cost (US$/kW)	O&M Costs (US$/kW/yr)	Capacity Factor (%)	Annual output (GWh/year)	Lifetime (years)	LRMC (US$/kWh)
Landfill gas to energy (internal combustion)						
270kW	4,000	157	90%	2.12	20	0.08
Waste to energy (anaerobic digester/biogas)						
100kW	5,000	150	85%	.75	20	0.10

Source: Confidential.

Note : discount rate of 11%.

Conclusions on Waste-Based Energy in Anguilla

A biogas plant (about 100kW) may be the most feasible waste-based energy project in Anguilla, given the available waste stream. A small landfill gas to energy plant (270kW,

[101] S. Last (2008). Mechanical Biological Treatment Website (http://www.mbt.landfill-site.com/EfW/efw.php)

[102] United States Environmental Protection Agency, *Landfill Gas to Energy Project Development Handbook*, 2010

internal combustion) may be the next closest potential in the medium to long term. Provided that there exists enough waste stream (with a sufficiently good composition) to build an economically viable plant, the LRMC for both types of plants is very attractive—of course, only one of the two could be realized.

Appendix H: Calculation of Long Run Marginal Cost of Renewable Energy Generation

We use the following assumptions for calculating the LRMCs of each renewable energy generating technology (US$ per kWh):

- *Capacity factor*—that is, the share of time, expressed in percentage, at which a plant can operate at full capacity. This involves estimating the yearly output each renewable generation technology could produce (capacity factor multiplied by installed capacity multiplied by hours in a year provides the annual energy output). This would include resource availability (for example available solar energy, wind speed profile, and conversion efficiency of the technology);
- *Capital costs, in US$*—we estimate capital costs based on discussions with the Government and stakeholders about market conditions in Anguilla (where available, such as for solar technologies), information from other Caribbean or small island countries we have worked in (Turks and Caicos Islands, Barbados, Jamaica, Mauritius), and our experience of the North American and Caribbean renewable generation market;
- *Operation and maintenance (O&M) costs, in US$ per kW per year*—we estimate O&M costs based on the same sources used for capital costs;
- *Lifetime, in years*—we estimate the lifetime of renewable generation equipment based on our experience of renewable generation technologies, in most cases 20 years being a reasonable approximation;
- *Discount rate*—we assume a real discount rate of 9 percent for distributed renewable energy technologies (based on information provided by AREO on typical rates available from commercial banks in Anguilla), and 11 percent for utility scale ones (a conservative assumption, based on information provided by ANGLEC on a 10 percent WACC for its conventional operations). We recognize that developers of utility scale technologies may, in fact, secure a lower cost of capital; however, we keep a value of 11 percent to assess the viability of utility scale renewables more conservatively.

The formula to calculate the cost of power from any technology is:

$$\text{Cost of power (US\$ per kWh)} = \frac{\text{Annualized capital and O\&M costs (US\$)}}{\text{Annual energy output (kWh per year)}}$$

- *Tariffs and conventional energy costs*—we estimate tariffs and conventional energy generation costs based on a cost for Diesel No. 2 of US$4.00 per gallon (see Appendix F).

Appendix I: Calculation of Marginal Cost of Carbon Abatement for Renewable Energy Technologies

We calculate the cost of CO_2 abatement as follows:

- *Country-wide emission factor of 0.7 tons of CO_2e per MWh*—first, we calculate emission factors for each plant type based on the carbon content of Diesel fuel, according to the guidelines of the Intergovernmental Panel on Climate Change (IPCC)[103] and estimated thermal efficiency factors (the percentage of the fuels' energy content that is transformed in electricity).[104] Then, we include losses. Finally, we calculate a weighted average of plant emission factors (based on relative generation in MWh) between High Speed and Low-Speed units operating in Anguilla[105]. The result (0.7 tons of carbon dioxide equivalent (tCO_2e)[106] per MWh generated) is close to common rough approximations of emissions factors from fossil fuel plants; and
- *Cost of abatement*—we calculate the cost savings (US$ per kWh) of each technology by subtracting its LRMC from the appropriate benchmark generation cost (as discussed in 5.2.2) for Anguilla's diesel plants. Then, we divide the cost savings by the avoided emissions (that is, the emission factor but expressed in tCO_2e per kWh instead of MWh). We use the following formula:

$$\text{Cost of abatement (US\$ per ton of } CO_2\text{)} = \frac{\text{Cost savings (US\$ per kWh)}}{\text{Avoided emissions (tons of } CO_2 \text{ per kWh)}}$$

[103] 19.2 kg of carbon per GJ for diesel. We convert carbon into CO_2 by a factor of 3.67 to account for the higher molecular weight of CO_2 after oxidation of carbon (44/12 is the ratio between the molecular weights of carbon and oxygen)

[104] Assumed thermal efficiency factor of 39% for high speed diesel units, and 41% for medium speed diesel units.

[105] Assumed 98 percent of generation in Anguilla is from medium-speed diesel units, and the remaining 2 percent from high-speed units.

[106] The word 'equivalent' refers to the fact that, based on IPCC guidelines, greenhouse gases other than carbon dioxide may be expressed in carbon dioxide terms using their global warming potential.

Appendix J: ANGLEC Corporate Rules for Renewable Energy

It is proposed that the by-laws be amended:

- in paragraph 4.1 by adding the following sentences after the full stop:

  In managing the business and affairs of the company, the directors, and any person to whom their powers are delegated under paragraph 4.10 or otherwise, shall comply with the Corporate Rules for Renewable Energy set out in the Schedule.

  In the management of the business and affairs of the company, the Corporate Rules for Renewable Energy set out in the Schedule have effect, subject to any variation by the directors—or any person to whom their powers are delegated under paragraph 4.10 or otherwise—that is previously authorized, or subsequently ratified, by ordinary resolution of the shareholders.

- At the end after the chairman's signature by adding the following Schedule:

SCHEDULE

Corporate Rules for Renewable Energy

Preamble

Considering Anguilla's dependency on imported fossil fuels for electricity generation; its severe impact on the country; and the potential to generate electricity with renewable energy sources in a way that is economically viable, contributes to energy security, and enhances local and global environmental sustainability, the company adopts these corporate renewable energy rules to guide the management of the business and affairs of the company.

Principles

With these rules, the company commits to:

- Reliable electricity at least cost;
- Better energy security;
- Greater environmental sustainability;
- Transparency and consultation in generation planning; and
- Probity and competition in procurement.

Utility scale renewable energy generation

Before developing, procuring, or contracting new renewable energy generation capacity at utility scale, the directors shall:

- Prepare a demand forecast, which identifies expected future requirements for new firm and non-firm capacity, and the expected timing for commissioning.
- Prepare a least cost generation plan that identifies candidate plant for firm and non-firm generation capacity required to satisfy projected demand at least cost,

with full consideration of renewable energy generation options (including those at distributed scale) alongside conventional generation options.

- Consult with the public on the demand forecast and least cost generation options.
- Approve, in their own discretion, the least cost generation plan after making any changes that they consider desirable based on public consultation.
- Identify the best option to design, build, operate, maintain, and finance required new renewable energy generation capacity by:
  - Assessing three possible options: (i) fully developed by ANGLEC; (ii) procured to a specialized contractor under a Design, Build, Operate, and Maintain (DBOM) contract; or (iii) contracted to an Independent Power Producer (IPP); and
  - Selecting the option most likely to deliver reliable electricity at least cost.
- When the option identified is either procurement under a DBOM contract, or contracting an IPP:
  - Approve, in their own discretion, the bidding documents to be used;
  - Publish a request for expressions of interest for prequalification of bidders, stating minimum technical capacity, minimum financial capacity, and minimum relevant experience required;
  - Evaluate expressions of interest of qualified bidders;
  - Prepare a short list of up to five bidders;
  - Issue a request for proposals to shortlisted bidders, stating: full specifications of the goods, services, or works to be provided; full evaluation criteria (technical, financial, experience, and other) and detailed evaluation process, aiming to ensure reliable power at least cost and low financial risk; and any legal or commercial requirements;
  - Evaluate proposals received;
  - Approve, in their own discretion, the award of any contract;
  - Award one or more contracts to successful bidders; and
  - Announce successful bidders and publish key contract terms after contract signature.
- Regularly update demand forecasts and least cost generation plans, and consult with the public at each update.
- Perform themselves in a Board meeting (or by resolution in writing under clause 6.6 of the by-laws) tasks required to be done 'in their own discretion'. Such tasks shall not be delegated to a director, a committee of directors or the officers or staff of the company

Distributed scale renewable energy generation

Before contracting new renewable energy generation at distributed scale, the directors shall:

- Identify the maximum contribution that distributed renewable energy generation can make to the country's electricity supply without affecting grid stability.
- Create a grid and distributed generation code setting out rules for interconnecting distributed renewable energy generation to the grid, as well as limits on the maximum unit size and total capacity, if required.
- Create a Standard Offer Contract under which the company buys excess power from owners of eligible distributed renewable energy generation:
  - at a price that is fair having regard to the company's cost of generation that is offset by distributed generation under realistic dispatching conditions; and
  - for a term that is set out in the contract, and which is not less than the number of years that corresponds to the useful lifetime of the distributed renewable energy system;
- Try to secure under the company's public supplier's licence such other changes to the tariffs and conditions of supply that the directors consider necessary to promote the maximum possible development of economically efficient distributed renewable energy generation.

Appendix K: Recommended Legal and Regulatory Changes

K.1 Changes to the Electricity Act

We recommend amending the Electricity Act, Part 2, Section 2, subsection 2 by adding the following text in bold:

> *(2) Subsection (1) shall not apply to the use of any electrical plant which—*
>
> *(a) is powered only by wind and which is used by any person for the purpose only of supplying electricity to his own premises* ***, or selling excess electricity to a public supplier on terms agreed with the public supplier****;*
>
> *(b) is used only for the photovoltaic generation of electricity by any person for the purpose only of supplying electricity to his own premises* ***, or selling excess electricity to a public supplier on terms agreed with the public supplier****;*

K.2 Changes to ANGLEC's licence and Electricity Supply Regulations

We recommend adding the following definition in section 1.1 of both ANGLEC's public supplier's licence and Schedule I of the Electricity Supply Regulations:

> *'Approved Renewable Energy Costs' are:*
>
> - *renewable power generation investments that are made by the public supplier, and operating and maintenance expenses, depreciation, and any taxes of those investments that are incurred by the public supplier,*
> - *utility scale renewable power purchase costs that are incurred by the public supplier, as a consequence of purchasing renewable power from third parties, and*
> - *distributed scale renewable power purchase costs that are incurred by the service provider, as a consequence of purchasing renewable power from its consumers*
>
> *in accordance with the Schedule of ANGLEC's by-laws ('Corporate Rules for Renewable Energy').*

We also recommend adding in section 4.4 of both ANGLEC's public supplier's licence and Schedule I of the Electricity Supply Regulations the following statement:

> *The Minister or the Arbitrator shall consider that Approved Renewable Energy Costs are reasonably incurred.*

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