# Sustainable Energy Framework for Barbados

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# Acronyms and Abbreviations

| | |
|---|---|
| A/C | Air Conditioning |
| ASHRAE | American Society of Heating, Refrigeration and Air Conditioning Engineers |
| BB$ | Barbados Dollars |
| BCIC | Barbados Cane Industry Corporation |
| BEP | Barbados National Energy Policy (2006) |
| BL&P | Barbados Light & Power Company |
| BNOCL | Barbados National Oil Company Limited |
| BNSI | Barbados National Standards Institute |
| BNTCL | Barbados National Terminal Company Limited |
| BSJ | Bureau of Standards Jamaica |
| CARICOM | Caribbean Community |
| CCGT | Combined Cycle Gas Turbine |
| CEIS | Caribbean Energy Information System |
| CFL | Compact Fluorescent Lamp |
| CHENACT | Caribbean Hotel Energy Efficiency Action Program |
| $CO_2$ | Carbon Dioxide |
| DSM | Demand-Side Management |
| ECGP | Eastern Caribbean Gas Pipeline |
| ECGPC | Eastern Caribbean Gas Pipeline Company |
| EE | Energy Efficiency |
| EGFL | Enterprise Growth Fund Limited |
| EIA | Environmental Impact Assessment |
| ESCO | Energy Services Company |
| FCA | Fuel Clause Adjustment |
| FTC | Fair Trading Commission |
| GDP | Gross Domestic Product |
| GEED | Government Electrical Engineering Department |
| GEF | Global Environment Facility |
| GHG | Greenhouse Gas |
| GJ | Gigajoule |
| GLS | General Lighting Service (incandescent light bulbs) |
| Government | The Government of Barbados |

| | |
|---|---|
| GT | Gas Turbine |
| HCPV | High Concentration Photovoltaic |
| HFO | Heavy Fuel Oil |
| IDB | Inter-American Development Bank |
| IPP | Independent Power Producer |
| LCD | Liquid Crystal Display |
| LCPV | Low Concentration Photovoltaic |
| LED | Light Emitting Diode |
| LSD | Low Speed Diesel |
| MEPS | Minimum Energy Performance Standard |
| MFIE | Ministry of Finance, Investment, Telecommunications and Energy |
| MMBTU | Million British Thermal Units |
| MMscfd | Million of standard cubic feet per day |
| MSD | Medium Speed Diesel |
| MTBE | Methyl Tertiary Butyl Ether |
| N/A | Not Applicable |
| NPC | National Petroleum Corporation |
| O&M | Operation and Maintenance |
| OLADE | Organización Latinoamericana de Energía (Latin America Energy Organization) |
| OTEC | Ocean Thermal Energy Conversion |
| PBL | Policy-Based Loan |
| PPA | Power Purchase Agreement |
| PV | Photovoltaic |
| RE | Renewable Energy |
| SEF | Sustainable Energy Framework |
| SSA | Sanitation Services Authority |
| SWH | Solar Water Heater |
| TA | Technical Assistance |
| TCDPO | Town and Country Development Planning Office |
| TORs | Terms of Reference for the SEF assignment |
| TTBS | Trinidad and Tobago Bureau of Standards |
| US$ | United States Dollars |

# Sustainable Energy Framework for Barbados

# Executive Summary

The Inter-American Bank (IDB) hired Castalia and Stantec to help the Government of Barbados (the Government) prepare a 'Sustainable Energy Framework for Barbados' (SEF). This Final Report presents:

- The objectives of the Sustainable Energy Framework—the SEF should unlock viable investments in renewables and energy efficiency to reduce energy costs, improve energy security, and enhance environmental sustainability
- Barbados' Sustainable Energy Matrix—electricity generation in Barbados could include more renewable energy technologies, and consumption of electricity could be lower thanks to energy efficiency technologies, because most of these technologies are economically viable and could reduce energy costs. However, there are barriers that block these technologies, and that make the potentially 'sustainable' matrix different from the 'current' one
- Our recommendations for promoting renewable energy and energy efficiency—these form the core of the Sustainable Energy Framework for Barbados, and include proposed policy principles, regulatory changes, financial instruments, technical measures, and strengthening of institutional capabilities
- Projected costs and benefits of the SEF—by promoting renewable energy and energy efficiency technologies that are economically viable, Barbados can reach its Sustainable Energy Matrix in the next twenty years, and therefore reduce electricity generation costs, electricity consumption, $CO_2$ emissions, and dependency on fossil fuels.

## Objectives of the Sustainable Energy Framework

We suggest formulating the objectives of the SEF as follows:

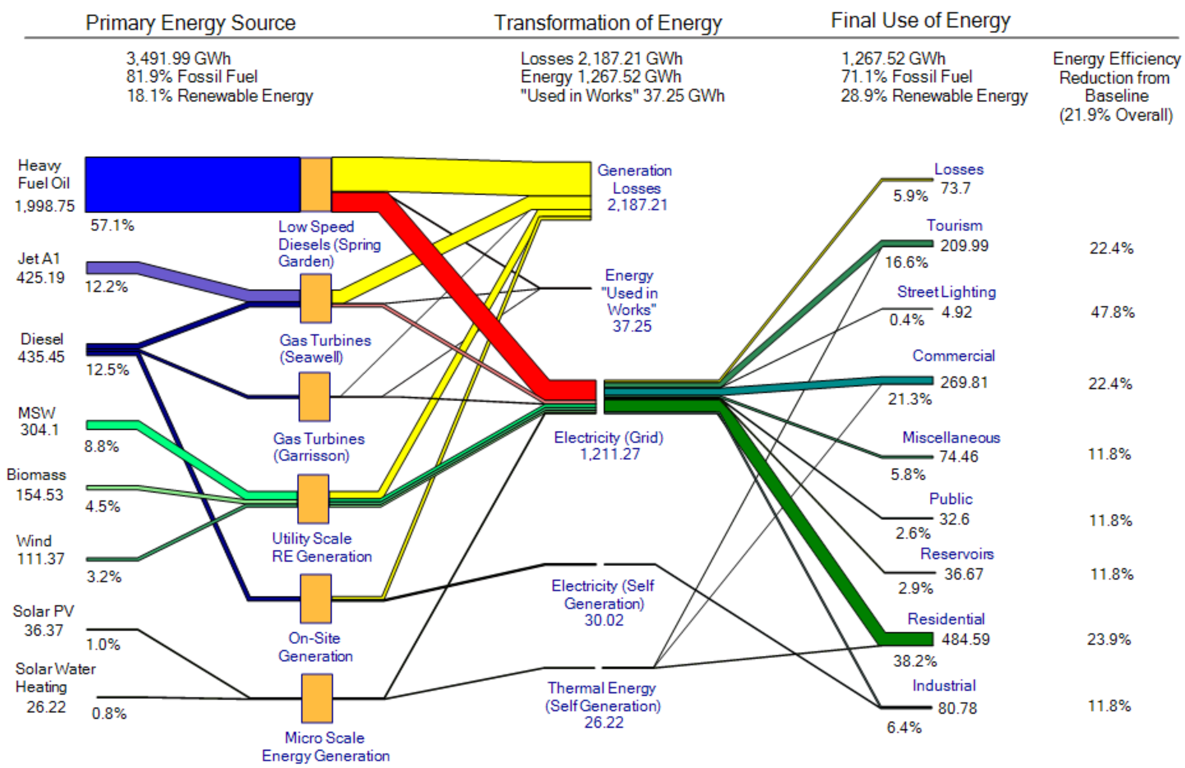
> *To unlock economically viable investments in Renewable Energy and Energy Efficiency that will reduce Barbados' dependency on fossil fuels, and thus*
>
> > *reduce energy costs,*
> > *improve energy security, and*
> > *enhance environmental sustainability.*

In Section 1 we discuss the bases for the SEF objectives, and we explain the tradeoffs between these objectives. In Section 2 we provide the background—current policy, regulation, institutions, electricity demand and supply, generation costs, tariffs, and existing programs for renewable energy and energy efficiency—necessary to understand the analysis and recommendations for the SEF.

## Barbados' Sustainable Energy Matrix

Figure ES 1 shows the Sustainable Energy Matrix for Barbados. This is a snapshot of what Barbados' generation and consumption of electricity could look like with increased use of renewable energy and energy efficiency technologies. The Sustainable Energy Matrix is different from the current one—this is because currently there is low uptake of renewable energy and energy efficiency technologies in Barbados, despite the fact that most of these technologies are economically viable. In Section 3, we compare Barbados' Sustainable Energy Matrix (the potential) with its Current Energy Matrix (the present situation).

**Figure ES 1: A Sustainable Energy Matrix for Barbados (GWh)**




Source: Castalia and Stantec estimates and calculations.

Under the Sustainable Energy Matrix:

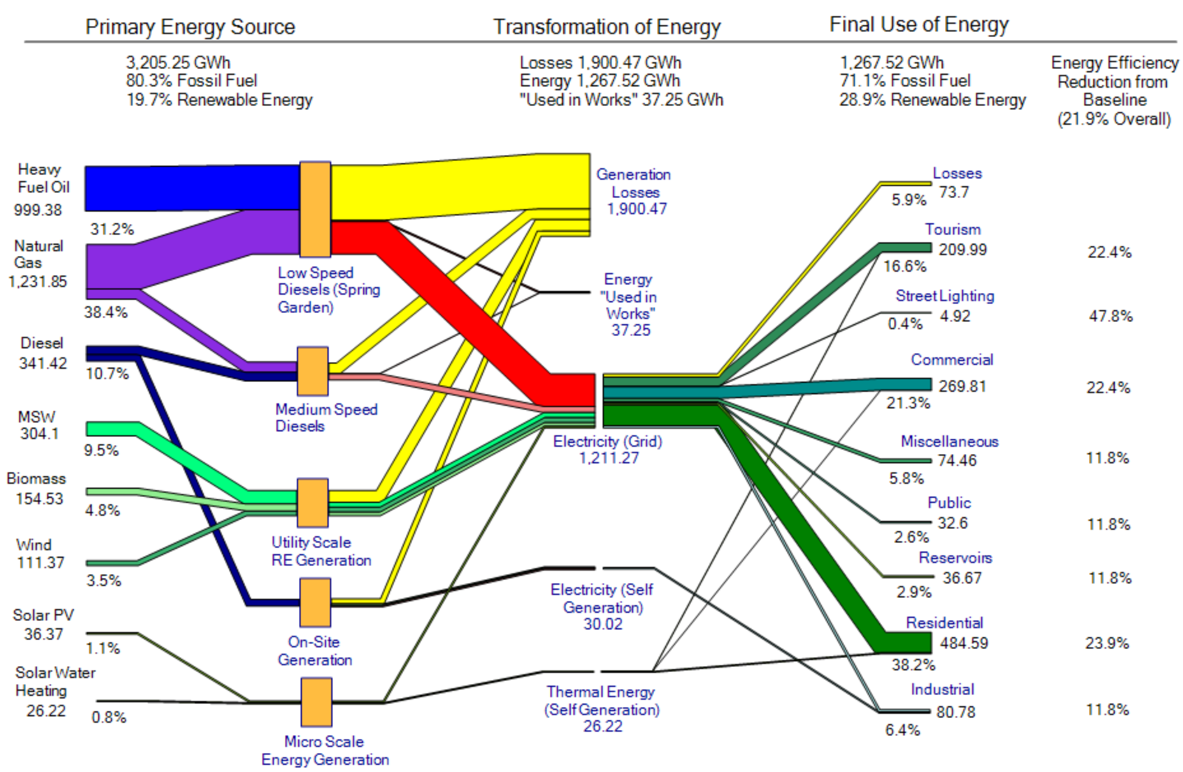
- **Renewable energy** would account for 29 percent of electricity consumption; the remaining 71 percent would come from conventional fossil fuel-based resources
- **Energy efficiency technologies** would account for an overall 22 percent reduction in electricity consumption compared to a 'business as usual' scenario (different sectors would have different energy efficiency potential—estimated at 24 percent for the residential sector; 22 percent for the tourism and commercial sectors; 12 percent for the industrial and public sectors; and 48 percent for street lighting).

Barbados could reach the Sustainable Energy Matrix over the next 20 years by implementing economically viable renewable energy and energy efficiency technologies. By 'economically viable' we mean those technologies that reduce the country's energy costs—renewable energy and energy efficiency technologies that have an annualized cost of implementation over their lifetime (US$ per kWh) lower than the cost of conventional generation (US$ per kWh, calculated with oil prices of US$100 per barrel, which is about the current price of 10-year oil futures). We use different conventional generation benchmarks, because different technologies displace different costs of generation—fuel only, or all-in generation costs. (For example, a wind farm can provide intermittent electricity that can replace generation from a thermal plant, thus displacing fuel cost, but cannot replace the need to have that thermal plant; on the other hand, a biomass cogeneration plant can provide baseload capacity that can replace a thermal plant—therefore avoiding its all-in cost.)

Technologies are 'commercially viable' when those who implement them save money—these technologies have an annualized cost of implementation over their lifetime (US$ per kWh) lower than the applicable tariff (US$ per kWh, also calculated with a Fuel Clause Adjustment at oil prices of US$100 per barrel). Some technologies are commercially viable, but not economically viable—they make sense to the individual because they save money, but they end up raising the country's cost of generation.

It is important to note that the increased levels of renewable energy and energy efficiency shown in the Sustainable Energy Matrix should be indicative targets, with the purpose of guiding policy and project implementation based on the economic viability of the underlying technologies. They should not be fixed targets to be achieved at any cost—this would be counter to the objectives of the Sustainable Energy Framework. Figure ES 2 shows an alternative Sustainable Energy Matrix including more generation with natural gas.

**Figure ES 2: Alternative Sustainable Energy Matrix including Natural Gas (GWh)**




Source: Castalia and Stantec, based on preliminary information on the expansion of natural gas in Barbados.

Note: This is a conservative estimate—if possible, all thermal generation should be converted to natural gas because this would be the lowest-cost generation option for Barbados, and it would allow maximizing the investment for the Eastern Caribbean Gas Pipeline.

An Eastern Caribbean Gas Pipeline (ECGP) is currently being considered, and would provide low-cost natural gas to Barbados from Trinidad (perhaps as low as US$7 per MMBTU, based on a preliminary estimate provided to us by the Government). If the ECGP is implemented, electricity generation with natural gas would be the cheapest option for Barbados—likely cheaper than any renewable energy technology (although there would still be scope for some renewables, in particular for improving energy security). BL&P is considering investing in dual fuel generators which could run on Heavy Fuel Oil (HFO) or natural gas—these would likely be Low Speed Diesel (LSD) plants.

**Many renewable energy technologies are viable, but are not being used**

The Sustainable Energy Matrix includes electricity generation from the following economically viable renewable energy technologies—Figure ES 3 shows that their generation cost (a horizontal bar) is lower than each technology's conventional generation benchmark (continuous vertical lines):

- Solar water heaters, for homes. The cost per kWh for a residential solar water heater is around US$0.09 /kWh. This is considerably lower than the fuel cost of even the most efficient conventional plant (US$0.14 per kWh)
- Wind at utility scale (on-shore and off-shore), is estimated to cost US$0.11 per kWh (on-shore) and US$0.13 per kWh (off-shore). Again, both costs come in under the fuel cost of the most efficient conventional plant (US$0.14 per kWh)
- Biomass cogeneration, on a large scale operated by the utility. This is estimated to cost US$0.11 per kWh. The biomass plant can provide firm power at less than the all-in cost of low speed diesel plant (US$0.19 per kWh)
- Hybrid PV/thermal systems, on a small scale. These systems are estimated to have a cost of US$0.13 per kWh, again lower than the fuel cost of the most efficient conventional plant (US$0.14 per kWh)
- Municipal Solid Waste to Energy, on a large scale operated by the utility. This technology can provide firm power at an estimated cost of US$0.18 per kWh, which is slightly less than the all-in cost of low speed diesel plant (US$0.19 per kWh)

Seawater Air Conditioning, on a commercial scale, is also economically viable and commercially proven, and can provide cooling power at US$0.18 per kWh, effectively replacing conventional generation that costs US$0.19 per kWh. However, its realization is likely to be hampered by planning and approval difficulties, and for this we did not include it in the Sustainable Energy Matrix.

The Sustainable Energy Matrix also includes a few renewable energy technologies that are commercially viable—Figure ES 3 shows that their generation cost is lower than the tariff (a dotted vertical line)—and that we expect will become economically viable in the near future. We expect this to happen because the cost of these technologies has been falling consistently, and is projected to continue falling. These technologies include the following distributed scale technologies ('distributed scale technologies' are those located at customer premises, in close proximity to the load being served):

- Certain types of solar photovoltaic (PV) systems—50kW thin film PV systems with fixed mounting, 50kW high concentration PV systems with dual axis tracking, and 5kW low concentration PV systems with single axis tracking
- Solar water heaters for commercial and industrial use.

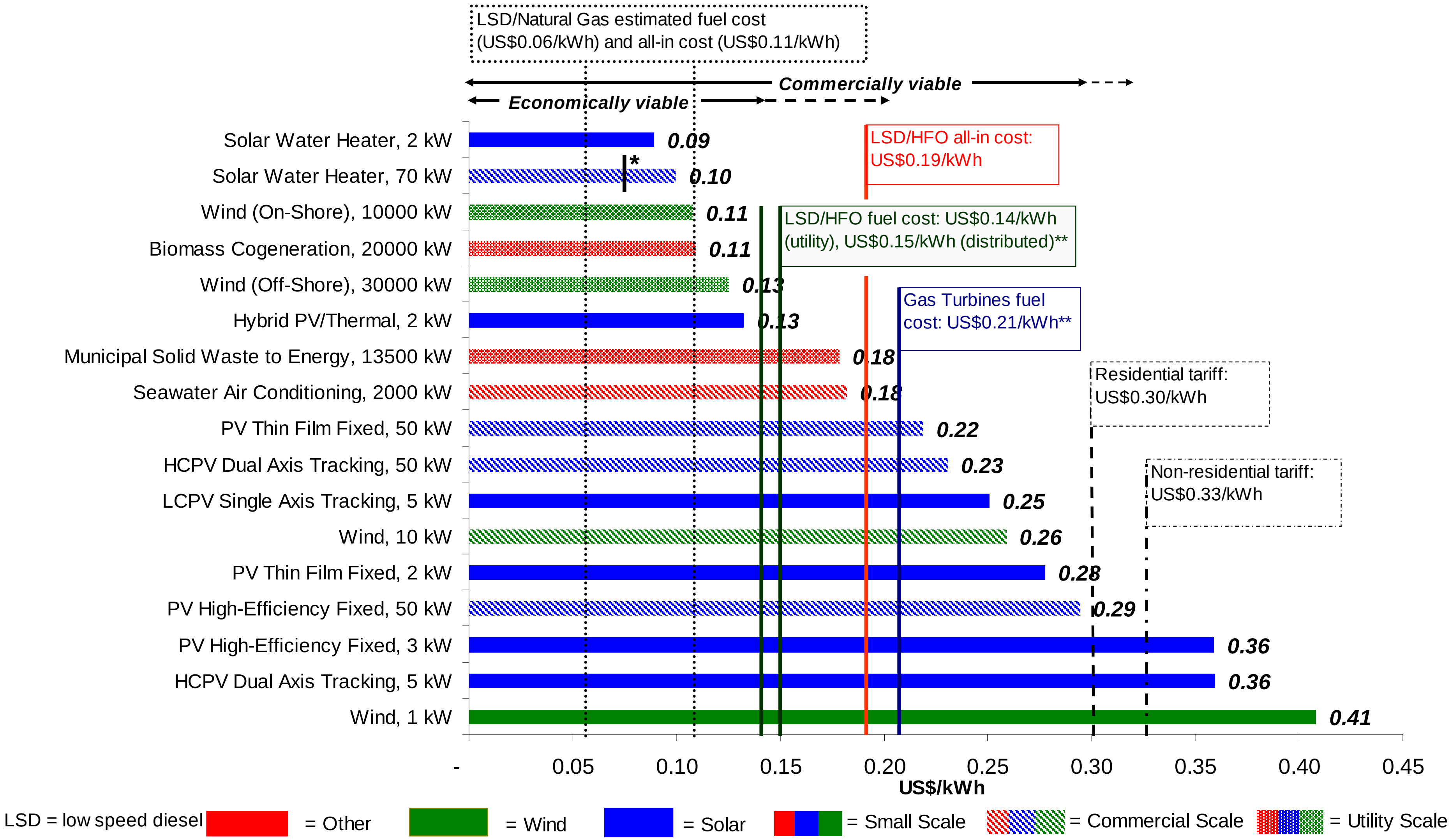
Other types of PV systems, and wind systems not at utility scale, are not economically viable and are not expected to become so in the near future. Therefore, they are not included in the Sustainable Energy Matrix.

Despite the fact that most of these renewable energy technologies are viable (at least, commercially), their current uptake in Barbados is low—there are no renewable generation plants at utility scale, and very few ones at distributed scale. The barriers that explain this low uptake are the following:

- Utility scale renewable technologies are not being used mainly because the regulatory regime under which Barbados Light & Power—BL&P, the country's sole electricity provider—operates provides no incentives to adopt them
- Distributed scale renewable technologies are not being used firstly, because customers are not allowed to connect their systems and sell electricity to the grid—however, the Rider for Renewable Energy, approved by the Fair Trading Commission (FTC) on a pilot basis for a limited number of systems and for a period of only two years starting 1 July 2010, is an important step in this direction; secondly, because these technologies have a high upfront cost, and access to credit by households and businesses is often limited; and thirdly, because customers are unfamiliar with the technologies
- Finally, both utility scale and distributed scale renewable technologies are also not being used due to an inappropriate permitting and planning process.

Figure ES 3 also shows the fuel-only and all-in cost of LSD plants operating with natural gas (these dual fuel plants are the most likely plants that BL&P would invest in for its expansion plan). Under this scenario, biomass cogeneration would be just viable (compared to an all-in cost of US$0.11 per kWh). However, utility scale wind could not compete with a fuel-only cost of US$0.06 per kWh, and other renewable energy technologies would also not be viable. As noted, there would still be some scope for renewables, in particular considering diversification of the matrix for energy security purposes—and considering that the natural gas price assumption this scenario is based on (US$0.07 per MMBTU) is a preliminary estimate.

**Figure ES 3: Cost of Renewable Generation Technologies, Avoided Cost of Conventional Generation, and Tariffs (US$ per kWh)**




Source: Castalia and Stantec estimates

Note: * For "Solar water heater, 70kW" the comparator is fuel oil boiler heating (US$0.08 per kWh). ** 'Fuel costs' also include variable O&M costs; and are grossed up for losses (6.6%) for distributed technologies, but *not* for utility scale technologies. Generation costs and tariffs estimated based on oil prices of US$100 per barrel, and natural gas prices of US$7 per MMBTU. All-in cost of LSD with natural gas contingent on availability from the planned Eastern Caribbean Gas Pipeline.

**Proposed solutions to increase the use of viable renewable energy technologies**

In Section 4, we describe the renewable energy technologies, analyze their potential and the barriers to their uptake, and identify possible solutions to overcome these barriers. Table ES 1 below summarizes barriers and proposed solutions for RE.

**Table ES 1: Barriers to, and proposed solutions for, viable RE technologies**

| Barrier | Proposed Solution |
|---|---|
| No commercial viability | None. Renewable technologies that are not commercially viable are not economically viable, and therefore should not be implemented. |
| Limited access to capital | Create a consumer finance instrument within the proposed "Smart Fund", consisting of a subsidized hire purchase scheme for economically viable distributed renewable generation technologies. |
| Incomplete information | Promote renewable technologies that are economically viable. Provide information on their costs, how to purchase and install them, and their environmental benefits. |
| Planning and Permit problems | Direct the Town and Country Development Planning Office to move to a standardized, technology specific approach for the planning and permitting process that streamlines the development of viable renewable energy technologies. |
| Lack of Grid Connection Rules | Introduce new rules that allow electricity consumers to sell excess capacity to the grid, based on the experience that will be gained under the BL&P Pilot Program for renewables. These rules will need to cover the technical and safety aspects of connection to the grid, metering arrangements, and the price to be paid for power. Provisions also need to be made to prevent grid-stability problems in the face of large amounts of intermittent generation. |
| Economic Regulation Distortions | Require BL&P to prove that its choice of generators is the most economically efficient for Barbados. Amend the fuel cost adjustment mechanism so that it allows for both utility scale and distributed renewable technologies to recover their costs provided these are below BL&P's avoided cost. Disaggregate the electricity tariff structure to make it more cost reflective, and thus promote efficient energy efficiency and distributed generation investments, while discouraging economically inefficient investments. Make incentives under the Tourism Development Act consistent with the Government's intention to use tax and customs incentives to favor sustainable energy technologies over conventional ones—particularly solar water heaters over electric ones. |

**Most energy efficiency technologies are viable, but are not being used**

The Sustainable Energy Matrix includes electricity savings from the following economically viable energy efficiency technologies—Figure ES 4 shows that their savings cost (a horizontal bar) is lower than each technology's conventional generation benchmark (a continuous vertical line):

- All lighting technologies for households and businesses—Compact Fluorescent Lamps (CFLs), T8 Fluorescent Lamps with Occupancy Sensors, T5 High-Output Fluorescent Lamps—and Magnetic Induction Street Lights for public use
- Power monitors—these devices provide real-time information on energy consumption and expenditure, and induce behavioral changes that save energy
- All mechanical technologies for businesses—Premium Efficiency Motors, Variable Frequency Drives, and Efficient Chillers
- All air conditioning (A/C) technologies—systems for window installation mostly in households, or split systems for businesses
- Liquid Crystal Display (LCD) monitors for computers—this is the only energy efficient technology that has a significant uptake in Barbados.

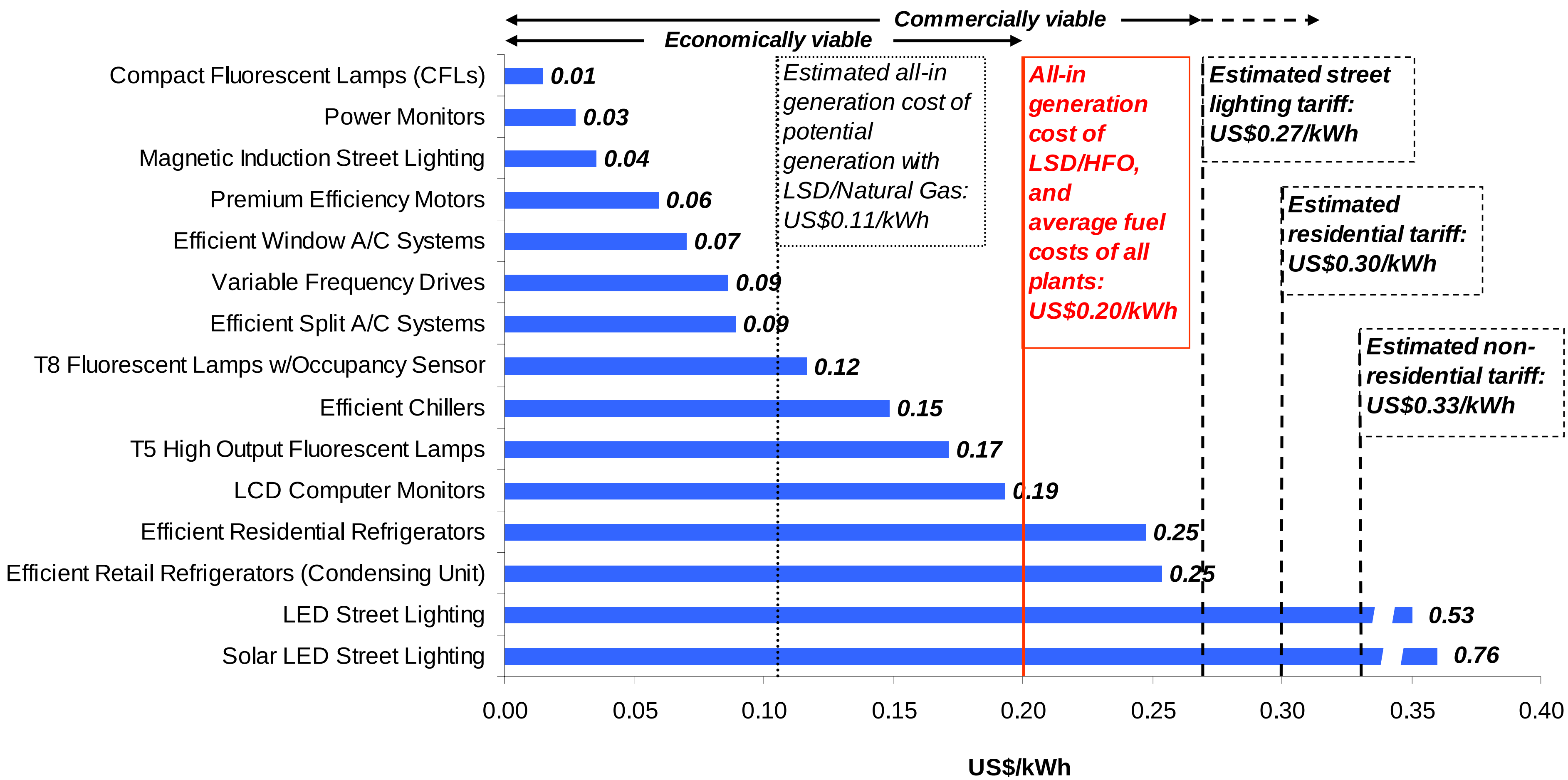
Refrigerators for households and businesses are commercially viable (they save customers money—Figure ES 4 shows that their savings cost is lower than applicable tariffs, represented by dotted lines), but they are not economically viable. This surprising result can be explained by the fact that imported efficient fridges are designed to perform well under conditions different than those found in Barbados.

Light Emitting Diode (LED) lights for street lighting are not economically—or commercially—viable. Unless their cost drops significantly, they are not a good solution for street lighting. Adding a solar PV panel to them will only make them even more expensive—and is not necessary either, since Barbados has virtually complete electricity service coverage.

In spite of almost all energy efficiency technologies being viable, their uptake in Barbados is low. The reason is not that they are not commercially viable—apart from LED lights, they all are. Tariffs are not a reason either—if anything, tariffs in Barbados (see Section 2.5) provide an excess of incentive for energy efficiency, to which consumers are clearly not responding. The low uptake of energy efficiency is rather due to the following barriers:

- **Limited access to capital**—many consumers would need to borrow to install the efficient technologies, and cannot find financiers willing to lend to them—or are charged prohibitive interest rates
- **Limited and uncompetitive equipment supply**—there is a chicken and egg problem; given limited uptake of many technologies in Barbados, they can be hard to purchase on the island, or are sold only at uncompetitive prices. Limited availability and high costs in turn retard uptake
- **Incomplete information**—where a technology is not widely used, people may be unaware of its benefits, again creating a chicken and egg problem
- **Agency problems**—these take place when the person who should invest in the equipment is not the same person who uses it—this happens in the public sector, in the development of new construction, and in leased buildings or rented homes.

**Figure ES 4: Cost of Energy Efficiency Technologies, Avoided Cost of Conventional Generation, and Tariffs (US$ per kWh)**




Source: Castalia and Stantec estimates.

Note: LSD = Low Speed Diesel plants, and HFO = Heavy Fuel Oil. LSD plants currently use HFO. All-in cost of LSD plants using natural gas estimated and contingent on availability of pipelined natural gas from the planned Eastern Caribbean Gas Pipeline. Generation costs and tariffs estimated based on an assumption of oil prices of US$100 per barrel, and natural gas prices of US$7 per MMBTU. All generation costs are grossed up for losses (6.6%).

**Proposed solutions to increase the use of viable energy efficiency technologies**

In Section 5, we describe the energy efficiency technologies, analyze their potential and the barriers to their uptake, and identify possible solutions to overcome these barriers. below summarizes barriers and proposed solutions. Table ES 2 below summarizes barriers and solutions.

**Table ES 2: Barriers to, and proposed solutions for, viable EE technologies**

| Barrier | Proposed solution |
|---|---|
| Lack of commercial viability | None—this is not a barrier. All economically viable EE technologies are also commercially viable, and pay for themselves. |
| Tariff distortions | None—this is not a barrier. If anything, the tariff structure provides excessive incentives for energy efficiency. A disaggregated tariff structure (mentioned in Section 4.3.2) will provide more correct price signals, but still make energy efficiency commercially viable. |
| Limited access to capital | Establish a consumer finance instrument (a subsidized hire purchase scheme) within the Smart Fund for viable energy efficiency technologies on terms that make them attractive. |
| Limited and uncompetitive supply of equipment | Establish financial instruments within the Smart Fund that will create a critical mass for key equipment on the supply side, and jump-start the market for them: (i) grants for promoting CFLs, (ii) a 'cash for clunkers' trade-in program for efficient air conditioners, and (iii) low-interest retrofit loans for residential and non-residential buildings, starting with those audited under the SEF. Establish technical standards for key technologies, and use them to establish eligibility for tax and customs incentives. |
| Incomplete information | Develop information campaigns for incentives described above (consumer financing, grants for CFLs, cash for clunkers for A/C, and low-interest retrofit loan), under an integrated approach that addresses both supply and demand within one program—as it was done for solar water heaters. Involve the private sector for marketing. Provide information that will orient purchase of equipment towards efficient technologies, also supported by the technical standards. Use standards to ban the import of substandard equipment, and consider phasing out incandescent lights. |
| Agency problems | Implement retrofits for the Public Sector Energy Conservation Program under a performance contracting scheme done by Energy Services Companies (ESCOs)—investments will be done by ESCOs who will profit from them. Mandate energy efficiency in the building code for new construction, also supported by the technical standards. |

## Our Recommendations for the Sustainable Energy Framework

Based on the proposed solutions to barriers shown in Table ES 1 and Table ES 2, we propose a comprehensive program of policy and regulatory changes which together create a Sustainable Energy Framework (SEF) for Barbados. We present this program in greater detail in Section 6. In summary, our recommendations for the SEF are as follows.

### Build the SEF around five core policy principles

The Government of Barbados may wish to base its sustainable policy framework on the following five core policy principles.

1. ***Win-win approach—Top priority is to be given to measures that both increase sustainability and reduce the cost of energy to the economy***. The government should focus its policies on promoting those measures that reduce costs while also reducing oil dependency and decreasing the potential impacts of global warming
2. ***Cost-benefit analysis—Where a measure could increase sustainability but would also increase costs to the economy, it will only be pursued if the sustainability benefits exceed the economic costs***. There are a number of additional technologies (not featured in the sustainable energy matrix) that could reduce oil imports and $CO_2$ emissions, but would, if deployed, *increase* the cost of energy to the country. Government should not, as a general policy, pursue those sustainable energy options that increase the cost of energy to the country. Government should consider particular measures on a case-by-case basis, but will need to be convinced that the sustainability benefits to Barbados offset the additional costs imposed on the taxpayers and energy users of Barbados
3. ***International support—The Government will work to ensure that Barbados has full access to international support for sustainable energy measures, in the form of concessional finance, grants, and carbon credits***. Global mechanisms to address climate change include the Clean Development Mechanism, and carbon mitigation strategies supported by grants and concessional loans provided by entities such as the Global Environment Facility and the United Nations Environment Program. These measures can allow for further cost reductions for Barbados in pursuing sustainable energy measures. They may also increase the range of sustainable energy measures that make sense for Barbados, by reducing the cost of certain measures, and so ensuring that they can be implemented without increasing energy costs for citizens of Barbados
4. ***Technology neutrality—Policy will promote all measures that increase sustainability and reduce costs, rather than favoring particular technologies***. There is no need to 'pick winners'. Rather, the objective should be to create a framework in which market participants have the incentive and ability to develop renewable generation projects that benefit the country, regardless of technology. For example, rather than prohibiting specific technologies because they might be too expensive, Barbados should just put in place a framework that allows any economically viable technology to sell power to the grid below avoided cost—this framework could apply to any technology that, in time, becomes economically viable

5. ***Build on existing strengths—Elements of Barbados' country energy system that serve the country well will be supported and developed to promote sustainable energy, not undermined***. Barbados' energy sector is lower cost and more reliable than most of its Caribbean neighbors. Making the energy sector more sustainable should not put this achievement at risk. Rather, the policy changes should be designed to build on existing strengths. In particular, the Government will be mindful of the need to ensure that BL&P can continue to operate as a professional, financially viable electricity utility, and that regulatory decisions are made by the FTC, in accordance with its statutory mandates. Government policy initiatives will respect the independence and autonomy of both the utility and its regulator, the FTC.

### Change the regulation of the power sector for promoting viable utility scale renewable energy

Greater use of renewable energy would increase sustainability and lower the cost of electricity service in Barbados. The regulatory regime applying to BL&P is intended to ensure that customers pay no more than is reasonably necessary for electricity, while also allowing the utility to recover its reasonable costs. To achieve this we recommend that the FTC develop a regulatory regime with three core elements:

- ***Requiring BL&P to show that its generation expansion plan is least cost***. The Fair Trading Commission (FTC) should require BL&P to demonstrate that its generation expansion plan is likely to result in the lowest cost of service, as a condition for allowing those costs to be passed on in tariffs. Specifically, BL&P should be required to (i) use internationally recognized least-cost expansion planning optimization software to generate its expansion plan; (ii) include in the planning process plausible renewable options agreed with the FTC that can meet commercialization criteria; and (iii) prepare the least cost expansion plan taking into account a range of future oil price scenarios. BL&P should present its least cost expansion plan including renewable energy options to the FTC for approval *ex ante*, that is before BL&P makes investments. The FTC's approval should be given based on checking that BL&P's assumptions are reasonable (in particular regarding oil price assumptions), and its analysis is accurate and correct. The FTC should not be involved in approving specific investment decisions of BL&P—the role of the regulator should be one of control, and not one of management. There would be a tariff setting principle saying that the rate base includes all FTC-approved investments

- ***Allowing BL&P to securely recover the costs of investments in renewable generation and fuel efficiency***. When BL&P invests in a new renewable generation plant, it substitutes a capital cost for a fuel cost. Provided that the expected capital cost is lower than the expected fuel cost, this lowers total system costs and customers should benefit. However, BL&P may be concerned about its ability to recover the cost of its investment, particularly if fuel costs should fall in the future. To overcome this risk, BL&P should have the option of getting FTC approval of a proposed renewable investment. The FTC should approve the investment if it is satisfied that the investment would be reasonably likely to lower the total cost of electricity generation. Once an investment was approved and operating, the fuel cost component of the tariff should be reduced by the amount of fuel saved, and in its place BL&P should be allowed to recover the cost of the renewable investment. This cost should be set at a fixed amount per year, sufficient to recover the capital cost of the plant (including a reasonable return on investment) as well as the operating and maintenance costs. The same mechanism should be allowed for any capital investment that reduces the total cost of electricity by reducing the amount of fuel used (such as converting gas plants to combined cycle operation). This mechanism could be captures by a Renewable and Fuel Efficiency Cost Recovery Clause, separate from the Fuel Clause Adjustment

- ***Requiring BL&P to purchase renewable and co-generated power from third party suppliers, where this is cheaper than providing power itself, and does not create risks to power quality or reliability***. On a small system like that in Barbados there are real advantages to having a single entity develop and operate the entire system. On the other hand, there is always the possibility that someone else may have a resource, technology, or insight that enables him or her to develop an opportunity that BL&P is not able or willing to develop. For these reasons, we recommend that BL&P be required to purchase power from third parties who can supply at some margin below BL&P's avoided cost. BL&P would establish 'avoided cost benchmarks' for firm and non-firm power; FTC would check the benchmarks, and establish thresholds below them for power purchase; third parties would be given the possibility to challenge BL&P's benchmark, and to have their proposal assessed autonomously by the FTC. The regime would have three main elements:
  - an obligation to purchase power at a margin below avoided costs when there is a credible offer by a third party that provides adequate guarantees of reliability and complies with all technical standards
  - a licencing regime for third party generators that sets conditions to be satisfied (location and type of facility, technical capacity, and financial capacity) for obtaining a licence without requiring an Act of Parliament
  - setting principles for Power Purchase Agreements (PPAs) with third party generators according to best practices, and including provisions for: PPA term at least for useful system lifetime; payments for energy and capacity (subject to indexation and adjustment); compliance with Grid Code and technical standards; provisions for main tenance outages and 'step-in rights'; liquidated damages; insurance; termination; and dispute settlement.

Enacting these regulatory changes for utility scale renewable energy would require in turn:

- ***Issuing a Ministerial Policy Direction on Regulation to the FTC***. Economic regulation of electricity providers is the preserve of the FTC. We recommend that the Government use its powers under the Fair Trading Commission Act to give the FTC a general policy directive encouraging it to implement the recommendations in this report, in accordance with the Government's sustainable energy policy. This policy statement would enable the FTC to make efficient renewable generation (utility scale and distributed) an explicit part of its regulatory approach, in a way that is consistent with other aspects of government policy; and to make energy efficiency inform its tariff regulation activities

- ***Introducing a new Law giving new powers to the FTC for third-party generation***. The current statutory regime is deficient in two key respects: an Act of Parliament is required to allow any new commercial power suppliers (as we verified together with the Government); and there is no clear mechanisms to require BL&P to buy power from third parties in cases where doing so could lower the total cost of electricity supply to customers, with no loss of power quality or reliability. We therefore recommend that the Government introduce a new law into Parliament that would provide the FTC with the following powers: (i) the power to issue licences allowing firms to generate and sell power commercially, provided that they demonstrate the necessary technical and financial capacity, and comply with safety and technical requirements; (ii) the power to require BL&P to buy power from other licenced generators, in cases where the FTC is satisfied that such third party supply would lower the total cost of power to customers in Barbados, over the medium term; the quality or reliability of power supply on BL&P's systems is not reduced; and no unreasonable financial risk is imposed on BL&P. The law (or regulations issued under the law) should also clarify that small scale distributed generation does not require a licence, but simply compliance with safety and technical standards.

**Change the regulation of the power sector for promoting viable distributed scale renewable energy**

Recent reductions in the cost of small scale solar and wind generation technologies mean that customers in Barbados will start to find it attractive to install these technologies on their premises. When customers invest in distributed generation, their consumption of the power BL&P generates with fossil fuels will decrease. At the same time, because the distributed renewable power is intermittent, and often will not fully meet customer's demands, those customers will continue to demand that BL&P maintain their connection to the power grid, and will expect BL&P to supply them with power when generation from the customer's own unit is not enough. Customers will also at times generate power in excess of their own needs. This power can be made available to the grid, and customers will expect to be paid for it.

It will be in Barbados' interest to develop a regulatory and tariff structure that facilities efficient investment in distributed renewable generation. At the same time, it should not give incentives for inefficient investments that will end up increasing the total cost of electricity supply in the country. To achieve these twin objectives, we recommend that BL&P develop, and FTC review and approve:

- ***A fully disaggregated, cost reflective tariff***. This would require disaggregating the current tariff into separate, cost reflective charges for (i) supply of energy; (ii) connection to the distribution system; and (iii) provision of generating capacity in order to give customers the ability to rely on BL&P for back-up and stand-by power by paying only the capacity and connection charges. It would also be beneficial to reduce cross-subsidies between customer classes, and have tariffs that vary by time of day in line with cost variations over the day, so far as this is practical given the additional metering and billing costs involved

- ***Feed-in tariffs and metering rules for distributed generation***. The FTC should also require BL&P to purchase power from small distributed generation units. The price BL&P is required to pay should be no more than its avoided cost.

Generally this will be the avoided fuel cost. To implement this policy it would be necessary to meter separately the power that the customer buys from BL&P, and the power BL&P buys from the customer (since they are charged at different prices). BL&P's Pilot Program proposes bi-directional metering, which is a good step in this direction. We would not recommend net metering, as this would be equivalent to setting a feed-in tariff at the retail rate. The result of net metering would be that the utility pays considerably more than avoided cost for power, and so the total cost of the electricity supply goes up. If the utility is to remain financially viable, this cost sooner or later needs to be passed on to customers. The ultimate effect of net metering, then, is that those customers who do not have distributed generation end up subsidizing those who do.

**BL&P to establish a Grid Code**

As other generators connect to the system, BL&P will need to retain control of the grid to ensure safety, reliability, and power quality. To this end, BL&P should develop a Grid Code—that is, a set of technical and operating standard to apply to all generators, both utility scale and distributed, who connect to the grid. This Grid Code should be subject to approval by the FTC to ensure that it does not impose restrictions on third party generators beyond those that are necessary to ensure safety, reliability, and power quality across the grid. The Grid Code may be largely developed from existing policies and procedures of BL&P, and from the technical rules proposed in BL&P's proposed Pilot Program for distributed renewable generation.

**Strengthen the Town and Country Development Planning Office with Standardized Environmental Permitting and Planning Regulations for Renewable Energy**

The Government should direct the Town and Country Development Planning Office (TCDPO) to move to a standardized, technology-specific approach for the environmental permitting and planning of renewable energy projects. This would streamline the development of viable technologies. Developing standard environmental and planning regulations for renewables would make things easier for project developers by identifying the form and content of Environmental Impact Assessments (EIAs) related to renewable energy, and the full criteria to be met for obtaining planning approval.

The environmental permitting and planning regulations should:

- Establish the power for the TCDPO to prescribe criteria for a register of qualified and approved persons for preparing Environmental Impact Assessments for renewable energy—criteria may regard professional and academic qualifications; years of experience; knowledge of renewable energy technologies; skills in preparing EIAs for renewable energy developments; and previous experience in Barbados, the Caribbean Region, or tropical small island countries
- Establish the content of EIAs for renewable energy projects—EIAs should be made to include five standard parts for all developments: (i) a description of the method, extent, and duration of activities involved in the construction, operation, maintenance, and decommissioning of the renewable energy development; (ii) an assessment of the likelihood, severity, and extent of the relevant impacts, whether adverse or beneficial, that the activities mentioned are expected to have; (iii) a description of actions that the developer commits to undertake or have undertaken to mitigate, avoid, or remedy adverse environmental impacts, and an

estimate of the likelihood and extent to which such plans may be effective; (iv) a monitoring plan to be implemented through a specialized independent third party; and (v) a demonstration of the financial ability to undertake required actions

- Establish the specific activities and potential impacts that Environmental Impact Assessments for key renewable energy technologies should cover—regulations should prescribe that EIAs for key RE technologies for Barbados address the specific activities and impacts involved in these developments, and list what such activities and impacts are

- Establish the framework to set technology-specific Standards developers must comply with—regulations should also create the framework for the TCDPO to issue Standards that specify the detailed levels of acceptability of environmental impacts for key renewable energy technologies. A Standard for any particular renewable energy technology should consist of a matrix which, for each impact that needs to be addressed, specifies: (i) a level below which the impact is allowed—activities that cause an environmental impact not exceeding this level should not be a cause for rejecting a development permission; (ii) a level above which the impact is prohibited—activities that cause an environmental impact exceeding such level should be a cause for rejecting a development permission; and (iii) a band between these two levels—activities that cause an environmental impact within such band should be assessed on a case by case basis

- Establish the power for the TCDPO to set specific fees for monitoring and enforcement of compliance—developers must include in EIAs a monitoring plan to be implemented by a specialized independent third party, and must pay a fee that covers the reasonable cost of doing this.

**Mandate Energy Efficiency design in the Building Code**

The Government should encourage the Barbados National Standards Institute (BNSI) to mandate energy efficiency measures in the building code. Barbados' building code does not address energy efficiency—limited information, and well as agency problems, lead to overlooking many measures that would avoid wasting energy. Building energy standards provide a degree of control over building design and encourage energy conscious design in building. These inefficiencies could be reduced over time if the building code required energy efficient designs and materials in new buildings and major renovations.

The BNSI has developed a draft building code that addresses problems specific to tropical countries, but this draft building code does not provide a comprehensive standard for the energy performance standard of buildings. Additional energy efficiency rules are needed, and in particular include the following:

- Lighting, by defining a maximum lighting density (Watts per square meter) based on the space type

- Insulation, by stating minimum levels for wall R-values, window properties, and "tightness" of the envelope

- Equipment efficiency, by setting minimum standard for mechanical equipment such as air conditioners.

A standard for Barbados could quickly be developed from an existing one already used in another country. We recommend that a standard such as the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 90.1 2007 be reviewed for its application in Barbados. Also, the ASHRAE Standard 189.1 Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings was published in February 2010. Energy efficiency performance requirements of this new standard are higher than the ones of ASHRAE 90.1, and could be considered once it is finalized. These standards mentioned may provide a good basis for the BNSI for constructing the building code.

**Establish a Smart Fund for promoting economically viable RE and EE projects**

The Government intends to establish a Smart Fund to promote EE technologies and RE projects. This Smart Fund will provide grants and subsidized loans to promote increased use of EE and RE. The Government is negotiating a US$10 million Investment Loan with the IDB; the proceeds of this loan will be used to capitalize the Fund. This Fund can become an excellent instrument for overcoming some of the key barriers to the uptake of viable energy efficiency and distributed renewable generation technologies, as described above.

We recommend that the Smart Fund be dedicated to overcoming these problems by providing finance to overcome the access to capital problem; funding campaigns to develop a critical mass of users of some of the most promising technologies, in order to break through the chicken-and-egg problem, and develop a new market equilibrium in which these technologies become the new normal, and so benefit from stronger competition and economies of scale in the supply chain; and providing information on the experience with the technologies the fund is supporting, ensuring that the experience of satisfied users is disseminated to their peers, and made available to suppliers to use in marketing their products.

To this end, we recommend that the Smart Fund offer the following five distinct components:

- ***A Pilot Consumer Finance Facility (Hire Purchase)***—A US$0.5 million revolving fund that provides loans at below-market rates to supporting low-interest hire purchase schemes. This facility would offer capital at low interest rates—around five percent—to approved retailers and finance firms that provide hire purchase for consumer durables. Given the small size of this component, we recommend competitively selecting only one company for the pilot phase. The approved retailer or finance firm would be able to draw on a credit line offered by the Facility to offer hire-purchase finance on approved consumer-scale energy efficiency and renewable generation technologies such as solar water heaters, solar photovoltaic generators, and efficient air conditioning units. The participating retailer or financier would be required to pass on savings from their lower cost of finance to customers in lower interest rates. This Finance Facility would revolve—that is, as the line of credit was repaid by the retailer, the funds would be lent out again to support additional hire purchase finance. A five percent interest rate should be enough to cover administration costs of the Finance Facility, making it self-sufficient. The MFIE indicated that it intends to testing how this innovative mechanism would work and that, if successful, it would consider replicating it under a possible second phase of the Investment Loan that is being considered with the IDB. Replication would entail selecting more than one retailer or provider of finance, and establishing several lines of credit

- ***Compact Fluorescent Lamps Promotion***—A US$0.5 million grant facility to kick-start the market for Compact Fluorescent Lamps (CFLs). The goal is to customers familiar with the technology, change their buying habits, and ensure that CFLs are available wherever people normally shop for light bulbs. The Smart Fund would work with participating retailers on a limited time give-away program. Under this program, the Smart Fund would pay the wholesale cost of CFLs, and the retailers would source the CFLs and give them away to customers. Retailers would agree certain conditions with the Smart Fund, such as a limit to the number of CFLS each customer can take, and only giving the CFLs away with purchases of other products over a certain value, to stop the system being abused. This promotion should get the CFLs into shops, retailers marketing them, and people using them. This measure would complement the phase-out of incandescent light bulbs that the Government intends to enact (see below)
- ***Air-conditioner rebate trade-in program***—A US$1.5 million grant facility that would give people credits worth about half the value of a new efficient air-conditioning unit, in exchange for an old unit. Under this scheme, participating retailers would accept inefficient AC Units, and give customers a rebate of a fixed amount—set to about half the value of an efficient unit of broadly the same type—on the purchase of a new efficient air conditioner. The retailer would be responsible for destroying and safely disposing of the old unit. The Fund would reimburse the retailer for the rebate given. The exact percentage of the rebate can be modeled once the Fund is operational, but should not be below 33 percent to avoid undermining the very rationale of this component—the barrier that is being targeted with the grant is the limited supply of equipment rather than the lack of financing (which is addressed by the hire purchase and retrofit finance components)
- ***Energy Efficiency Retrofit and Renewable Energy Finance Facility for SMEs***—A US$6.5 million below-market loan facility to pay a portion of the cost of energy efficiency retrofits and installation of small renewable energy systems. This facility would lend commercial and industrial enterprises (including hotels, according to the Government's indication) funds to cover up to half the costs of efficiency retrofits, provided these follow the recommendations of an approved energy audit. This facility will help overcome the access to finance barrier, and also prompt the uptake of efficient commercial and industrial technologies such as efficient motors, efficient chillers, Variable Frequency Drives, and lighting technologies. Providing finance for these technologies around an energy audit program will help to ensure that recommendations of the audits can be implemented, and that the technologies being financed are appropriate. It will also make it easier to achieve economies of scale in equipment supply, since auditors will be able to coordinate the types of units recommended and group orders together. This Finance Facility can operate on a revolving basis, with the funds repaid from early loans being lent out again, thus increasing the number of retrofits that can be supported. The interest rate on the facility will be set at a level to make it self-supporting

- ***Discretionary Facility***—A US$1.0 million grant facility for the Government's discretionary use on activities that would not generate any revenues, but that would be important for increasing the use of EE and RE by households and businesses in Barbados. The Government could use such facility for funding awareness activities, or replicating activities of the SEF Pilot Program (purchase and installation of small RE systems, and distribution of CFLs). This component would also cover administrative costs of MFIE for supervising the Fund management.

The Smart Fund should be supervised within the Ministry of Finance, Investment and Energy, but the actual management of the Funds can be outsourced to the Enterprise Growth Fund Limited (EGFL) against payment of a spread for the loan components (EE Retrofit and RE Finance Facility, and Pilot Consumer Finance Facility), and of a disbursement fee for grant components (Air conditioner rebate trade-in program, and CFL promotion). Outsourcing management of the Smart Fund to the EGFL seems a reasonable option because

- The EGFL has significant experience in providing credit to small and medium enterprises in Barbados—this is consistent with the Smart Fund's main focus on SMEs—and in channeling Government funds
- The EGFL is open to different arrangements regarding the spread it would apply on Government funds for its clients—this could be a fixed spread negotiated with Government, as well as a flexible spread within an agreed range (1-2 percent, according to the EGFL's experience)
- The EGFL has solid and established contacts with private companies through Barbados' key SME associations—in particular the Barbados Manufacturers' Association, the Small Business Association of Barbados—and has used such associations for effectively marketing its credit products with companies
- The EGFL can also administer grants from the Government, with payment of a disbursement fee (up to 1 percent on funds disbursed).

The Government should seek additional grant and concessional loan funds to further capitalize and expand the Fund, allowing for the programs that prove successful to be continued and expanded—in particular, the Pilot Consumer Finance Facility, which was originally conceived to use most of the funds available from the Investment Loan. The IDB has already indicated a willingness to provide a kind of line of credit, allowing further funds to disbursed for the same purposes after the first US$10m has been deployed.

**Procure an ESCO for Implementing the Public Sector Energy Conservation Program**

Implementation of this valuable program is lagging behind the Government's expectations. Audits for 15 public buildings were completed, but retrofits expected to begin before the end of 2009 still wait for complete terms of reference to be launched. The Energy Unit has prepared draft terms of reference for outsourcing the retrofit of those buildings that have already been audited to an Energy Services Company (ESCO) under a performance-based contracting scheme. Under this arrangement, an ESCO would be procured to finance the capital works needed. The ESCO would guarantee a pre-established amount of savings, and would receive its return through a share of the savings achieved.

We agree that the ESCO approach is a good one. It will help to overcome the twin problems of implementing such programs entirely within the public sector—namely a lack of finance and a lack of incentives. Our recommendations are simply that:

- The Energy Unit move forward rapidly with implementation of the ESCO approach to the Public Sector Energy Conservation Program
- Those parts of the Ministry of Finance in charge of government budgeting and expenditure actively support the Energy Unit in this effort, given the potential this program has to reduce government expenditure.

**Leave customs and tax provisions for RE and EE largely unchanged, but better define 'environmentally preferred products' for tax incentive purposes, banning the import of substandard CFLs, and customs exemption eligibility**

Barbados has introduced a number of tax and customs incentives for renewable energy and energy efficiency equipment. The BNSI is also developing standards (known as 'certificates') for air conditioners and refrigerators. It is expected that these certificates will establish minimum performance standards for these appliances, and provide the basis for customs staff to decide whether they are eligible for reduced duties. We understand that BNSI's criterion for starting with air conditioners and refrigerators is that these are among the most common types of equipment sold. Our analysis shows that other types of equipment—such as premium efficiency motors, or efficient lighting technologies—are much more cost-effective than refrigerators, but lack a certificate. In the case of CFLs, the ability to get a duty exemption without a certificate may be a reason why there are low-quality lamps on the market.

The only changes we recommend to the current arrangements are that:

- The Barbados National Standards Institute complete the standards that can be used to define with certainty what constitutes 'Environmentally Preferred Equipment' for the purposes of income tax deductions, and the Inland Revenue formally adopt these. Careful attention will need to be paid to refrigerators, since our analysis has shown that refrigerators that are considered energy efficient in North America do not necessarily perform well in Barbados
- The Customs Department (perhaps in conjunction with the BNSI) set minimum standard that CFLs must reach to qualify for the reduced rate of duty, and ban importation of sub-standard CFLs from any source
- The Government consider adjusting the duty free regime for imports for the tourism industry, to ensure there is a differential between conventional equipment and energy efficient equipment in this sector also. Currently, since all equipment for the tourism industry can be imported duty free, the duty waiver that incentivizes purchase of more efficient equipment in other sectors has no practical effect on tourist investments. A practical approach would be to limit the duty exemption on equipment for tourism purposes to equipment that is certified as energy efficient, under the scheme being developed by the BNSI.

While it is true that greater customs and tax incentives would create greater incentives to purchase energy efficient products, we do not recommend extensions of these incentives programs, for the following reasons:

- For some products, such as air conditioners, reducing the cost of energy efficient products might lead people who otherwise would not have bought the appliance to buy one, thus increasing total energy consumption
- For some customer categories, distorted electricity tariffs already create incentives to invest in energy efficiency and distributed renewable generation beyond the economically optimal level
- The analysis in this report shows that cost is not the binding constraint preventing uptake of efficient energy technologies and distributed generation. Rather, it is a lack of capital, information, and widespread competitive supply. Government will get greater results for each dollar spent through initiatives such as those proposed for the Smart Fund, which directly address these barriers, than it will through further tax deductions and customs waivers.

**Consider phasing out incandescent light bulbs**

The Government of Barbados has indicated that it wishes to take a further step in direct regulation for supporting efficient lighting by phasing out traditional incandescent light bulbs, or General Lighting Service (GLS). This would entail a restriction in (i) import, and (ii) sales of incandescent light bulbs.

If the Government were to regulate the use of GLS, with the aim of removing GLS from the market, we recommend that the most effective way to do this would be through a gradual phase out, much like what is currently operating in Australia. The proposed policy should follow these stages:

1. ***Setting a deadline for phase out of all inefficient light-bulbs*** (for example, 2015)—in consultation with key stakeholders, including industry, consumers, various government agencies and technology developers, policy makers should set a final deadline by which it is feasible to phase out all inefficient residential GLS
2. ***Issuing a policy that establishes phased levels of acceptable efficiency of light-bulbs by the established deadline***—light sources that produce less than 25 lumens per watt of energy consumed (a measurement of light intensity commonly accepted to be the limit for efficient lighting) are inefficient, given currently available technology. Such a level of efficiency should represent the Minimum Energy Performance Standard (MEPS) used
3. ***Implementing a phased and progressive restriction on the import and sale of inefficient light-bulbs***—initially the most inefficient light sources should be removed from the market (less than 15 lumens per watt), progressing to the more efficient (less than 25 lumens per watt). The most effective policy instrument by which inefficient light sources can be effectively removed from the market is the implementation of a MEPS.

Since Barbados (like many countries today, also given the large predominance of China in producing light bulbs) imports most or all of its GLS bulbs, it can enforce a phase-out of GLS by restricting the import of certain light bulbs. The restriction would be based on the bulbs' failure to meet requirements set by a MEPS. The MEPS can be increased over time until only light bulbs with the required level of efficiency are imported.

Import restrictions are commonly supplemented with a staggered restriction on the sale of inefficient light-bulbs. For example, if GLS that produced less than 15 lumen per Watt had complete import restrictions enforced form January 2011, then by December 2011 the market will have sold much of the standing stock, and had time to import CFL alternatives for when a restriction on selling less than 15 lumen per Watt GLS comes into force. The MEPS can then be increased to restrict the importation of the next tier of inefficient lighting, providing that an efficient and acceptable substitute is available or developed.

It is important to note that a MEPS does not necessarily promote one particular type of light bulb technology over another, but rather promotes a light bulb technology that complies with required efficiency levels—this is consistent with the recommended technology-neutral principle of the SEF. At a MEPS of 25 lumens per Watt, CFLs are likely to be the technology best placed commercial expansion, but other technologies would also comply (and possibly be even more efficient, although also more costly). The cheapest technology that complies with required efficiency levels is likely to prevail.

**Enact an Energy Labeling Program in a Regional Context**

Energy labeling is an important factor in identifying energy efficient equipment and influencing consumer decisions to purchase the appliance. At least the most common equipment should be validated with a clear 'certificate' by the Barbados National Standards Institute. Certificates need to ensure that devices imported achieve promised results. As noted, the Barbados National Standards Institute is already working on certificates for air conditioners and refrigerators.

Our field work shows the importance of making sure that these standards are set with Barbados-specific conditions in mind—the case of refrigerators is a good example—and not simply adopted from overseas. It would not be economically efficient for Barbados to develop its own testing facilities strictly for testing products, especially given that there is an existing testing facility in Jamaica.

We recommend that Barbados be at the forefront of a Caribbean energy labeling program for major energy using equipment, such as refrigerators and air conditioners. This program could build upon the certificates BNSI is working on, and achieve economies of scale by ensuring that they represent a standard common to other Caribbean countries. The Government should explore the possibility of testing equipment in Jamaica's facilities, and involve in the process the BNSI, the Bureau of Standards Jamaica (BSJ), and the Trinidad and Tobago Bureau of Standards (TTBS) as a start.

**Launch Institutional Strengthening for the Renewable Energy Unit and the Government Electrical Engineering Department**

Institutional strengthening is required for two key entities:

- ***The Renewable Energy Unit of the Energy Division of MFIE***. Interviews with MFIE's Energy Division indicated that there has not been a sustained effort to build capacity for the Divisions' RE Unit. The Energy Division is well aware of this situation, and has already completed the administrative task of creating seven new positions for the RE Unit. These positions remain not filled and temporarily frozen due to the Government's strained fiscal position. However, the Energy Division has indicated that some funds are available for filling at least 'some' of these positions in the short term—unfreezing the positions would pertain to the

Ministry of Civil Service. The positions created are 6 technical positions, and 1 clerical position. We strongly support filling, as possible based on available funds, 3 or 4 of the technical positions in the short term, and considering more than one junior candidate in addition to at least one senior candidate.

- ***The Government Electrical Engineering Department***. The GEED focuses primarily on the safety and compliance with standards of electrical installations in Barbados. While the Chief Electrical Officer of the GEED has had formal training and experience in RE technologies, other staff do not have the training and experience required to inspect installation as the numbers of these increases—particularly after the approval of the pilot Rider for Renewable Energy. The number of GEED employees required for inspection of RE installations is adequate, but they need appropriate training. We recommend that allocating funds for specific training of existing GEED staff in installation of the most common RE systems, particularly solar and wind. A regional approach with other Caribbean countries would be the most efficient way to contain costs and allow exchange of experience and information among experts of different countries with similar needs.

Regarding other Government entities, institutional strengthening of the TCDPO is being addressed separately with IDB support, and can be effectively completed with the development of standard environmental permitting and planning regulations, as recommended above. The FTC can perform all of its daily activities with current capabilities, and for others activities that take place at a lower rate—such as licence applications, or future rate applications—outsourcing is the most efficient, effective option (as well as one that is already used and proven by the FTC).

Finally, the SEF Pilot Program we designed includes an awareness campaign to be outsourced to a specialized entity, and focusing on EE and energy conservation through the distribution of CFLs and power monitors. A budget of US$50,000 was provided for this pilot awareness campaign. Based on this experience, the Government may replicate the campaign for a broader audience, with funding through the Discretionary Facility of the Smart Fund.

# Projected benefits of the SEF

As we explain in Section 7, reaching a Sustainable Energy Matrix by 2029 could:

- Cut total electricity costs by US$283.5 million—net effect of higher capital costs (by US$386.5 million) but lower fuel costs (by US$670 million)
- Cut $CO_2$ emissions by 4.5 million tons
- Reduce reliance on fossil fuels to about 71 percent.

Table ES 3 below summarizes costs and benefits of the SEF.

## Table ES 3: Summary of Costs and Benefits of the Sustainable Energy Framework (SEF) for Barbados

| Scenarios (20-year time horizon to 2029) | RE and EE Economically Viable Potential | | | Economic Costs and Benefits over 20 years [3] | | | $CO_2$ Emissions Reductions | | Stakeholders: Winners and Losers | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Energy displaced (RE) or saved (EE) [1] | Proportion of RE in final consumption in 2029 [2] | EE savings compared to BAU in 2029 | Fuel costs (cumulative NPV) [4] | Capital costs (cumulative NPV) [5] | Cost-benefit compared to BAU | Emissions (cumulative) | Emission reductions compared to BAU | Customers: Average bill (residential, commercial, industrial) [6] | BL&P [7] | Government: Cumulative Foreign Exchange Savings [8] |
| | GWh/year | % | % | US$ M | US$ M | US$ M | $tCO_2$ M | $tCO_2$ M | US$/month | | US$ M |
| **Business As Usual (BAU)**<br>(Thermal capacity: 128MW new, -104.5 retirements by 2029) | - | 1.5% | - | 2,648 | 166 | - | 19.3 | - | 118; 700; 861 | - | - |
| **Renewable Energy (RE)**<br>Wind, utility scale (40MW)<br>Biomass cogeneration (20MW)<br>Solid waste to energy (13.5MW)<br>Solar water heating (19.7)<br>Solar PV (20MW) | 372.6 | 27% | - | 2,451 | 337 | -26 | 17.4 | -1.9 | 118; 700; 861 | Potential small cost (short-medium term). Potential benefits | 3.94 |
| **Energy Efficiency (EE)**<br>Main EE technologies include efficient lighting, air conditioners, premium motors, chillers, variable frequency drives, and power monitors | 445.1 | 1.9% | 21.9% | 2,485 | 348 | 19 | 18.7 | -0.6 | 89; 451; 764 | Potential small cost (short-medium term). Potential benefits | 3.26 |
| **Sustainable Energy (RE+EE)** | 817.7 | 28.9% | 21.9% | 1,978 | 552.5 | -283.5 | 14.8 | -4.5 | 89; 451; 764 | | 13.4 |

Notes: (**1**) Based on projected energy required to meet demand (including losses) without and with energy efficiency, and on the portion of the energy that could be provided by economically viable renewable generation technologies. (**2**) The BAU scenario includes the 10MW wind farm in Lamberts. Energy efficiency further reduces the energy required to meet demand, thus further increasing the percentage share of renewables. (**3**) Present value of fuel and capital costs calculated using a discount rate of 6 percent over a 20 year period. (**4**) Based on oil prices escalating to US$100/bbl in 2020, and staying at this level until 2029. (**5**) Capital costs of renewable energy technologies: as shown in Section 4. Capital costs of energy efficiency technologies: based on a US$0.12 weighted average cost to save 1kWh, as mentioned in Section 5.2.3. (**6**) Based on projected average monthly consumption per customer with and without energy efficiency in 2029 (residential: 297kWh/month and 395kWh/month; commercial: 1,367kWh/month and 2,121kWh/month; industrial: 2,314kWh/month and 2,610kWh/month); and on an average residential tariff of US$0.30/kWh, and non-residential tariff of US$0.33/kWh, assuming oil prices of US$100/bbl. (**7**) In the short-medium term, reduced consumption of electricity generated by the utility could reduce BL&P's Return on Investment (ROI). In the long term, BL&P investments could adjust the asset base to demand. On the other hand, BL&P faces no additional cost (and potentially some benefit) from RE development as long as it develops economically viable RE technologies, and purchases RE from third parties at (or below) avoided cost. BL&P can also enjoy potential benefits from entering the RE and EE business. (**8**) Based on a purchase price for US Dollars for Government and BNOCL of BB$2.04 per US$, that is with an additional cost of US$0.02 for each US Dollar purchased. The Government subsidized the Fuel Clause Adjustment between December 2007 and October 2008, at an overall cost of about US$18 million (see Section 2.5).

# How to Use this Report for the Policy Matrix of the Policy-Based Loan

The Government and the IDB are negotiating a Policy-Based Loan (PBL) known as "Support for Sustainable Framework for Barbados", or BA-L1022. This Report contains some (but not all) of the 19 'triggers' for the first phase of the PBL ("First Programmatic PBL").

The table below is built on the 'Policy Matrix' contained in Annex II of the "Proposal for Operation Development" between the Government and the IDB. It provides guidance on where to find, in this Report (sections in Volume 1 excluding the Executive Summary, and Appendices in Volume 2), the content that corresponds to each trigger that pertains to our assignment.

Some triggers are external to this report, and pertain to other entities such as the FTC or BNOCL. In these cases, the table shows a shaded cell indicating 'Not Applicable' (N/A), and the entities to which it pertains.

| First Programmatic PBL (August 2010) | Reference in This Report |
|---|---|
| **I. Macroeconomic Stability** | |
| 1. Macroeconomic framework is consistent with the objectives of the program and with policy letter | N/A (MFIE) |
| **II. Development of a Sustainable Energy Framework for Barbados (SEFB)** | |
| 2. Study assessing RE generation potential, presented to Cabinet | Section 4: Renewable Energy in Barbados' Current and Sustainable Energy Matrix<br>Appendix C: Potential Renewable Energy Technologies<br>Appendix D: Waste to Energy Technologies and Environmental Impact<br>Appendix E: Ocean Thermal Energy Conversion<br>Appendix F: Ocean Wave Energy Conversion<br>Appendix G: Provisions for Grid Stability<br>Section 2.3.3: Generation Costs |
| 3. Indicative targets for RE, presented to Cabinet | Section 3: A Sustainable Energy Matrix for Barbados<br>Section 7: Projected Benefits of the Sustainable Energy Framework<br>Appendix M: Assumptions and Results for Projected Benefits of the SEF |
| 4. Recommendations for RE policy and | Section 6.1: Core Policy Principles |

| First Programmatic PBL (August 2010) | Reference in This Report |
|---|---|
| legislation, presented to Cabinet | Section 6.2: Electricity Sector Regulation and Tariff Reforms<br>Section 6.7: Customs Provisions and Tax Incentives—Steady as she Goes |
| 5. Recommendations for establishing "Smart Energy Fund" to have the financial instruments and mechanisms to improve investments in RE, presented to Cabinet | Section 6.5: Establish a Smart Fund for Increasing Investments in RE and EE<br>Appendix L: Smart Fund Design |
| 6. Rider to introduce special tariffs and terms for the SEF pilot program, approved by FTC | N/A (FTC, MFIE, and BL&P) |
| 7. Study assessing EE potential by sector, presented to Cabinet | Section 5: Energy Efficiency in Barbados' Current and Sustainable Energy Matrix<br>Appendix H: Potential Energy Efficiency Technologies<br>Appendix I: Site Visits for Energy Efficiency<br>Appendix J: Capabilities of Local and Regional Energy Services Companies |
| 8. Indicative targets for EE by sector, presented to Cabinet | Section 3: A Sustainable Energy Matrix for Barbados<br>Section 7: Projected Benefits of the Sustainable Energy Framework<br>Appendix M: Assumptions and Results for Projected Benefits of the SEF |
| 9. Recommendations for EE policy and legislation, presented to Cabinet | Section 6.1: Core Policy Principles<br>Section 6.4: Mandate Energy Efficient Design in the Building Code<br>Section 6.6: Procure an ESCO for Implementing the Public Sector Energy Conservation Program<br>Section 6.7: Customs Provisions and Tax Incentives—Steady as she Goes<br>Section 6.9: Enact an Energy Labeling Program in a Regional Context<br>Appendix K: Energy Audit Guidelines |
| 10. Recommendations for establishing "Smart Energy Fund" to have the financial instruments and mechanisms to improve investments in EE, presented to Cabinet | Section 6.5: Establish a Smart Fund for Increasing Investments in RE and EE<br>Appendix L: Smart Fund Design |
| 11. Under the SEF pilot program, a proposal to | Appendix P: SEF Pilot Program |

| First Programmatic PBL (August 2010) | Reference in This Report |
|---|---|
| distribute Compact Fluorescent Lamps (CFLs) and power monitors is presented to Cabinet | Appendix Q: Environmental Impact Assessment for Compact Fluorescent Lamps Disposal |
| 12. Recommendations for a phase-out plan for incandescent lamps, presented to Cabinet | Section 6.8: Consider a Phase-Out Plan for Incandescent Light Bulbs |
| 13. Plan to establish a RE unit in BNOCL, approved by BNOCL Board | N/A (MFIE and BNOCL) |
| 14. Environmental and Social Assessment of alternatives for the sustainability of the sugar cane sector for BCIC, in preparation | N/A (MFIE and BCIC) |
| 15. Government of Barbados (GOBA), through NPC, has agreed on the TORs for a study to analyze: (i) recommendations for upgrade and expansion of the natural gas transmission and distribution network; and (ii) recommendations for the efficient and sustainable use of fossil fuels | N/A (NPC, BNOCL, and MFIE) |
| **III. Measures for Mitigation and Adaptation to Climate Change in the Energy Sector** | |
| 16. GHG emissions reduction potential for the SEFB, presented to Cabinet | Section 7: Projected Benefits of the Sustainable Energy Framework<br>Appendix M: Assumptions and Results for Projected Benefits of the SEF |
| 17. The design of RE projects under the SEF Pilot Program and the "Smart Energy Fund" incorporate resilience to climate change impacts | N/A (Ministry of Environment, Water Resources, and Drainage, and MFIE) |
| **IV. Institutional Strengthening, Capacity Building and Public Awareness for Sustainable Energy** | |
| 18. Recommendations for institutional strengthening, public education and capacity building needs for key entities of the energy sector, presented to Cabinet | Section 6.10: Launch Institutional Strengthening for the Renewable Energy Unit and the Government Electrical Engineering Department<br>Appendix N: Institutional Capabilities Assessment |
| 19. Recommendations to strengthen and upgrade capacity to assess the environmental impact of large RE projects, presented to Cabinet | Section 6.3: Strengthen the Capabilities of the Town and Country Development Planning Office with Standardized Environmental Permitting and Planning Regulations for Renewable Energy |

# 1 Introduction

The Inter-American Bank (IDB) hired Castalia and Stantec ('the Consultants') to help the Government of Barbados ('the Government') prepare a 'Sustainable Energy Framework' (SEF) for Barbados. This Final Report represents the last deliverable of our work, and completes the SEF assignment by providing our comprehensive analysis and policy recommendations for renewable energy (RE) and energy efficiency (EE) in Barbados.

This Report incorporates all final understandings with the IDB and the Government on our assignment, in particular as emerged through: (i) our trip to Barbados from 8 to 12 March 2010, for presenting to the Government and the IDB our draft final report; (ii) videoconference calls with the IDB and the Government on 29-30 April 2010, for discussing activities and structure of a 'Smart Fund' supporting RE and EE projects, and to be capitalized with a US$10 million 'Investment Loan' by the IDB to the Government; and (iii) communication by the SEF Project Manager on 17 May 2010, confirming the Government's approval of the Smart Fund's activities and structure discussed.

In this Introduction, we:

- Present the objectives of the Sustainable Energy Framework for Barbados
- Describe the objectives of the Government for the energy sector—these are the basis for the objectives of the SEF
- Present the structure of this Final Report.

## 1.1 Objectives of the Sustainable Energy Framework for Barbados

According to our Terms of Reference (TORs), the objective of the SEF is:

> *To promote and support sustainable energy and energy conservation programs in order to ensure a sustainable development in Barbados, providing alternatives to minimize the dependency on fossil fuels.*[1]

Based on our understanding of the Government's energy sector objectives (see following section), and on meetings with Government authorities, we suggest formulating objectives of the SEF as follows:

> *To unlock economically viable investments in Renewable Energy (RE) and Energy Efficiency (EE) that will reduce Barbados' dependency on fossil fuels, and thus*
>
> *reduce energy costs,*
>
> *improve energy security, and*
>
> *enhance environmental sustainability.*

Improving energy security and enhancing environmental sustainability can be pursued while reducing energy costs, provided that households and businesses in Barbados invest in viable RE and EE technologies. However, further improving energy security and enhancing environmental sustainability by using RE and EE technologies that are not economically viable implies a tradeoff with the objective of reducing energy costs:

[1] Terms of Reference for the Sustainable Energy Framework for Barbados, Section 5, Paragraph 2.1.

- Figure 4-1 and Figure 5-1 show the cost in US$ that RE and EE technologies respectively require to generate (or save) one kWh. Technologies that are not viable will require additional costs (compared to the cost per kWh of conventional generation) to pursue greater energy security
- Figure 4-2 and Figure 5-2 show the cost in US$ that RE and EE technologies respectively require to abate an additional ton of carbon dioxide ($CO_2$). Technologies that are not viable have a positive abatement cost that represents the additional cost (compared to the current price of $CO_2$) to reduce global warming.

## 1.2 Objectives of the Government for the Energy Sector

Although the Government intends the SEF to represent its comprehensive energy policy, Barbados already has elements of a sustainable energy policy.

While actions, objectives, resources, and priorities are still not organized in one comprehensive design, the Government has formulated objectives for the energy sector and launched various initiatives. We describe the Government's energy sector objectives below—these represent the basis for the objectives of the SEF presented above. We also review the Draft National Energy Policy of Barbados, which was prepared in 2006 (but never adopted). We review the Government's initiatives for sustainable energy in Section 2.6.

### 1.2.1 The Government's Energy Sector Objectives

In his inaugural speech in February 2008, the Prime Minister of Barbados stated that "the single biggest challenge of our generation is the drain on foreign exchange created by the high cost of oil", and that the Government was "prepared to be bold and move aggressively in the area of energy conservation, reducing the oil import bill and preserving our delicate environment for the future".[2] We understand from the Prime Minister's statement that the Government has three main objectives related to energy:

1. Reduce energy costs
2. Achieve greater energy security
3. Improve environmental sustainability.

These objectives all relate to the need to address the predominance of imported fossil fuels in the energy sector of Barbados. In 2009, all of the electricity generated in the country[3] was produced with fossil fuels. Power generation represents the main use of fuels in the country (50 percent), followed by transport (33 percent).[4] Barbados produces some oil, but domestic demand (about 10,000 barrels per day) greatly exceeds local supply (about 1,000 barrels per day). This results in oil imports in excess of 9,000 barrels per day; that is 90 percent of its consumption. We discuss the Government's three main energy-related objectives below.

[2] Prime Minister's Inaugural Speech, Government House, Barbados, February 2008.

[3] As discussed in Section 4.1.2, there are a few experimental renewable electricity installations, but their generation is negligible.

[4] Barbados Light & Power, *Annual Report* 2008.

**Reducing energy costs**

Energy costs are a concern for the Government both at a macroeconomic level, and at an individual level of consumers. In a keynote address delivered on June 11, 2008, the Prime Minister mentioned that Barbados spent US$208 million on oil imports in 2007, representing about 7 percent of Gross Domestic Product (GDP)—a level comparable to Government expenditure on education[5]—with "devastating effects" on direct production costs, and therefore on the competitiveness of Barbadian businesses.[6] The Prime Minister therefore announced the Government's commitment to reducing the energy bill, and protecting its citizens from imported inflation.

Electricity in Barbados is generated by a single provider (Barbados Light & Power—BL&P) that can directly pass fuel costs through to consumers by using a Fuel Clause Adjustment (FCA). The FCA reached an all-time high in August 2008 of BB$0.495 per kWh (approximately US$0.25). This would have meant a monthly electricity bill of about US$158 for a second-block residential customer consuming 400kWh per month.[7] This figure is striking when average income per capita in Barbados is considered—about US$612 per month, according to the Central Bank of Barbados.[8] However, residential customers were cushioned from the full impact of the increase through a government subsidy on fuel oil used for electricity generation. As we discuss in Section 2.5, this subsidy of the FCA cost the Government about BB$36 million over less than one year.[9]

After reaching a peak of US$147 per barrel in July 2008, oil prices dropped to US$32 per barrel by February 2009. However, prices have since rebounded, and are about US$74 per barrel as of 1 June 2010[10]—the prospect of returning to mid-2008 prices is not unrealistic (ten-year oil futures currently trade at close to US$100).[11] This calls for continued engagement by the Government to protect households and businesses alike, using instruments that are more effective and affordable than direct subsidies for increases in fuel prices.

The Government also saves money when oil imports decrease. The reason is that BL&P purchases fuel denominated in BB$ from the Barbados National Oil Company, Limited (BNOCL)—a Government-owned entity—while the BNOCL pays for imports of fuel in US$. The Government therefore incurs a cost to purchase foreign exchange (US$) to buy the fuel through BNOCL, for resale to BL&P in BB$.

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[5] United Nations data. http://data.un.org/CountryProfile.aspx?crName=Barbados.

[6] Keynote Address delivered by The Prime Minister of Barbados, The Honorable David Thompson, at the opening of the Latin American Finance Conference held in Trinidad and Tobago, 11 June 2008.

[7] Assuming August 2008 rates, BBD 17.6 (for the first 100kWh), plus BBD 58.8 (for the next 300kWh), plus BBD 198 (FCA of BBD0.495 per kWh for all 400kWh), plus 15 percent VAT, for a total of BBD 315.6 or USD 157.8.

[8] Barbados Central Bank. http://www.centralbank.org.bb/country_info.shtml.

[9] Barbados Light & Power, *Annual Report 2008*, page 6.

[10] West Texas Intermediate (WTI): US$73.97, *The Financial Times*, 1 June 2010 (also see citation in section 5.2.2).

[11] Based on the price of ten-year futures for light sweet crude oil (WTI). See http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude.html

**Achieving greater energy security**

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".[12]

Barbados currently has relatively secure electricity generation capacity, having increased the system's reserve margin from almost zero in 1998 to around 43 percent in 2009 (see Figure 2-9). However, Barbados' electricity generation mix consists primarily of imported fuel oil and diesel. Insufficient diversification of energy resources is likely to jeopardize energy security, in particular due to the volatility of fossil fuel prices.

The Prime Minister's reference to imported oil's drain on foreign exchange as "the single biggest challenge of our generation" also hints at energy security problems. The reason for which foreign exchange matters is the fuel procurement mechanism described above (BNOCL buys fuel in US$, and sells it to BL&P in BB$).

**Improving environmental sustainability**

Environmental sustainability is a positive externality from which the entire present and future society benefits—sustainability can be defined as "forms of progress that meet the needs of the present without compromising the ability of future generations to meet their needs".[13] However, the cost of producing and consuming fossil fuel-based energy commonly does not reflect the value of negative environmental externalities.

The Government's reference to its commitment to protect the "delicate environment" of Barbados may relate to both local and global environmental sustainability. The latter concerns mostly anthropogenic global warming, which is generally associated with consumption of fossil fuels, and which may adversely affect a small island country like Barbados. The electricity sector in Barbados emits about 827,000 tons of $CO_2$ (see Figure 2-24), which accounts for more than half of the country's total emissions.

On the other hand, local environmental sustainability may also concern more direct pollution effects on Barbados' natural environment, which is a vital economic resource for the country's tourism industry. It is unclear whether there is any prioritizing of the Government's concerns between local and global environmental sustainability. In Sections 4.2.4 and 5.2.4, we show the additional cost of $CO_2$ abatement through renewable energy and energy efficiency technologies, respectively—and we compare it with the current cost of Certified Emissions Reductions.

### 1.2.2 The Barbados Draft National Energy Policy of 2006

A draft Barbados National Energy Policy (BEP) was prepared in 2006, but was never formally adopted by the Government. Based on the Barbados Sustainable Development Policy, the BEP formulated the following energy policy objectives:

- Providing adequate and affordable energy to all sectors of society as a prerequisite for a decent quality of life

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

[13] World Commission on Environment and Development. See http://www.un-documents.net/wced-ocf.htm.

- Maximizing the efficiency of energy use in production, storage, distribution and end-use
- Reducing dependence on fossil fuels with more emphasis on renewable energy technologies as primary energy sources
- Using an integrated mix of regulation and economic and market-oriented approaches for promoting competition within both the petroleum and electricity sectors, and for promoting best industrial and environmental practices
- Promoting research and development in energy efficiency, oil and gas exploration, and renewable energy technology
- Increasing exploration for oil and gas resources, and using newly discovered resources in such a manner as to ensure at least 50 percent transfer of known reserves of fossil fuels to the next generation
- Increasing private sector participation in a competitive energy sector
- Reflecting the inputs of the major stakeholders and ensuring accessibility to all.

The draft policy proposed that security in energy supply be ensured, among other things, by:

- Increasing the exploration and exploitation of onshore and offshore oil and gas resources
- Diversifying the fuel mix by transitioning to natural gas as the primary fossil fuel, achieving a fuel mix with 70 percent of demand satisfied from natural gas by the year 2026
- Reducing the dependence on fossil fuels thanks to the promotion of EE and RE.

The draft policy also proposed that a Demand Side Management (DSM) program be implemented in the public sector—this proposal was picked up by the Public Sector Energy Conservation Program, described in Section 2.6.1. The DSM program would also focus on the Barbados Water Authority (BWA)—the single largest energy consumer in Barbados—with the aim of reducing unaccounted-for water and examining the feasibility of using RE sources to satisfy BWA's pumping requirements. In support of EE, the draft policy also suggested an EE equipment labeling program, an EE building code, and a comprehensive public transport plan.

Regarding the petroleum sector, the draft policy intended to maximize EE by establishing a new oil terminal and associated infrastructure to increase the efficiency of petroleum product storage and distribution. The draft policy proposed that although Barbados on-shore oil and gas potential would continue to be exploited by the BNOCL, competitive bidding would be established for offshore exploration. The import of oil, however, was intended to be de-regulated, while the Government would maintain control of storage and terminals. It was also proposed that the Government allow new entities to enter the retail petroleum market. This market would be liberalized on the basis of a new regulatory environment which would include criteria for the establishment and relocation of gas stations, including environmental and safety standards.

In the past, the Government attempted to shield consumers from high oil prices by adjusting the tax on these products. However, the draft policy recognized that it would be unable to continue this implied subsidy indefinitely, and proposed that a new tax regime be defined.

The policy also proposed various environmental impact mitigation actions, such as replacing Methyl Tertiary Butyl Ether (MTBE) with ethanol, reducing sulfur content in diesel, preparing vehicle emissions standards, protecting groundwater and coastal zones devoted to petroleum storage, improving oil spill contingency plans, and encouraging waste-to-energy projects.

## 1.3 Structure of this Report

This Report is structured as follows:

- Section 2 contains the background necessary to understand the analysis and recommendations on a sustainable energy sector—we analyze the country's energy sector policy and regulatory framework, supply and demand of electricity, electricity generation costs, the tariff structure, and existing programs for supporting sustainable energy
- Section 3 presents a Sustainable Energy Matrix for Barbados that includes increased renewable energy and energy efficiency, and compares it to the country's current energy matrix. We also present an alternative Sustainable Energy Matrix including increased electricity generation with natural gas, based on the potential development of the Eastern Caribbean Gas Pipeline (ECGP)
- Section 4 analyzes renewable energy in Barbados' current and sustainable energy matrix—we find that current uptake of renewable technologies is low in spite of several technologies being viable; we analyze the barriers that prevent viable renewable projects from being implemented, and present possible solutions to overcome these barriers
- Section 5 analyzes energy efficiency in Barbados' current and sustainable energy matrix—we find that current uptake of efficient technologies is low in spite of most technologies being viable; we analyze the barriers that prevent viable energy efficiency projects from being implemented, and present possible solutions to overcome these barriers
- Section 6 pulls together the possible solutions for overcoming barriers to renewable energy and energy efficiency from the previous two sections, and expands them into a comprehensive program of policy and regulatory recommendations that together create a Sustainable Energy Framework for Barbados
- Section 7 presents the projected benefits—energy savings, financial savings, and reduced carbon emissions—of achieving a Sustainable Energy Matrix in Barbados over a twenty year timeframe.

The following Appendices are contained in Volume 2 of this Report:

- Appendix A presents laws and regulations governing the electricity sector in Barbados

- Appendix B describes key entities in Barbados with responsibility in the energy sector
- Appendix C provides detailed descriptions of potential renewable energy technologies analyzed in Section 4
- Appendix D analyzes various waste to energy technologies for Barbados, and assesses their environmental impact
- Appendix E describes the Ocean Thermal Energy Conversion (OTEC) technology (not commercially proven)
- Appendix F describes the Ocean Wave Energy Conversion technology (not commercially proven)
- Appendix G describes provisions for grid stability
- Appendix H provides detailed descriptions of potential energy efficiency technologies analyzed in Section 5
- Appendix I lists our site visits for assessing current penetration of energy efficiency technologies in Barbados, and potential for increased uptake
- Appendix J presents an assessment of capabilities of local and regional Energy Services Companies (ESCOs)
- Appendix K contains the Energy Audit Guidelines we prepared for the Government
- Appendix L presents the detailed design for the Smart Fund
- Appendix M describes assumptions and results for projected benefits of the SEF
- Appendix N contains our assessment of institutional capabilities of entities involved in the implementation of the SEF
- Appendix O contains case studies and lessons learnt on sustainable energy financing in other countries
- Appendix P contains documents we prepared for the SEF Pilot Program, which is financed by the Government and the Global Environment Facility (GEF) for introducing small renewable energy systems, compact fluorescent lamps, and power monitors in Barbados
- Appendix Q contains an Environmental Impact Assessment for CFL disposal.

# 2 Background to the Sustainable Energy Framework

In this Section, we provide the background necessary to understand the analysis and recommendations on a sustainable energy sector that follow. The section first describes the main policy, regulatory, and provider bodies in the sector. It then describes electricity sector demand, costs, performance, regulation and tariffs. It concludes by summarizing the initiatives government has taken to date for promoting renewable power generation and energy efficiency.

## 2.1 Institutional Outlines of the Energy Sector

Energy policy is the responsibility of the **Energy Division** within the **Ministry of Finance, Investment and Energy**. This unit has the responsibility for monitoring and regulating energy supply. Particular responsibilities include promoting the use of renewable energy technologies, and promoting the efficient use of energy. Broadly, energy policy in Barbados over the past few years has aimed at ensuring the security of energy supply, and making the further development of these supplies sustainable.

The country's sole commercial electricity provider is the **Barbados Light & Power Company Limited (BL&P)**. BL&P is a vertically integrated electric utility company responsible for the generation, supply and distribution of electricity. Apart from a change in name and some changes in shareholder and corporate structure, the utility has an unbroken history going back to before 1909. The ultimate shareholders in the utility are Leucadia National Corporation of the USA with 37 percent of the shares, the Barbados National Insurance Board with 23 percent of the shares, and approximately 2,800 other Barbadian investors.

BL&P is regulated by the **Fair Trading Commission (FTC)**. The FTC was established in January 2001 under the Fair Trading Commission Act. It took over utility regulation from the previous Public Utilities Board, and also has responsibility for competition law and general consumer protection. The FTC is an independent government entity. It obtains budgetary support from Government budget, and from levies on the entities regulated by the Commission. A recent World Bank study of regulatory authorities ranked the FTC among the top group due to its mechanisms and procedures for guaranteeing its autonomous administration.[14]

On the fuel side, three other government-owned entities are relevant:

- The **National Petroleum Corporation (NPC)** sells piped natural gas for domestic, commercial, and industrial use. Its mission is to provide an adequate, reliable, safe, and efficient gas service to customers at a reasonable cost
- The **Barbados National Oil Company Limited (BNOCL)** produces about 1,000 barrels per day of crude oil from onshore wells located at Woodbourne in St. Phillip. This crude is sent to PETROTRIN, the state-owned oil refinery of Trinidad and Tobago, to be refined in an exchange arrangement for refined product. The fuel oil received in exchange for the crude represents only about 10

[14] L. Andres, J.L. Guasch, M. Diop, S. Lopez Azumendi, *Assessing the Governance of Electricity Regulatory Agencies in the Latin American and Caribbean Region: A Benchmarking Analysis*. World Bank, November 2007.

percent of Barbados' fuel requirements. BNOCL purchases fuel for electricity generation and sells it to BL&P

- The **Barbados National Terminal Company Limited (BNTCL)** is a subsidiary of BNOCL. Initially, BNOCL would source and freight petroleum products to Barbados, and ownership would pass to BNTCL at the ship's flange. BNTCL would then store and sell products to users. The commercial relationship between BNOCL and BNTCL changed in 2005—now BNTCL is only responsible for storage of products. The new arrangements mean that BNTCL operates only as a terminal facility, charging a throughput fee for product moved through its facilities. BNTCL moves the fuel oil product through the ESSO Holborn terminal that it is leasing, and a newly installed pipeline. BNTCL has also built a pipeline between its Fairy Valley Terminal and BL&P's generation facility at the Seawell generation station. The new pipeline became operational early in 2006.

More details on all these entities are provided in Appendix B.

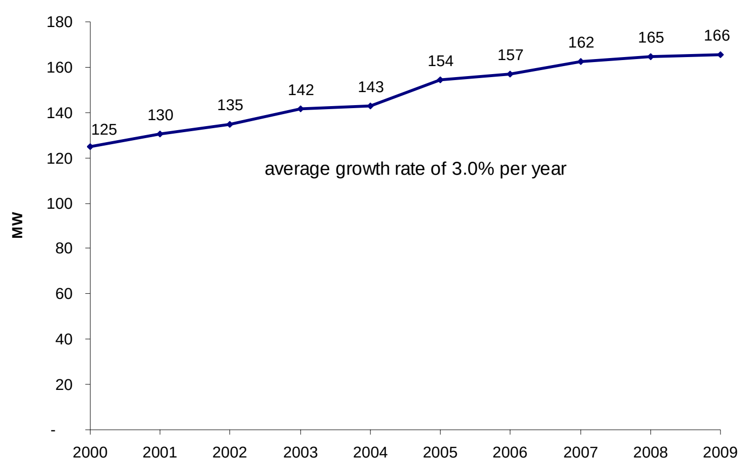
## 2.2 Electricity Demand

In this section, we provide and overview of current demand for electricity in Barbados, and its evolution over the past 10 years.

### 2.2.1 Peak Demand Growth

As shown in Figure 2-1, peak demand in Barbados has been growing steadily over the past 10 years at around 3.0 percent per year, from 125MW in 2000 to 166MW in 2009, while total electricity consumption has been growing at around 3.6 percent annually.[15] This compares with average GDP growth over the same period of 4.1 percent. [16].

**Figure 2-1: Peak Demand (2000-2009)**




Source: BL&P Annual Reports 2000-2008, and for 2009 data from BL&P management.

[15] We calculate all average growth rates over a given period as geometric averages.

[16] World Bank, *World Development Indicators*, 2009.

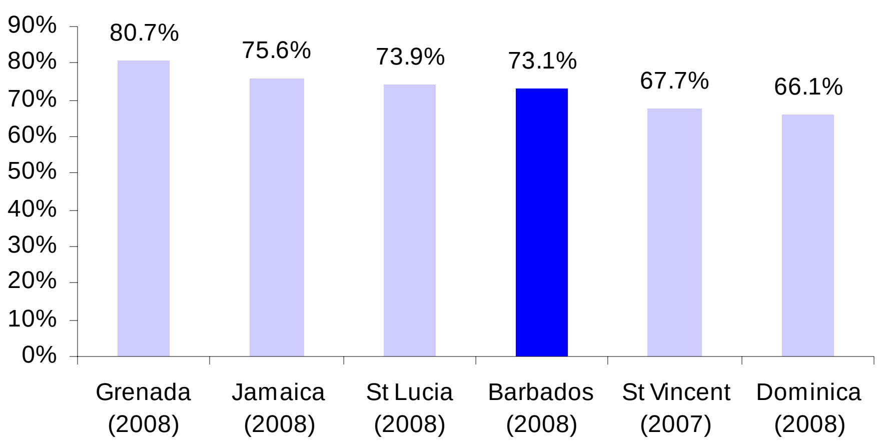
Peak demand determines the required generation and distribution capacity. According to BL&P, in Barbados the system peak occurs at around 12pm each day and is relatively constant throughout the year.

### 2.2.2 Load factor

Barbados' system load factor—defined as the ratio between average net generation load over the year and peak demand—was 73.1 percent in 2008. A higher system load factor indicates a steadier load, with less need for generation capacity per unit of power consumed. Barbados ranks in the middle of other Caribbean countries, as shown in Figure 2-2—it could further reduce peak load compared to countries such as Grenada, the best performer, but its load is less peaky than Saint Vincent's or Dominica's.

The load factor could be improved 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 cost-reflective tariffs that charge people more for consuming at peak compared to off-peak times, and through awareness campaigns.

**Figure 2-2: Comparing the Load Factor in Barbados with other Caribbean countries**




Source: Utilities' Annual Reports.

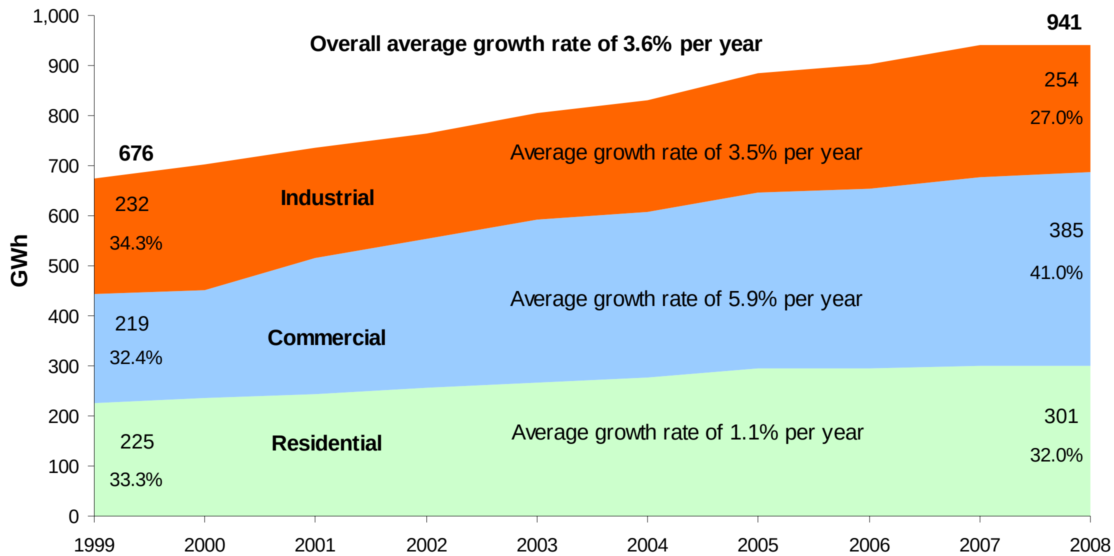
### 2.2.3 Consumption of Electricity

Figure 2-3 shows the trends in electricity consumption 1999 to 2008,[17] by the following three categories**:**

- **Residential customers**: This includes customers in BL&P's tariff categories of Domestic Services and Employees
- **Commercial customers**: This includes customers in BL&P's tariff category for General Service
- **Industrial customers**: This includes customers in BL&P's tariff categories for Secondary Voltage,[18] Large Power, and Street Lighting.

[17] BL&P consumption data for 2009 not available for this Report.

**Figure 2-3: Electricity Consumption by Customer Type**




Source: BL&P Annual Reports 1999-2008.

Total electricity consumption during the period grew steadily at around 3.6 percent per year, from 676 GWh in 1999 to 941 GWh in 2008, with commercial customers accounting for most of the growth. Electricity consumed by commercial customers increased from 32 to 41 percent of total consumption. Tourism has been the main driver for commercial demand growth. From 1999 to 2008, the tourism sector increased its consumption of electricity at a rate of about 8.5 percent per year.[19]

To better understand the drivers of growth in electricity consumption by different customer classes, we examine the number of customers and average consumption per customer. In particular, an understanding of the average consumption per customer provides insights into the potential for promoting energy efficiency.

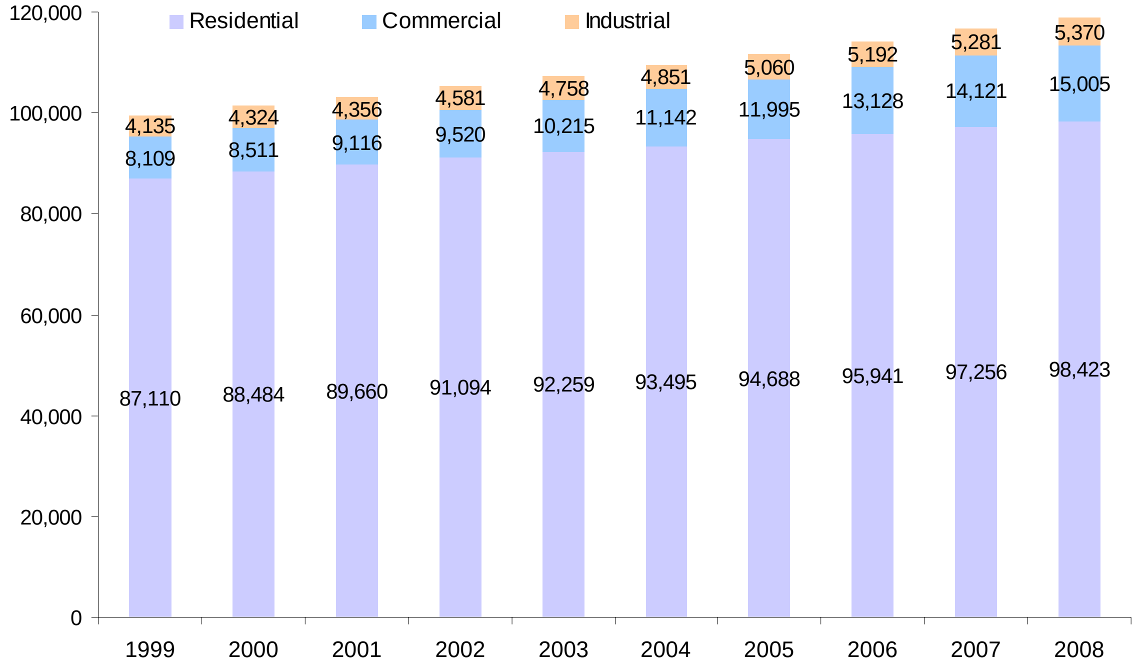
### Customer Numbers

The total number of electricity customers served by BL&P has grown from 99,354 in 1999 to 118,798 in 2008, with a steady growth rate of 2.0 percent per year. Residential customer growth has averaged 1.4 percent per year, which reflects the low level of population growth over the past ten years. The number of industrial and commercial customers has been growing at slightly faster rates, with growth of commercial customers reflecting an expansion in the number of tourism operators.

[18] According to BL&P, Secondary Voltage mostly includes commercial and tourism companies, as well as industrial companies

[19] Note that this assignment does not specifically cover RE or EE potential in the tourism sector. A separate assignment, the Caribbean Hotel Energy Efficiency Action Program (see section 2.6.3), addresses this sector.

**Figure 2-4: Number of Customers by Type**



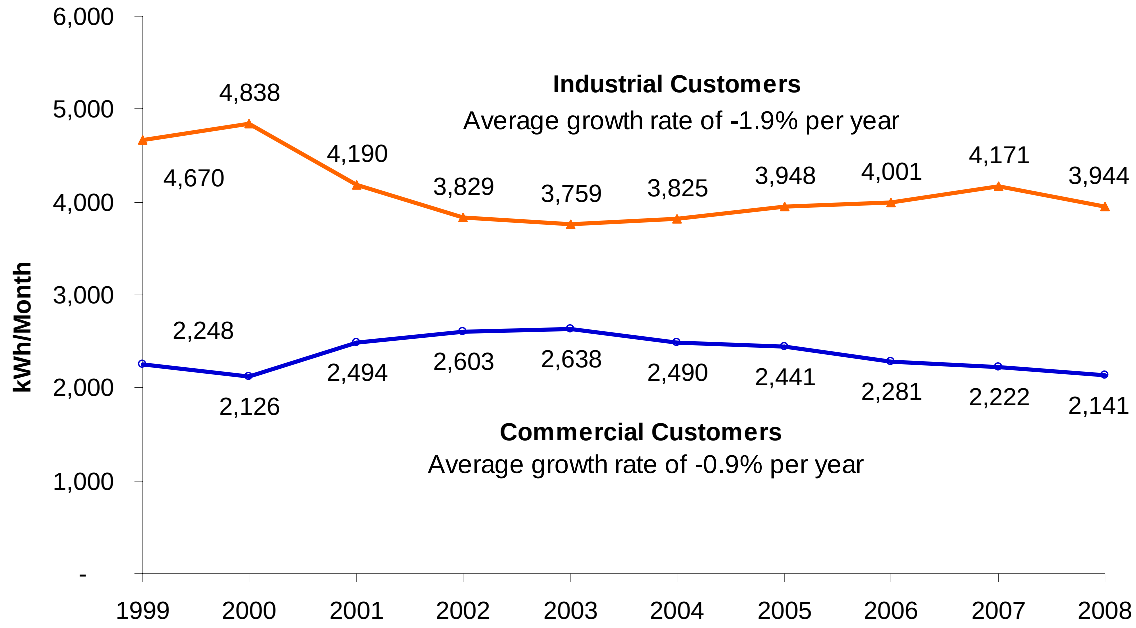

Source: BL&P Annual Reports 1999-2008.

### Average Consumption per Customer

Figure 2-5 and Figure 2-6 show average consumption per customer across different customer classes. These trends are important because energy efficiency measures target a reduction of average consumption. We note the following trends over the past ten years:

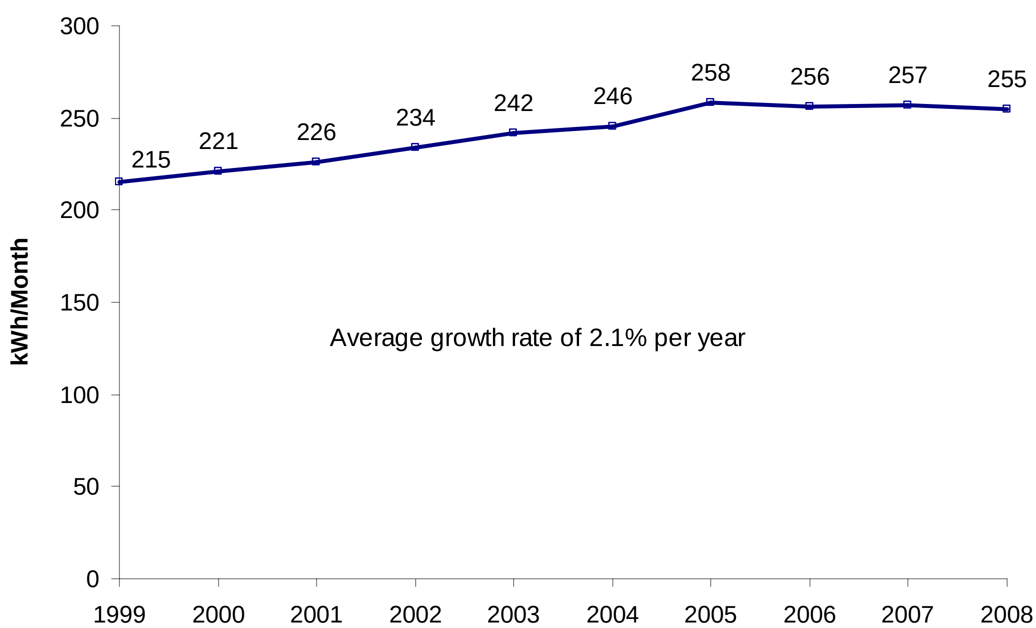
- **Industrial demand**—Average consumption per customer decreased during the past ten years. The average consumption per industrial customer declined sharply during the 2000–2001 recession, and again during the 2007–2009 recession, with growth experienced from 2003 to 2007
- **Commercial demand**—Average consumption for commercial customers has been relatively steady over the past ten years, declining gradually since 2003
- **Residential demand**—Average consumption per residential customer grew at 3.2 percent per year from 1999 to 2005, and remained relatively constant since 2005. The average annual growth rate over the last 10 years is about 2.1 percent.

**Figure 2-5: Average Consumption by Industrial and Commercial Customers**




Source: BL&P Annual Reports 1999-2008.

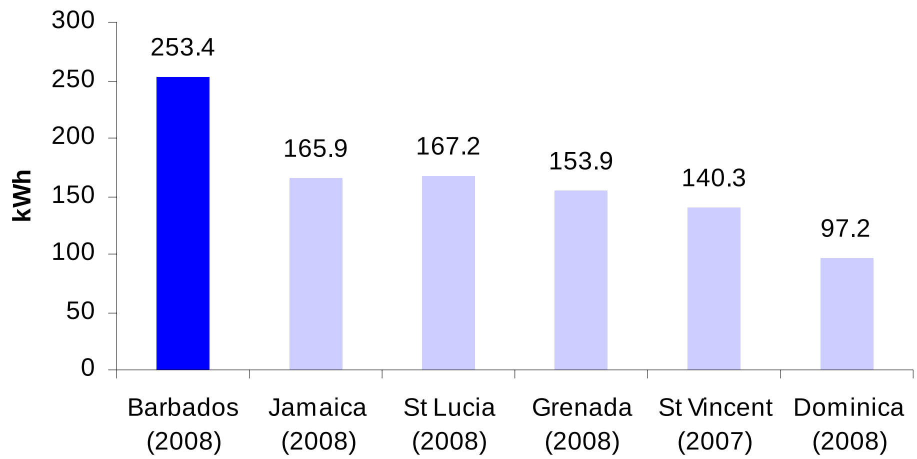
**Figure 2-6: Average Consumption by Residential Customers**




Source: BL&P's Annual Reports 1999-2008.

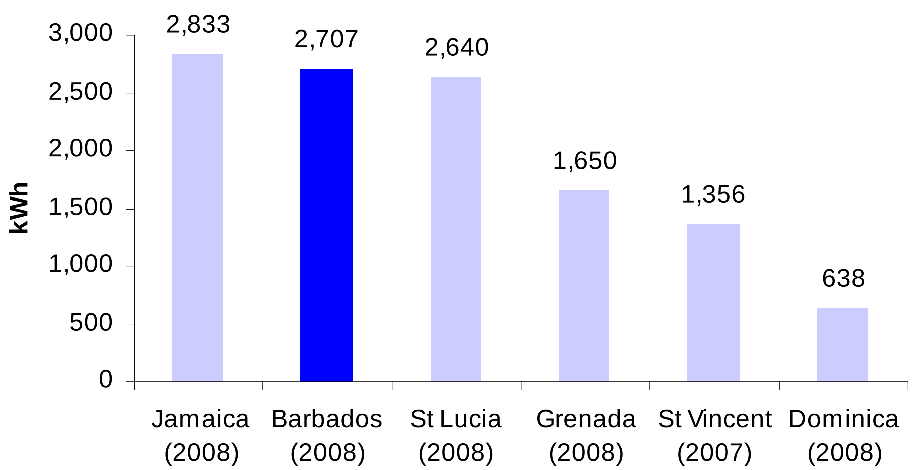
Both residential and non-residential customers in Barbados consume, on average, more electricity than their peers in most Caribbean islands, as shown in Figure 2-7 (residential) and Figure 2-8 (non-residential).

**Figure 2-7: Residential Average Consumption per Month in Barbados and the Caribbean**




Source: Utilities' Annual Reports.

**Figure 2-8: Non-Residential Average Consumption per Month in Barbados and the Caribbean**




Source: Utilities' Annual Reports.

Table 2-1 summarizes the statistics for electricity consumption by each customer class.

**Table 2-1: Customer Numbers and Average Consumption by Customer Class**

| Customer Class | Customer Numbers | | Customer Number Growth Rate | Average Consumption (kWh per month) | | Average Consumption Growth Rate |
|---|---|---|---|---|---|---|
| | 1999 | 2008 | | 1999 | 2008 | |
| Residential | 87,110 | 98,423 | 1.4% | 215 | 255 | 2.1% |
| Commercial | 8,109 | 15,005 | 6.9% | 2,248 | 2,141 | -0.9% |
| Industrial | 4,135 | 5,370 | 3.1% | 4,670 | 3,944 | -1.9% |

Source: BL&P Annual Reports 1999-2008.

## 2.3 Electricity Supply

This section presents:

- **Generation capacity**—Barbados' generation mix consists entirely of thermal plants. Installed capacity per capita is high, and high reserve margins have been restored since 2002, but BL&P plans to decommission over 27 percent of capacity in the next 10 years
- **Dispatch and generation**—low speed diesel plants account for most of Barbados' generation due to their efficiency
- **Generation costs**—these are high by international standards, but low compared to other Caribbean islands. The price of oil is the biggest driver of generation costs. We also present estimated generation costs using natural gas, based on potential availability of natural gas via pipeline from Trinidad and Tobago for BL&P's projected dual-fuel plants
- **Fuel consumption**—most of the fuel consumed for electricity generation in Barbados is heavy fuel oil, which powers BL&P's low speed diesel plants, the most fuel-efficient of the utility's generation plants
- **System losses**—Barbados' losses are among the lowest in the Caribbean (6.6 percent), and lower than many industrialized countries
- **$CO_2$ emissions**—emissions have been growing at a slower pace than electricity demand since 2005, thanks to the commissioning of low speed diesel plants.

### 2.3.1 Generation Capacity

BL&P is the only company in Barbados that generates electricity for supply to the national grid, although a number of larger electricity consumers have facilities to self-supply electricity. BL&P accounts for around 92 percent (239.1 MW) of total generation capacity in the country. Data on the actual consumption and demand from self-generating customers is limited—BL&P's estimate is that self-generating customers own 16MW of generation capacity.[20] Below we describe BL&P's generation capacity, focusing on plant mix and reserve capacity margin.

[20] Estimate based on data provided by BL&P management on customers who generate their own power.

**Plant mix**

BL&P currently owns three types of plant with a total of 239.1MW of installed generating capacity:

- **Steam turbines**—BL&P's two steam plants were built in 1976, and are due to be decommissioned in 2012. They have the highest $CO_2$ emission factor among BL&P's plants—1.39 tons of $CO_2$ per MWh of electricity generated. These steam plants are currently operated on heavy fuel oil and have a fuel efficiency of around 3.78kWh per liter. The fuel costs around US$0.105 per kWh[21]
- **Low speed diesel**—BL&P has 113.5MW of low speed diesel plants, of which 50MW were built before 1990 and will be decommissioned in the next 20 years. All the low speed diesel plants use heavy fuel oil as the main source of fuel, and have a fuel efficiency of about 4.93 kWh per liter. Fuel costs between US$0.06 – 0.07 per kWh[22]
- **Gas turbines**—BL&P owns 86MW of gas peaking plant, of which 13MW will retire in the next 20 years. Gas plants consume diesel and jet fuel. The fuel efficiency for plants that consume diesel is around 2.82 kWh per liter, and around 2.94 kWh per liter for plants that consume jet fuel. Fuel costs between US$0.12 and US$0.185 per kWh, depending on the fuel used (the gas turbines have been running on diesel fuel over the past few years, due to the lower cost of diesel compared to jet fuel.)[23]

The table below shows BL&P's current generation capacity. For each unit, the table also gives its rating, $CO_2$ emissions factor, year of installation, and the fuel it uses.

**Table 2-2: BL&P's Generation Plant (2009)**

| Generating Unit (Location) | Maximum Continuous Rating (MW) | $CO_2$ Emissions Factor (tCO2e/MWh) | Year Installed | Fuel Type |
|---|---|---|---|---|
| **Steam Turbines (Spring Garden)** | | | | |
| GEC Unit S1 | 20.0 | 1.39 | 1976 | HFO |
| GEC Unit S2 | 20.0 | 1.39 | 1976 | HFO |
| **Subtotal** | **40.0** | | | |
| **Low Speed Diesel (Spring Garden)** | | | | |
| MAN B&W Unit D10 | 12.5 | 0.69 | 1982 | HFO |

[21] Calculation based on a heat rate of 12,393 BTU per kWh, fuel energy rate of 18,698 BTU per pound and fuel price of US$350 per Metric Ton.

[22] Calculation based on a heat rate of 7,282 - 8,449 BTU per kWh, fuel energy rate of 18,698 BTU per pound and fuel price of US$350 per Metric Ton.

[23] Communication with BL&P management, 27 January 2010. Price of fuels is controlled by the Government in Barbados, adjusted based on world prices. All fuels for manufacturers—including BL&P—is duty free, but there is no preferential treatment for diesel that distorts the utility's fuel choice for gas turbines. In December 2009, BL&P purchased diesel fuel at an average price of BB$1,363 per ton, and jet fuel at an average price of BB$1,468 per ton.

| Generating Unit (Location) | Maximum Continuous Rating (MW) | $CO_2$ Emissions Factor (tCO2e/MWh) | Year Installed | Fuel Type |
|---|---|---|---|---|
| MAN B&W Unit D11 | 12.5 | 0.69 | 1982 | HFO |
| MAN B&W Unit D12 | 12.5 | 0.69 | 1987 | HFO |
| MAN B&W Unit D13 | 12.5 | 0.69 | 1990 | HFO |
| Waste Heat Turbine Unit WH01 | 1.5 | 0.69 | 1985 | Note 1 |
| MAN B&W Unit D14 | 30.0 | 0.69 | 2005 | HFO |
| MAN B&W Unit D15 | 30.0 | 0.69 | 2005 | HFO |
| Waste Heat Turbine Unit WH02 | 2.0 | 0.69 | 2005 | Note 1 |
| **Subtotal** | **113.5** | | | |
| **Gas Turbines (Garrison)** | | | | |
| ABB Stal Unit G02 (Garrison) | 13.0 | 0.95 | 1990 | Diesel |
| ABB Stal Unit G03 (Seawell) | 13.0 | 0.95 | 1996 | Diesel |
| ABB Stal Unit G04 (Seawell) | 20.0 | 0.95 | 1999 | Jet Fuel |
| ABB Stal Unit G05 (Seawell) | 20.0 | 0.95 | 2001 | Jet Fuel |
| ABB Stal Unit G06 (Seawell) | 20.0 | 0.95 | 2002 | Jet Fuel |
| **Subtotal** | **86.0** | | | |
| **Installed Capacity** | **239.1** | | | |

HFO – Heavy Fuel Oil

Note 1 – Unit uses heat recovered from exhaust gases

Source: File on installed plant provided by BL&P management.

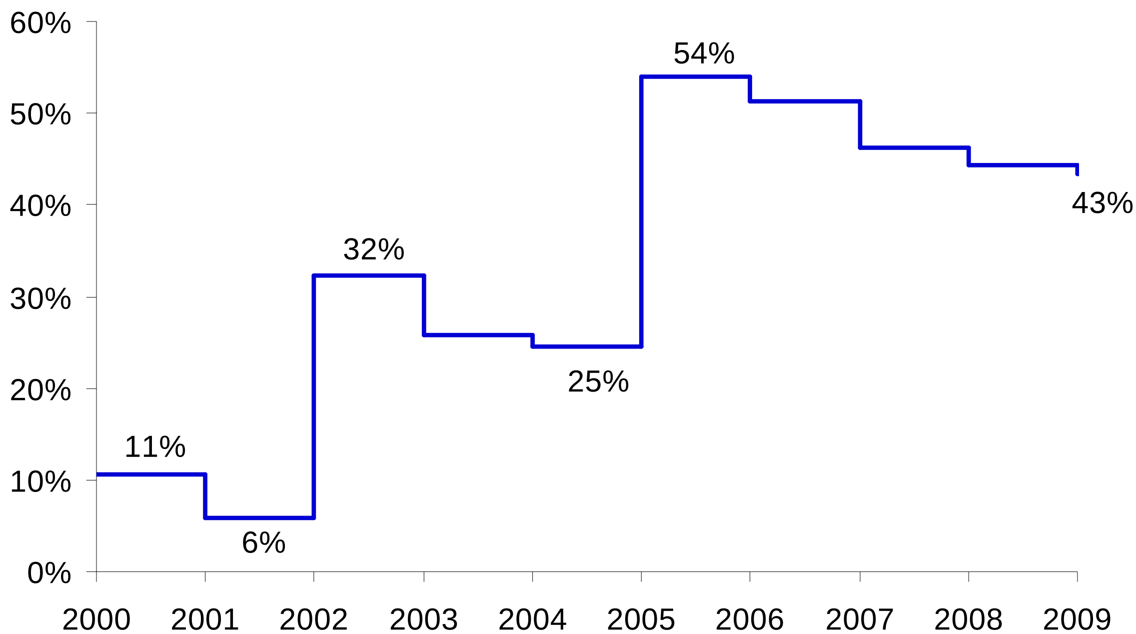
### Reserve margin

Generation capacity is built to meet peak demand and to ensure that sufficient electricity can be generated to meet electricity consumption needs over a given period. 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 generation capacity less peak demand and then divided by peak demand. A reserve capacity margin of zero 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.

Another typical standard for a reserve capacity margin is to ensure that reserve capacity is available to back up the single largest generating unit on the system (this is known as an N-1 security standard). In Barbados, N-1 security would require 30MW of reserve capacity to back up the MAN B&W Units—this would correspond to a reserve capacity margin of 18 percent.

Figure 2-9 shows the reserve capacity margin in Barbados over the last 10 years. Barbados had a very low reserve capacity margin in 2000-2001. Subsequent investment in thermal plant, however, restored the reserve capacity margin to about 43 percent in 2009. The figure illustrates that new thermal plants were commissioned in 2002 and 2005.

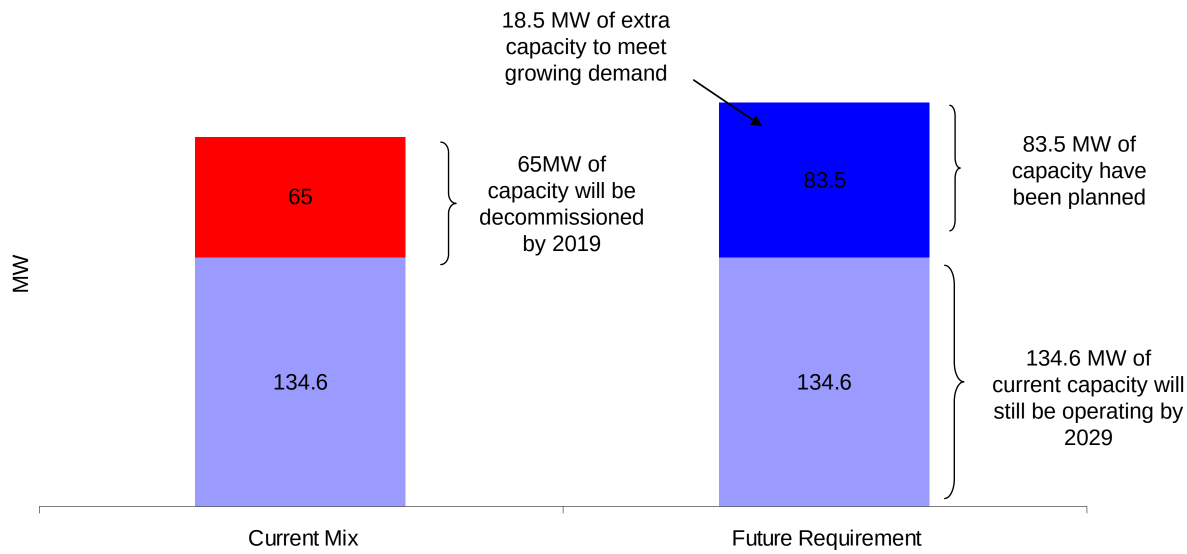
**Figure 2-9: BL&P's Reserve Capacity Margin**




Source: BL&P Annul Reports 2000-2008, and information provided by BL&P management for 2009.

Recent investment has increased the security of supply in Barbados. However, BL&P still faces a challenge to maintain security of supply, due to the significant amount of plant that will be decommissioned in coming years. As shown in Figure 2-10, BL&P will need to decommission 65MW of capacity over the next 10 years. This is equivalent to more than 27 percent of current generation capacity. BL&P plans to invest in 83.5 MW of new capacity to meet demand growth and replace the plant being retired. The need to invest in new capacity may create an opportunity to invest in renewables without stranding existing conventional capacity.

**Figure 2-10: Plant Mix and Capacity Requirements**



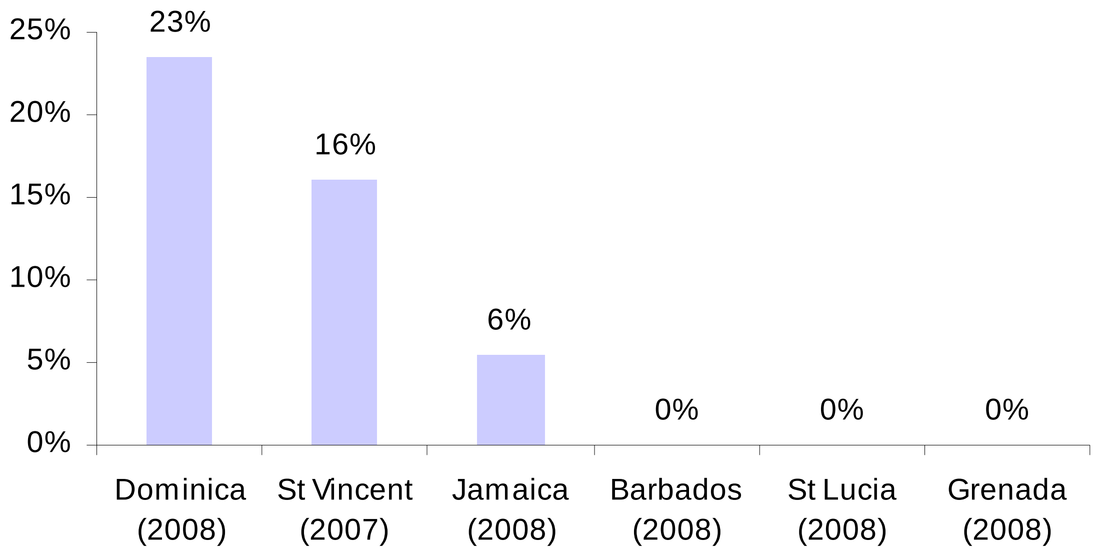

Source: Generation plant data provided by BL&P management, and Castalia estimates for future requirement.

### Renewable energy

Barbados has no utility scale renewable generation capacity. Renewable energy generation in Barbados is limited to a few small solar PV and wind systems installed by households, and experimental systems located at Government facilities. Solar water heaters comprise the most significant use of renewable energy in the country. According to Government and BL&P estimates, solar water heaters have reached a penetration of 60 percent in high-and-middle-income households.

Figure 2-11 compares the share of energy generated by renewable sources in various Caribbean countries. Barbados, Saint Lucia and Grenada have no renewable generation at the utility scale, while Dominica has the highest share, almost all of which is accounted for by hydro.

**Figure 2-11: Benchmarking of Renewable Energy Generation as a Percentage of Total Generation**




Source: Utilities' Annual Reports

Note: only utility scale generation considered.

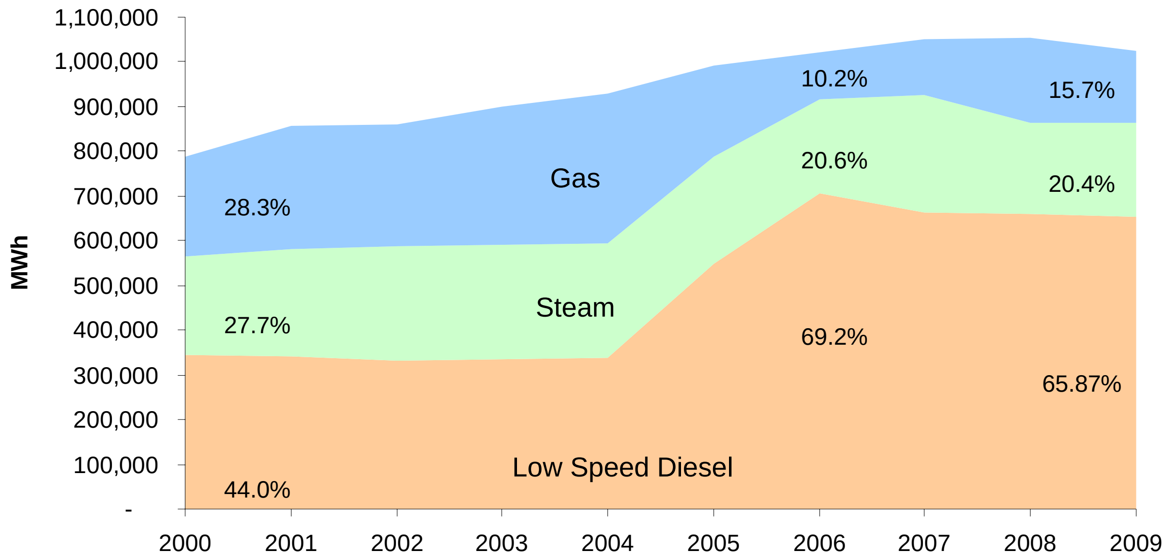
### 2.3.2 Plant Dispatch and Generation

The three types of generation capacity owned by BL&P have different cost and operating characteristics. When deciding how to meet demand over the short run, BL&P should operate its generation assets in a way that minimizes costs. Short run costs include fuel costs and other variable costs incurred when the plant is operated. Short run costs determine the dispatch pattern in an electricity system—plants with the lowest short run cost will be dispatched first (these are known as base load plants), and plants with higher short run costs will be dispatched as demand increases (these are known as mid-merit and peaking plants).

In Barbados, low speed diesel plants have the lowest short run costs. Low speed diesel plants also have the lowest $CO_2$ emissions factor among BL&P's generation plants. Steam turbines have moderate short run costs, and should be dispatched whenever demand exceeds the generation capacity of low speed diesel plants. Steam plants have a very high $CO_2$ emissions factor. Gas turbines have the highest short run costs, and should be operated solely as peaking plants. These plants have a moderate $CO_2$ emissions factor.

Figure 2-12 shows the energy generated by plant type from 2000 to 2009. Generation from gas turbines increased steadily to meet demand growth from 2000-2004, until the two new low speed diesel plants were commissioned in 2005. After these new plants were added to the system, energy generated from low speed diesel plants rose sharply and generation from gas turbine peaking plants decreased.

**Figure 2-12: Energy Generated by Plant Type, 2000-2009**




Source: BL&P's Annual Reports

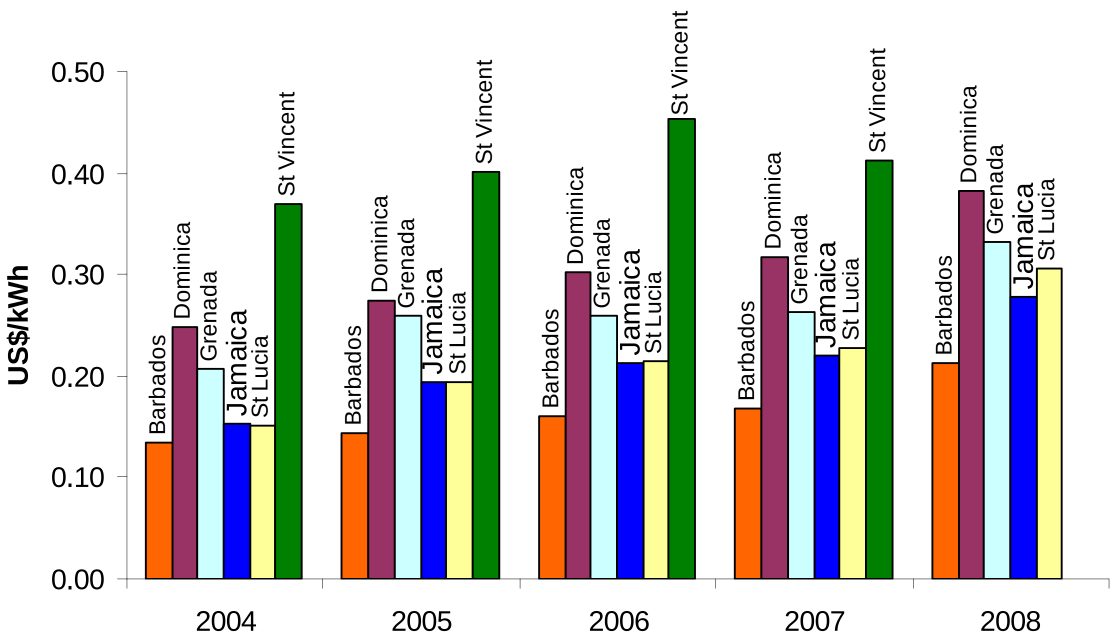
### 2.3.3 Generation Costs

BL&P is a relatively efficient power generator. While generation costs in the region of US$0.20 kWh are high by the standards of larger systems, these high costs are largely due to the small system size and the need to import fuel—this is shown below by benchmarking BL&P against other Caribbean utilities. BL&P generation costs are largely driven by oil prices. Its most efficient generators are its low speed diesel units, as the following analysis shows.

**Benchmarking generation costs**

The average generation operating cost per unit of energy sold in Barbados is among the lowest in the Caribbean. This is shown in Figure 2-13 below.

**Figure 2-13: Average Generation Operating Cost per kWh Sold in Barbados and in the Caribbean, 2004—2008 (US$/kWh)**



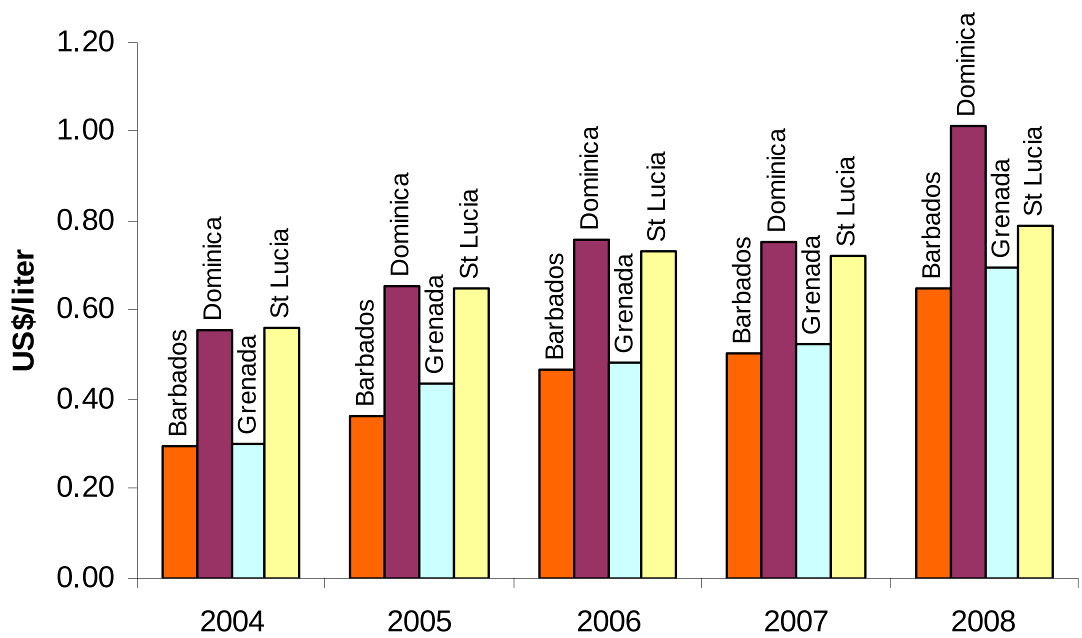

Source: Annual Reports of Utilities of Barbados, Dominica, Grenada, Jamaica, St Lucia, and, St Vincent

Note: Data for St Vincent (2008) is not available.

The reason for the relatively low cost of generation in Barbados is a combination of its low fuel price and the efficiency of its generators (heat rate). This allows Barbados to outperform St Vincent and Dominica, even though these countries have hydro as part of their generation mix. Performance of St Lucia is close to the one of Barbados, but it is higher in part because the utility (LUCELEC) burns diesel in its engines, whereas BL&P has managed to cut costs by using Heavy Fuel Oil in its low speed diesel units. Figure 2-14 compares the average fuel cost per liter in Barbados with that in other Caribbean countries. BL&P's low system losses also contribute to its good performance on generation costs per unit sold.

This does not mean that there is no potential to further reduce generating costs. With a different generating mix, Barbados's cost of power could drop.

**Figure 2-14: Average Costs of Fuel per Liter Consumed in Barbados and in the Caribbean, 2004—2008 (US$/liter)**




Source: Annual Reports of Utilities of Barbados, Dominica, Grenada, and St Lucia

Notes: The figures include all oil-derived fuel used. For Barbados this includes Heavy Fuel Oil, diesel and jet fuel. For the other countries it includes only diesel. Data for St Vincent and Jamaica are not available

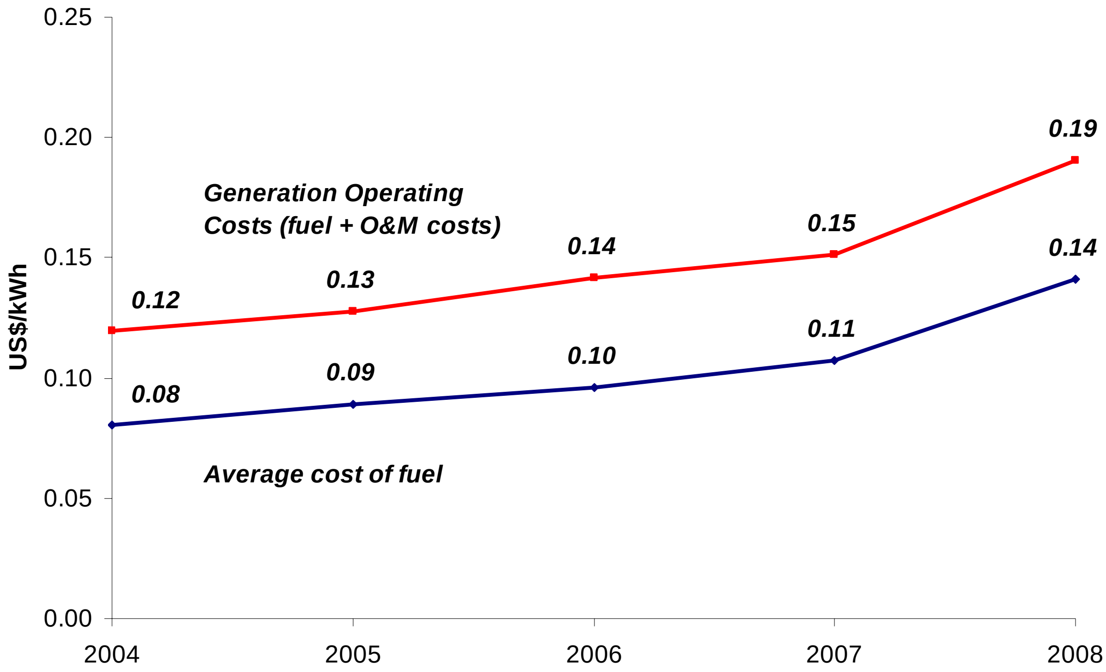
### Generation costs in Barbados are heavily dependent on fuel prices

The cost of generating electricity in Barbados fluctuates with changes in the price of oil because all of BL&P's generators operate on oil-based fuels. The cost of fuel for generation accounts for the majority of BL&P's operating expenses: 64 percent in 2007, and 68 percent in 2008.[24]

Over the five years to 2008, the average cost of fuel has increased by 76 percent, from 0.08 US$/kWh in 2004 to 0.14 US$/ kWh in 2008. This is shown in Figure 2-15 below. Fuel costs for 2009 will have come down somewhat, as oil prices fell, but remain well above the level registered 5 years ago.

[24] BL&P *Annual Report* 2008, page 46.

**Figure 2-15: Average Cost of Fuel and Generation Operating Costs for BL&P, 2004—2008**

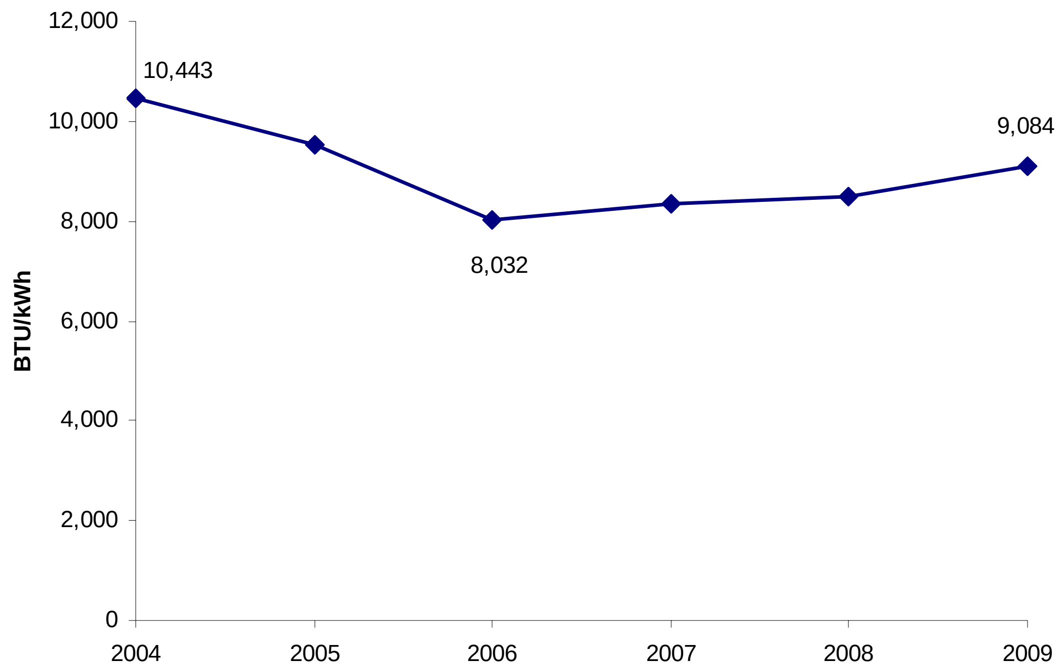



Source: BL&P.

For the figure above we define "Generation Operating Costs" as the sum of total fuel and generation-related operating expenditures divided by gross generation. We do not include capital costs in our calculations at this stage.

The average heat rate (gross British Thermal Unit of fuel burned to generate each kWh of electricity) of generators in Barbados decreased 23 percent from 2004 to 2006 and increased 11.5 percent from 2006 to 2008, as shown in Figure 2-16 below. Therefore the increase in generation costs is attributable to increases in fuel costs as well as the change in the average heat rate of generators in Barbados.

**Figure 2-16: Average Heat Rate of BL&P Generators, 2004—2009**




Source: BL&P Annual Report and Fuel Summary Sheet

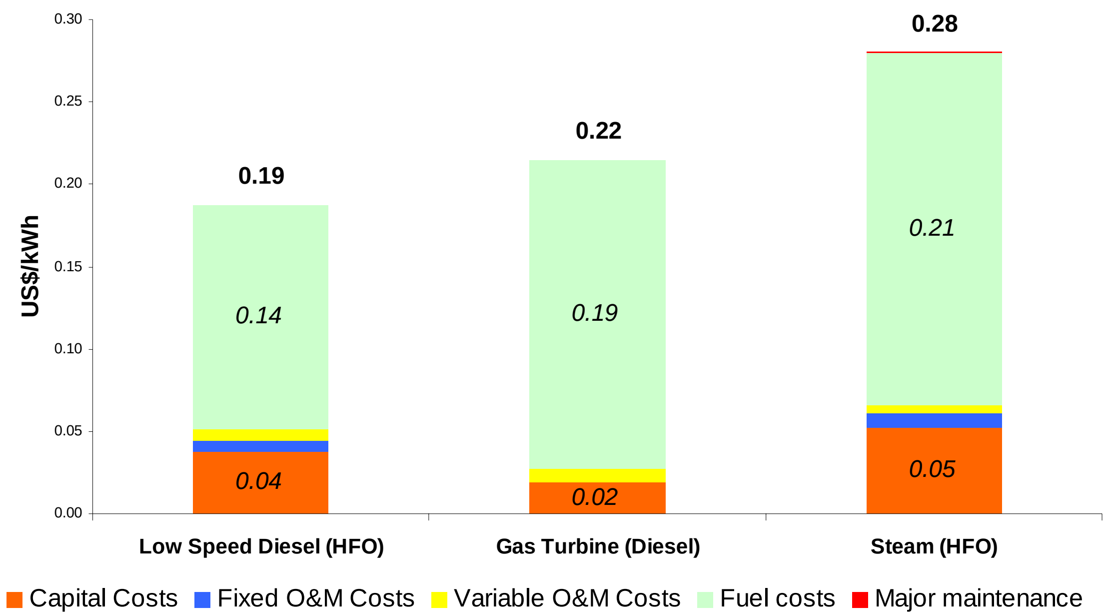
## Low speed diesel generators are currently the most efficient generators in Barbados

Low speed diesel plants, running on heavy fuel oil, are the cheapest form of generation in Barbados. At an oil price of US$100 per barrel,[25] they cost 0.19 US$/kWh. This is the all-in cost of generation—it includes capital costs (discussed below), as opposed to the costs above which only included the operating costs (fuel plus O&M). These plants are the most cost-efficient of the current mix because even though they do not have the lowest capital cost, their fuel efficiency is significantly lower than the two other types of generation.

The two other types of generation operating in Barbados are gas turbines, running on diesel fuel and jet fuel; and steam plants, running on heavy fuel oil. Figure 2-17 shows the all-in costs of generation for the three types of generators that are currently operating in Barbados.

[25] Based on the price of ten-year futures for light sweet crude oil (WTI). See http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude.html.

**Figure 2-17: All-in Costs of Generation of BL&P Plants**




Source: BL&P data on current plants, and Castalia estimates on capital costs, WACC, tax rate.

Note: Figure based on fuel cost of US$100 per barrel.

To calculate the all-in costs of the different generators in Barbados, we include all costs that are part of the long-run marginal cost of electricity generation:

- Capital costs
- Fixed O&M costs
- Variable O&M costs
- Fuel costs
- Major maintenance.

Our calculations are based on 2007 data provided by BL&P on its existing plants[26] and the following assumptions:

- Capital costs equal to US$1.7 million per MW for small low-speed diesel plants, and US$1.5 million per MW for large low-speed diesel plants; US$1.3 million per MW for small gas turbine plants, and US$1.1 million per MW for large gas turbine plants; and US$2.1 million per MW for steam plants. These capital costs have been confirmed by BL&P
- Pre-tax Weighted Average Cost of Capital (WACC) = 12 percent
- Annual inflation in Barbados = 8 percent[27]

[26] BL&P, *System Expansion Study 2007*, Final Report; and data sent by BL&P management on 25 September 2009.

- Tax rate = 15 percent
- Oil price = US$100 per barrel, based on the current value of ten year oil futures.[28]

**Electricity generation with natural gas would be the cheapest option for the future**

An Eastern Caribbean Gas Pipeline (ECGP) for exporting natural gas from Trinidad and Tobago to various other Caribbean has been proposed, but has not yet materialized. The Eastern Caribbean Gas Pipeline Company (ECGPC)—owned by Guardian Holdings (40.5 percent), Trinidad & Tobago Unit Trust Corp (40.5 percent), National Gas Company of Trinidad & Tobago (10 percent), and Intra Caribbean Gas Pipeline Limited (9 percent)—is the current name of the partnership that proposed the project in 2002, and that is still in charge of its development, which could be completed by 2014. Based on a recent interim report by the consulting company Nexant (provided by the SEF Project Manager),[29] the ECGP appears to be technically feasible (in spite of a few remaining risks and uncertainties), and preliminary cost estimates indicate that capital costs are reasonable (the ECGPC's estimate of its capital cost has decreased from US$800 million to US$675 million).

Barbados would be served by the initial section of the pipeline, stretching for 172 miles from Tobago to the northwest of Barbados (further sections would then reach Martinique, St. Lucia, and Guadeloupe). The pipeline is designed to provide 50MMscfd to Barbados, and a combined 100MMscfd to other islands. Nexant's interim report estimates that Barbados could obtain pipeline natural gas at a levelized fuel price (based on yearly demand 2014-2028) of US$7.4 per GJ (the lowest of all countries, being the closest). This price is consistent with the high end of current natural gas futures on a ten-year horizon.[30]

We calculated all-in costs of generation with natural gas based on (i) capital and operating costs and technical data provided by BL&P for its possible future plants;[31] (ii) WACC, inflation, and tax rate assumptions presented above for all-in costs of generation from liquid fuel plants; and (iii) a natural gas price of US$7.0 per MMBTU (equivalent to US$7.4 per GJ). Figure 2-18 summarizes these costs for the dual fuel plant types that BL&P is considering for its expansion plan, and compares them to the all-in costs of generation of current plants shown in Figure 2-17. Not surprisingly, the figure shows that generation costs using natural gas would be much lower:

- Low Speed Diesel and Medium Speed Diesel plants (LSD and MSD, for baseload capacity) would have an average all-in cost of US$0.11 per kWh—BL&P is considering LSD plants with a capacity between 31MW and 48MW, and MSD plants with a capacity of 17.1MW (but is likely to prefer LSD plants)[32]

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27 Central Bank of Barbados.

28 Based on the price of ten-year futures for light sweet crude oil (WTI). See http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude.html.

29 Nexant, *Caribbean Regional Electricity Generation, Interconnection, and Fuels Supply Strategy—Interim Report*, January 2010. Submitted to the World Bank.

30 See http://www.cmegroup.com/trading/energy/natural-gas/natural-gas.html.

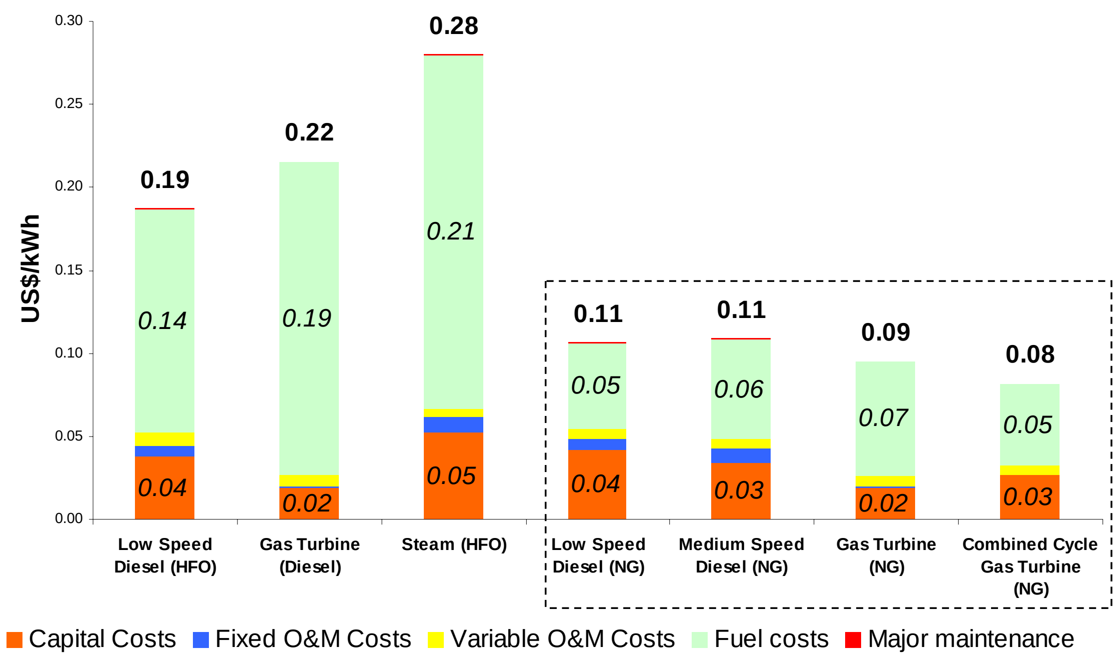
31 BL&P, *System Expansion Study 2007*, Final Report; and data sent by BL&P management on 25 September 2009.

32 Communication with BL&P, 28 April 2008.

- Gas Turbines (GTs, for peak capacity) would have an average all-in cost of US$0.09 per kWh—BL&P is considering GTs with a capacity between 21MW and 39.8MW

- Combined Cycle Gas Turbines (CCGT, with enough flexibility to cover the whole load shape), with an even higher efficiency, would have an all-in cost of US$0.08 per kWh—BL&P is considering CCGTs with a capacity between 30MW and 54MW

**Figure 2-18: Estimated All-in Costs of Generation of Potential Natural Gas Plants Compared to Current BL&P Plants**



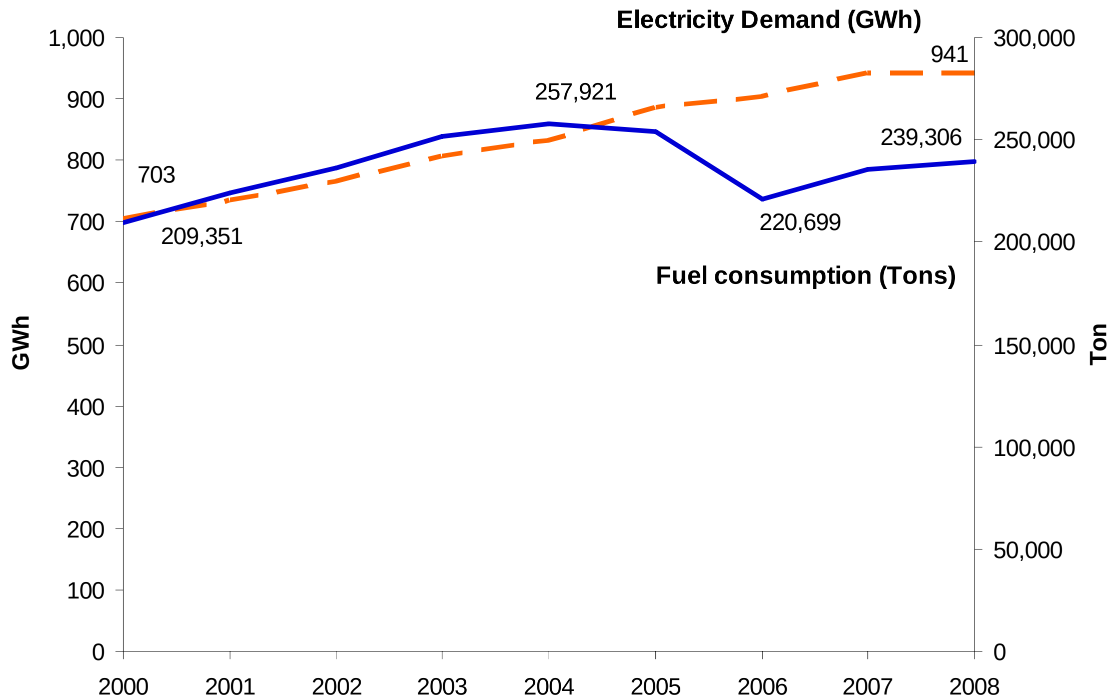

Source: BL&P data on possible future plants considered for its expansion plan, and Castalia estimates on capital costs, WACC, tax rate.

Note: Figure based on oil price of US$100.0 per barrel for liquid fuels: heavy fuel oil (HFO) and diesel; and on a natural gas price of US$7.0 per MMBTU.

### 2.3.4 Fuel Consumption

Fuel consumption depends on trends in energy demand, plant mix, and fuel efficiency. Figure 2-19 compares fuel consumption and electricity demand. Fuel consumption tracked electricity demand from 2000 to 2004—both grew at around 4.5 percent per year. In 2005, after the two low speed diesel plants were commissioned, fuel consumption fell initially and then started to increase again due to demand growth.

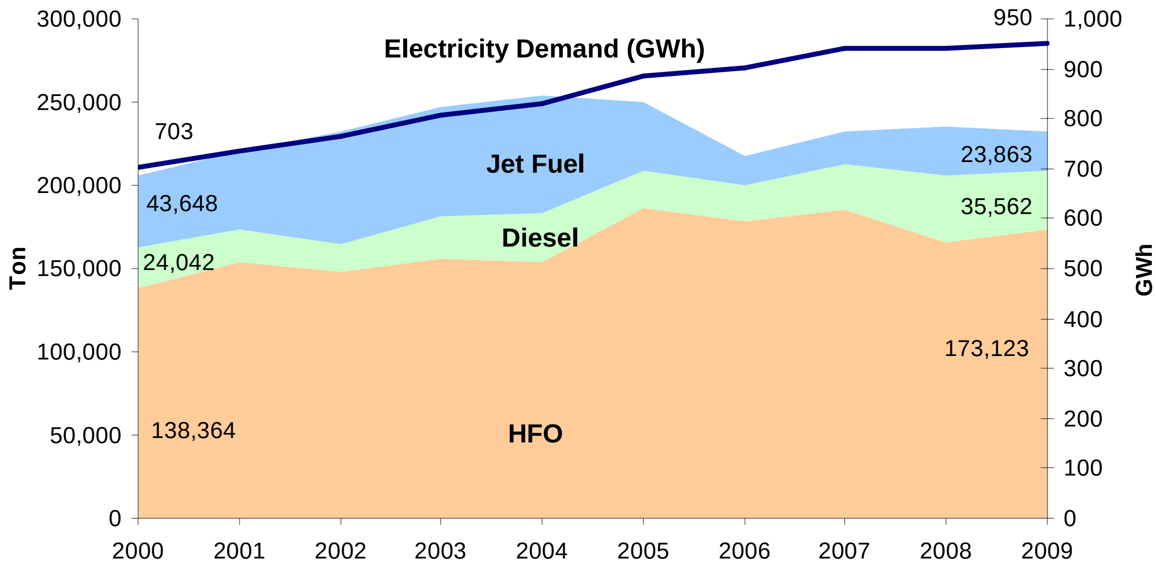
**Figure 2-19: Comparison between Electricity Demand and Fuel Consumption**




Source: BL&P Annual Reports 2000-2008, and Fuel Consumption Summary.

Figure 2-20 shows levels of fuel consumption by type from 2000 to 2009. In 2005, the consumption of heavy fuel oil rose sharply, and the consumption of jet fuel and diesel used in gas turbines fell as a result of the commissioning of the low speed diesel plants.

**Figure 2-20: Fuel Consumption by Type**

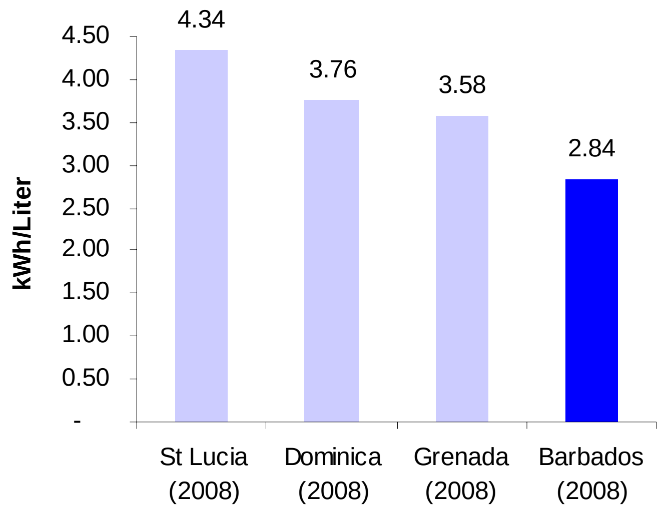



Source: BL&P's Fuel Consumption Summary, Annual Reports 2000-2008, and information provided by BL&P management for 2009.

### Fuel efficiency

Fuel efficiency measures the amount of electricity generated from each liter of fuel used. Figure 2-21 shows the fuel efficiency of the plants running on diesel fuel—other Caribbean countries only use diesel fuel, whereas Barbados also uses heavy fuel oil and jet fuel. Barbados' figure of 2.84kWh per liter is low compared to other Caribbean countries, but this comparison is misleading—when all plant types consuming oil-derived fuels are considered, Barbados performs well compared to other Caribbean countries, as shown in Figure 2-22.

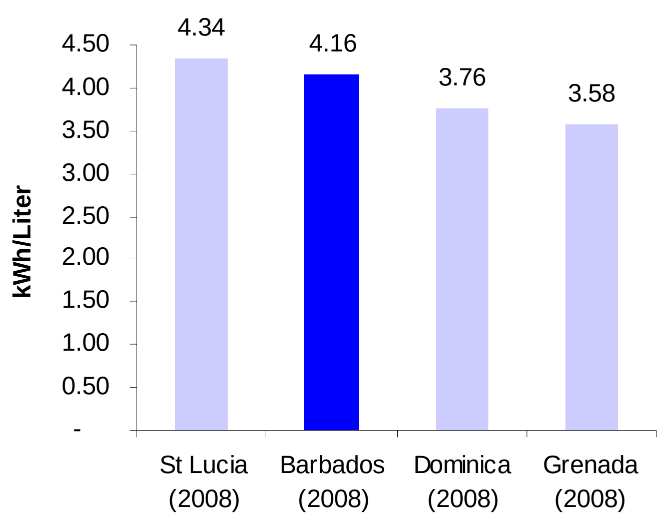
**Figure 2-21: Benchmarking of Fuel Efficiency (Diesel plants only)**




Source: Utilities' Annual Reports.

Note: Data for Barbados only considers the three gas turbines running on diesel fuel. Data for St. Vincent and Jamaica are not available for this indicator.

**Figure 2-22: Benchmarking of Fuel Efficiency (all plants consuming oil-derived fuels)**



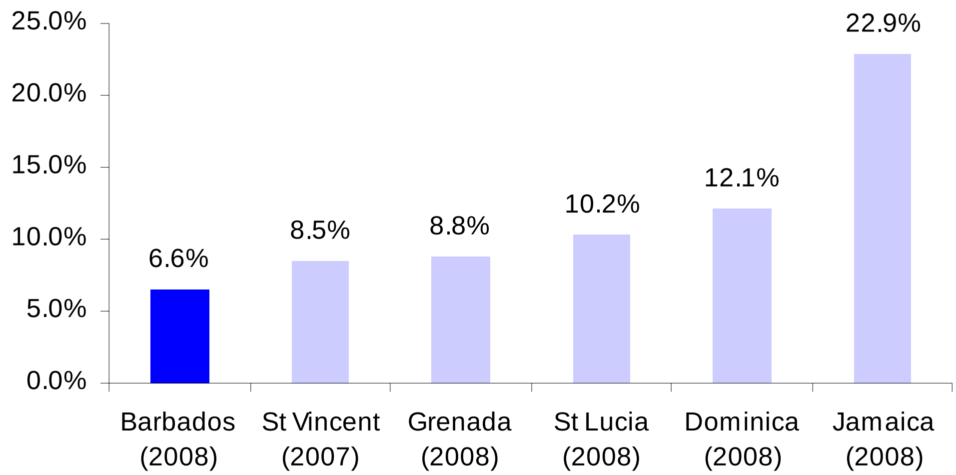

Source: Utilities' Annual Reports.

### 2.3.5 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. Figure 2-23 compares system losses in Barbados to those of other

Caribbean countries. BL&P has the lowest system losses among countries considered—6.6 percent.[33]

**Figure 2-23: Benchmarking of System Losses**




Source: Utilities' Annual Reports

### 2.3.6 $CO_2$ Emissions

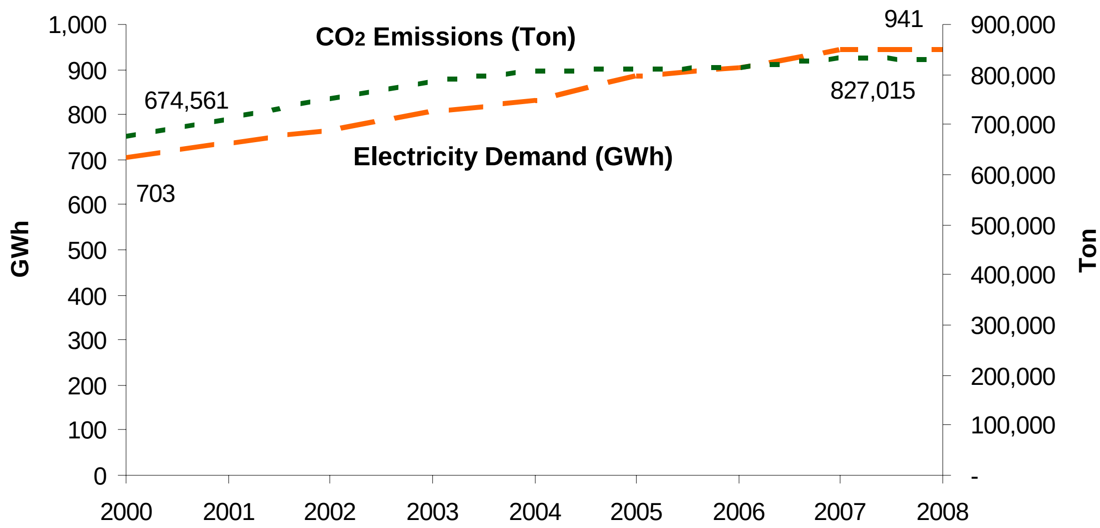
Electricity generation accounted for 56.8 percent of Barbados' $CO_2$ emissions in 2000. This contribution rose to 61.4 percent in 2005[34] (data on aggregate $CO_2$ emissions in the country are not available for more recent years). As the largest source of $CO_2$ emissions in Barbados, reducing emissions from electricity generation will have a significant impact on the country's emissions profile. Based on 2005 data, reducing $CO_2$ emissions from electricity generation by one percent can reduce the country's $CO_2$ emissions by 0.614 percent.

Figure 2-24 compares the $CO_2$ emissions from electricity generation with electricity demand. $CO_2$ emissions tracked the electricity consumption from 2000 to 2004; both grew at around 4.5 percent per year. Since the commissioning of the new low speed diesel plants that have the lowest emission factor in BL&P's current plant mix, $CO_2$ emissions have been growing at a much slower annual rate of 0.62 percent, while electricity demand has been growing at around 3 percent per year.

[33] This figure does not include a small amount of electricity losses in works (see Section 3.1.2).

[34] Source: World Bank, *World Development Indicators*, 2009. In 2000, BL&P produced 674,561 tons of $CO_2$ while Barbados produced 1,187,136, tons of $CO_2$ (56.8 percent). In 2005, BL&P produced 807,300 tons of $CO_2$ while Barbados produced 1,315,400 tons of $CO_2$ (61.4 percent)

**Figure 2-24: Comparison between Electricity Demand and $CO_2$ Emissions**




Source: BL&P. $CO_2$ emissions calculated based on plant's $CO_2$ emission factor and energy generated.

## 2.4 Regulatory Framework for Electricity

The section reviews tariff regulation, licencing, third party providers and common carriage regulation, as well as the Minister's powers to give general policy direction on electricity regulation. These are the matters most important to providing efficient renewable power in Barbados in the future. Appendix A provides additional information on regulation of the electricity sector.

### 2.4.1 Tariff regulation

The FTC is responsible for economic regulation of the power sector. The FTC was created as an independent regulatory, competition and consumer protection body by The Fair Competition Act (Chapter 326D of the Laws of Barbados). The FTC is empowered to regulate electricity utilities by the Utilities Regulation Act (Chapter 282 of the Laws of Barbados).

Under s.3 of the Utilities Regulation Act, the FTC is empowered to establish principles for arriving at the rates to be charged by electricity utilities, and to set the maximum rates. In establishing principles for setting rates, the Commission is required by s.4 of the same Act to have regard to the promotion of efficiency on the part of service providers, and to ensuring that that an efficient service provider be able to finance its functions by earning a reasonable return on capital. The Commission is also enjoined to protect the interests of consumers by ensuring that utility service is safe, adequate, efficient and reasonable. Section 10 of the Utilities Regulation Act mandates that all rates set by the Commission be fair and reasonable. Rules for setting the conduct of rate hearings are set out in Utilities Regulation (Procedural) Rules 2003.

Overall, this adds up to a mainstream, Anglo-American style regulatory regime. Our conclusion is that the Commission can best discharge its functions by creating incentives for the utility to be efficient, and then setting tariffs in a way that passes on to customers the reasonable cost of service, but no more. The FTC most recently announced a rate decision for BL&P on 28 January 2010. This decision is described as part of the analysis of electricity tariffs in section 2.5.

In section 5 we show that the regulatory approaches adopted in Barbados to date have fallen somewhat short of the ideal described. The regulatory regime has not as yet minimized generation costs—these costs would have been lower if BL&P had already invested in efficient renewable generation. In Section 6 we suggest ways that the FTC could use its existing powers to establish rate-setting principles that more effectively promote investment in efficient renewable power generation.

### 2.4.2 Licencing and third party provision

BL&P is currently the only entity supplying the grid with power. In the future, other people and firms may wish to generate power from renewables or other efficient sources, and sell that power to the grid. People will also want to generate their own electricity from renewable sources. This section analyses the laws governing such self supply and third party supply (by third party supply we mean the supply of power by entities other than the utility or a customer supplying itself). It consider first the question of licencing or approval to generate and supply power, then ability to sell power to the utility, and finally the ability to sell power to other customers over the utilities lines.

#### Licencing and approval to generate

The Electric Light and Power Act (ELPA), provides that

> *"….no local authority, company or person shall supply electricity in any area except under an Act or under a provisional order granted under this Act: Provided that this section shall not prevent any company or person from affording a supply of electrical energy to any other company or person where the business of the company or person affording the supply is not primarily that of the supply of electrical energy to consumers."*

Section 5. of the same Act then provides that (1) "The Minister may from time to time, by provisional order, grant to any local authority, company or person the right, which may include an exclusive right, to supply electricity for any public or private purposes within any area electricity, and for such period as the Minister may think proper,…". Subsection 5(3) then provides that a provisional order shall have 'no force' unless confirmed by an Act of Parliament.

The Electricity Act (Chapter 277 of the Laws of Barbados) is also relevant. This Act provides for the inspection and control of electrical works by the Electrical Engineer. It is primarily concerned with the safety of electricity supplies, and *inter alia*, provides for the Electrical Engineer to inspect all electrical installations to determine whether they have been carried out in accordance with the requirements of the regulations made under the Electric Light and Power Act before energy is supplied.

The statutory regime is unusual, to say the least. Our interpretation of its effect is as follows:

- Self-supply of power is allowed without any need for licences or orders under the ELPA. Self supply is however subject to the safety and inspection requirements of the Electricity Act

- Third-party supply from cogeneration, or sale to the grid of excess power generated from an installation intended mainly for self-supply, would not require licences or orders under the ELPA, since in this case 'the business of the company or person affording the supply' would not be primarily that of electricity supply. Cogeneration, or sale of excess power from a unit intended primarily for self-supply, would also be subject to the safety and inspection requirements of the Electricity Act
- Third party generators set up solely to sell power to the utility or other customers can only do so subject to an Act of Parliament. While the Minister may grant a provisional order for such supply, it will only be effective when confirmed by an Act of Parliament.

The statutory regime is quite friendly to self-supply and cogeneration. However, the need for an Act of Parliament before anyone other than BL&P could operate a renewable generation business is a major impediment to the development of renewable power on the island.

A change to the law to bring it in line with the international mainstream would be a good idea. In most Commonwealth countries, a licence is needed to supply power to the public, but the Minister or the regulator is empowered to issue such licences. Section 6.2 recommends that the government amend the ELPA to empower the FTC to issue licences (as is the case in Dominica). In the alternative, if licencing is considered to be inherently a Ministerial prerogative, the Minister should be empowered to issues licences without the need for Parliamentary approval, as is the case in Jamaica.

**Selling power to the utility**

Besides being allowed to generate, a third party with an efficient renewable resource will want an assured market for the power. While there is nothing to stop BL&P from buying power from a third party generator, the utility is not currently required to do so, even if the third party was able to supply power more cheaply than BL&P could supply it itself. There are no rules that govern how the third party generator would connect to the grid in a technical sense—such rules are vital for safety and reliability. There is also no clarity on how BL&P could pass on the cost of purchased power in its tariffs.

BL&P has, as part of its current rate case, submitted a Renewable Energy Rider to the FTC. This rider would provide for small scale distributed generators such as solar photovoltaic panels, to connect to the grid, and to sell excess power to BL&P. This is a useful step forward, both in itself, and because it can provide a model for more widespread and larger scale third party connection to the grid in the future. However, the current proposal is quite limited, compared to what Barbados will eventually need. The proposals contained in the Renewable Energy Rider[35] call for no more than 200 generators, each with a maximum capacity of 5kW for domestic users and 50kW for large power users to be connected to the grid, but that the total capacity of renewable energy generators should not exceed 1.6MW which is about 1 percent of the overall system peak demand in 2008. This is a temporary proposal which is to last for three years.

In our opinion, the FTC can effectively encourage BL&P to buy power from third party generators, using its existing tariff regulatory powers. To do so the FTC would have to

[35] Source: Memorandum on Proposed Tariffs – Schedule K 10

establish appropriate tariff-setting principles—see section 6. However, the FTC's powers currently do not extend to requiring BL&P to buy power from third party generator. Since a statutory change is needed in any case to reform the licencing regime, we recommend that the law also be changed to give the FTC the power to require BL&P to purchase power from third party providers where it can be shown that this will reduce the cost of power, promote sustainability, and not threaten power quality or reliability on the grid. This recommendation is presented in detail in section 6.

**Common carriage**

Some third party generators may in the future wish to sell power directly to customers, over BL&P's network. For example, a wind generator may wish to sell power to the Barbados water utility, which could use the intermittent power for pumping water into storage tanks.

Our reading of the Utilities Regulation Act is that it likely does not provide the FTC with powers to require the BL&P to allow third parties access to its network—otherwise known as common carriage. Arguably, the provisions in the Fair Competition Act prohibiting use of dominance to reduce competition could be used to mandate common carriage. Similar statutory wording was held by the Privy Council to be sufficient to require the dominant telecommunications utility in New Zealand to interconnect with a new entrant. On balance though, this would be a legally risky course. We argue in section 6 that requiring common carriage should not be a policy priority, provided that BL&P can be required to purchase power from third parties in cases where the price of power is below avoided cost.

### 2.4.3 Policy directions

The FTC Act provides at Section 17 that "the Minister may, after consultation with the Chairman, give the Commission directions of a general nature in respect of the policy to be followed by the Commission in exercising its functions in respect of utility regulation, consumer protection matters and fair competition matters, and the Commission shall comply with those directions."

This provides the government with an appropriate way to indicate its policies with respect to renewable energy and energy efficiency to the Commission, while respecting the Commission's statutory independence and regulatory role. In section 6 we recommend that the Minister exercise this power to give the FTC policy direction in the area of renewable energy and energy efficiency.

## 2.5 Electricity Tariffs

On 25 February 2010 (following a decision in January 2010), the FTC published an order[36] in the "Application for a Review in Electricity Rates"[37] submitted by BL&P on 6 May 2009. The FTC largely allowed the increases BL&P requested. Average bills will increase by around 5% (given a constant fuel price).

This is the first change in BL&P's base electricity tariffs since 1983, when the Barbados Public Utilities Board (the precursor of the FTC) approved the existing tariff schedule.

[36] Fair Trading Commission, *Order No. 002/09*, 'In the matter of the Application by the Barbados Light & Power Company Limited for a Rate Review', published 25 February 2010 (dated 17 February 2010). http://www.ftc.gov.bb/library/blip_app/2010-02-17_final_tariff_ORDER_2009_ftc_and_barbados_light_and_power_co_ltd.pdf, accessed 17 February 2010.

[37] Barbados Light & Power Company Limited, *Application for a Review in Electricity Rates*, 6 May 2009.

Changes in electricity tariffs during the past twenty-seven years—a period during which the Retail Price Index in Barbados increased by over 100 percent[38]—depended solely on the Fuel Clause Adjustment (FCA).

This section presents

- BL&P's tariff schedule and its components (2.5.1)
- BL&P's average tariffs (2.5.2)
- Monthly electricity bills (2.5.3).

We conclude with key findings regarding the impact of the new tariff schedule on renewable energy and energy efficiency incentives (2.5.4).

### 2.5.1 BL&P's Tariff Schedule and its Components

BL&P's tariff schedule includes six tariff categories, as described in Table 2-3.

**Table 2-3: BL&P's Tariff Schedule**

| Tariff Category | Application |
|---|---|
| Domestic Service Tariff (DS) | Residential customers with a demand up to 5kVA |
| Employee Tariff (EMP) | All employees and pensioners of BL&P, for domestic purposes |
| General Service Tariff (GS) | Non-residential customers with a demand up to 10kVA |
| Secondary Voltage Power Tariff (SVP) | Residential and non-residential customers (excluding street lighting) above the limits for Domestic Service and General Service tariffs |
| Large Power Tariff (LP) | Non-residential customers (except street lighting) that receive supply at primary voltage and have a demand of 50kVA or greater |
| Streetlights Tariff (SL) | Street lighting |

Source: BL&P, *Application for a Review of Electricity Rates*, 6 May 2009.

BL&P's tariffs consist of four components, not all of which are applicable to all six tariff categories. The four components are:

1. A base energy charge (not applicable to the Streetlights Tariff)
2. A variable fuel charge—the FCA (applicable to all tariff categories)
3. A demand charge (applicable to Secondary Voltage Power and Large Power tariffs)
4. A customer charge (not applicable to the Employee Tariff).

[38] BL&P, *Annual Report 2008*, page 2. According to the Central Bank of Barbados and the Barbados Statistical Service, the Index of Retail Prices grew by 57.5 percent between May 1994 and October 2009—although data prior to May 1994 is not available from these sources. Barbados Statistical Service, *Index of Retail Prices October 2009* http://www.barstats.gov.bb/Documents/Census/IRP_Bulletin_October_2009.pdf; and Central Bank of Barbados, *Economic and Financial Statistics November 2009*, http://www.centralbank.org.bb/WEBCBB.nsf/vwPublications/5DA234D6F8E7D1450425768E00562BCC/$FILE/EFS_NOV_2009.pdf. Accessed 25 January 2010.

The FTC's order of February 2010 approves BL&P's new tariff schedule, which was submitted according to instructions from a decision of the FTC in January 2010. The order provides that the new tariffs come into effect on bills issued as of 1 March 2010. An additional FTC ruling of March 2010[39] approves three new pilot tariffs.

Regarding changes in the tariff structure, the FTC

- Approved an inclining block structure for the Domestic Service, General Service, and Employee tariffs
- Ordered that the maximum for the first block of the Domestic Service Tariff be increased from 100 to 150kWh, and recognizes that by doing so "a portion of the reduction in the revenue requirement was taken out by the Commission for the DS class"[40]
- Ordered that the remaining balance of the reduced revenue requirement be allocated between Large Power and Secondary Voltage Power tariffs in a 60:40 ratio
- Ordered that the demand charge for Secondary Voltage Power and Large Power customers be based on the actual peak demand incurred each month[41]
- Rejected the initially proposed Employee Tariff as unduly discriminatory, and orders four tariff blocks for BL&P's employees, the first two of which (up to 150kWh and 500kWh per month, respectively) have base energy rates only 20 percent lower than the early payment discounted rate for the corresponding Domestic Service blocks[42]
- Approved the General Service Tariff and the Streetlight Tariff proposed by BL&P
- Approved a new formula for the FCA that covers all of BL&P's fuel costs for electricity generation (the previous formula subtracted BB$0.0264 per kWh, which was incorporated in base energy charges)
- Approved pilot tariffs proposed by BL&P—a Time-of-Use Tariff, an Interruptible Service Rider, and a Renewable Energy Rider[43]—but mandated that these may only be implemented for a period no longer than two years.

The sections that follow present the details of BL&P's new tariff schedule, explaining the design of each charge.

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[39] Fair Trading Commission, 'Findings Report: The Barbados Light & Power Co. Ltd. Pilot Programmes', published 19 March 2010 (dated 17 February 2010). http://www.ftc.gov.bb/index.php?option=com_content&task=view&id=19&Itemid=46, accessed 17 February 2010.

[40] FTC *Decision*, page 63.

[41] Instead of on the customers' highest demand of the past 11 months, as BL&P proposed. The FTC and BL&P indicate the latter calculation as 'ratchet billing'.

[42] After applying a 15 percent discount for early payment (a payment in full made within 15 calendar days of the issue of the bill) in the Domestic Service Tariff.

[43] BL&P proposed a pilot "Time-of-Use Tariff" and an "Interruptible Service Rider" for larger customers only. The "Rider for Renewable Energy", discussed in detail in Section 4, is a pilot tariff proposed by BL&P for a limited quantity of small grid-connected solar PV and wind systems (up to 1.6MW total capacity or 200 systems, whichever is reached first). BL&P proposed that the 'Rider' be equal to BB cents 31.5 or 1.8 times the FCA, whichever greater.

### Base energy charges

Table 2-4 shows the new base energy charges in place for BL&P since March 2010.

**Table 2-4: New Base Energy Charges**

| Tariff category | New Tariff Schedule (kWh per month) | New Base Energy Charge (BB$/kWh) |
|---|---|---|
| Domestic Service (DS) | 0-150kWh | 0.150 |
| | Next 350kWh | 0.176 |
| | Next 1,000kWh | 0.200 |
| | Over 1,500kWh | 0.224 |
| Employee (EMP) | 0-150kWh | 0.108 |
| | Next 350kWh | 0.127 |
| | Next 1,000kWh | 0.180 |
| | Over 1,500kWh | 0.202 |
| General Service (GS) | 0-100kWh | 0.184 |
| | Next 400kWh | 0.217 |
| | Next 1,000kWh | 0.259 |
| | Over 1,500kWh | 0.290 |
| Secondary Voltage Power (SVP) | All kWh | 0.138 |
| Large Power (LP) | All kWh | 0.117 |
| Streetlights (LP) | NA | - |

Source: FTC, *Order in the Application for a Rate Review by BL&P*, published 25 February 2010.

Note: Charges shown do not include 15 percent Value Added Tax.

### Fuel charge—the Fuel Clause Adjustment

The FCA applies to all tariff categories, and allows the full recovery of BL&P's fuel costs for electricity generation. The FCA is calculated before every billing month, based on BL&P's projection of fuel costs, volumes of sales of electricity, and costs of any power purchases for the next month.[44]

Since 1 March 2010—as approved by the FTC in its order of 25 February 2010—the FCA covers all fuel costs for electricity generation, and base energy charges no longer cover any fuel costs. Previously, BL&P's base energy charges included BB$0.0264 per kWh for recovery of fuel costs, with the rest of the fuel cost collected through the FCA.

The old and new formulas for the FCA are shown below. The FTC has approved the transfer of the BB$0.0264 per kWh from base energy charges to the FCA, stating that "having all fuel costs collected through one mechanism (…) will provide customers with more transparency on the cost of electricity service."[45]

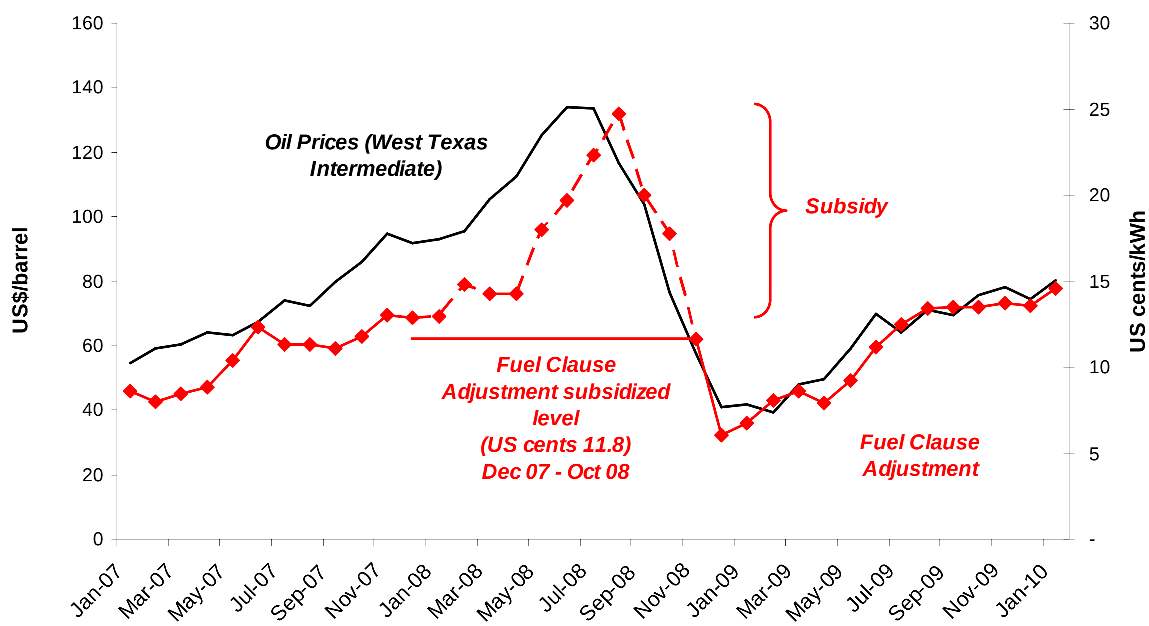
[44] BL&P, *Application for a Review of Electricity Rates*, 6 May 2009, Volume 3, pages 246 and 315.

[45] FTC *Decision* of 28 January 2010, page 6.

| Old FCA Formula<br>(1983—end-February 2010) | | New FCA Formula<br>(from 1 March 2010) |
|---|---|---|
| Projected cost of fuel for billing month<br>———<br>Projected kWh sales for billing months | Minus BB$0.0264 | Projected cost of fuel + projected cost of purchased power for billing month + net amount under/over-recovered and brought forward from previous month<br>———<br>Projected kWh sales for billing months |

The FCA is directly related to the price of oil, which determines the cost of fuel. Figure 2-25 shows the FCA and oil prices from January 2007 to January 2010. Based on the FTC's decision of 28 January 2010, the new FCA is BB$0.0264 above historical levels (through February 2010) for a given price of oil (corresponding to the base energy charges' fuel cost recovery component, re-transferred in the FCA).

**Figure 2-25: Oil Prices (US$ per barrel) and Fuel Clause Adjustment (US cents per kWh), December 2007—January 2010**




Sources: For the FCA, BL&P; for Oil Prices, Energy Information Administration (EIA) for West Texas Intermediate (WTI).

Note: The Government subsidized the FCA from December 2007 to November 2008, capping it at US cents 11.8.

The Government of Barbados subsidized the FCA from December 2007 to November 2008, a period when oil prices were mostly above US$100 per barrel. This subsidy kept the FCA at US$0.118 per kWh for eleven months. In August 2008, the non-subsidized FCA reached a peak of US$0.25 per kWh. As oil prices eased, the actual FCA fell below the subsidized level. The total cost of the subsidy to the Government was approximately US$18 million.[46]

[46] BL&P, *Annual Report 2008*, page 6.

The FCA was BB$0.16 (US$0.08) per kWh in April 2009, when oil prices were US$50 per barrel. Based on BL&P's expected oil prices of about US$80 per barrel in December 2009, the FCA was BB$0.30 (US$0.15) per kWh as of January 2010.[47] We expect that if oil prices are between US$80 and US$120 per barrel, the FCA should range between US$0.15 and US$0.20 per kWh.

With oil prices at US$100[48]—an assumption that we use below in Sections 4 and 5 to analyze the commercial viability of RE and EE technologies—we estimate a FCA of US$0.18 per kWh (US$0.21 per kWh including VAT). Our estimate is based on an analysis of historical trends in oil prices and FCA levels, and considers the recent reintroduction of US$0.0132 into the FCA from base energy charges. BL&P management finds our estimate reasonable.[49]

### Demand charges

Table 2-5 below shows new demand charges for Secondary Voltage Power and Large Power customers. The FTC's January decision orders that BL&P meet its reduced revenue requirement by lowering demand charges for SVP and LP. The balance in the reduced revenue requirement (after adjusting the first Domestic Service block) was allocated between LP and SVP in a 60:40 ratio. We note that the adjustment ordered for Employee tariffs, on the other hand, creates additional revenue from the Employee category. This additional revenue somewhat lowers the reduction needed in the demand charges for LP and SVP.

**Table 2-5: New Demand Charges**

| Tariff category | New Tariff Schedule (kWh per month) | New Demand Charge (BB$/kVA) |
|---|---|---|
| Secondary Voltage Power (SVP) | All kWh | 24.0 |
| Large Power (LP) | All kWh | 22.0 |

Source: FTC, *Order in the Application for a Rate Review by BL&P*, published 25 February 2010.

Note: Charges shown do not include 15 percent Value Added Tax.

### Customer charges

Customer charges apply to all tariff categories apart from Employee tariffs. The FTC approved increases in customer charges proposed by BL&P, stating that they reflect more accurately the cost of customer services.

According to BL&P's "Embedded Cost of Service Study",[50] BL&P's customer charges only cover customer services such as meters, meter reading, uncollectibles, billing, and accounting. According to BL&P, all other services—in particular, connection to the distribution grid, and provision of back-up and stand-by capacity—are bundled together in the base energy charge.

[47] Communication by BL&P regarding fuel price and FCA levels, 17 December 2009; and BL&P Fuel Clause Adjustment webpage. http://www.blpc.com.bb/que_.cfm?cat_=Fuel Clause Adjustment.

[48] Based on the price of ten-year futures for light sweet crude oil (WTI). See http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude.html.

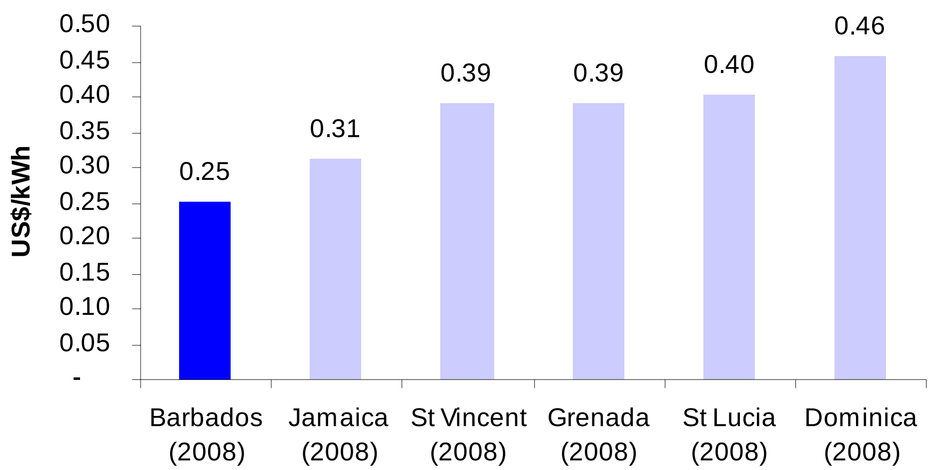
[49] Communication with BL&P management, 29 January 2010.

[50] Conversation with BL&P management, 1 December 2009.

### 2.5.2 BL&P's average tariffs

BL&P's average tariffs (calculated as total revenues from electricity sales divided by total sales of energy in kWh) reached US$0.25 per kWh in 2008. These average tariffs are high by international standards, although they are among the lowest in the Caribbean, as shown in Figure 2-26. BL&P's tariffs are lower than those charged by other Caribbean utilities.

**Figure 2-26: Comparing Average Tariffs in Barbados with Others in the Caribbean**




Source: Utilities' Annual Reports.

Table 2-6 shows average tariffs in Barbados from 2005 to 2008.

**Table 2-6: Average Tariffs in Barbados (US$/kWh), 2005-2008**

| Sector | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| **Overall average tariff** | **0.19** | **0.20** | **0.21** | **0.25** |
| Residential | 0.18 | 0.19 | 0.20 | 0.24 |
| Non-residential | 0.23 | 0.24 | 0.26 | 0.30 |
| Street lights | 0.19 | 0.20 | 0.22 | 0.25 |

Source: BL&P Annual Reports 2005—2008.

As shown in the table, in 2008 average residential tariffs were US$0.24 per kWh, while average non-residential tariffs were US$0.30 per kWh. BL&P's non-residential customers—in particular, hotels, which represent by far the largest share[51] of consumption by non-residential customers—cross-subsidize its residential customers.

More specifically, BL&P's 'Embedded Cost of Service Study' of 2008 shows that the Secondary Voltage Power and Large Power tariff categories cross-subsidize the Domestic Service, General Service, Employee, and Streetlights tariff categories. In December 2009, BL&P management stated that it favors reducing cross subsidies,[52] and that the "Application

[51] According to BL&P data, in 2008 hotels consumed 168.7GWh, which is equal to 18 percent of total sales and 31 percent of non-residential sales.

[52] Workshop *Preliminary Policy Recommendations for the Barbados Sustainable Energy Framework*, Bridgetown, 1 December 2009.

for a Review of Electricity Rates' would reduce, but not eliminate, them. In fact, the Application states that "the rates proposed (…) are designed to lessen the impact on those with low levels of consumption."[53] The FTC's decision of January 2010 approved this approach, and stated that "the purpose and process of designing rates are guided by both financial and social objectives".[54]

Table 2-7 shows BL&P's realized and approved rate of returns on rate base for the various tariff categories (excluding Employees). The FTC approved an overall return of 10.00 percent, instead of the 10.48 percent initially requested by BL&P. The figures shown below confirm BL&P's statement that the new tariff schedule will reduce cross subsidies (although not eliminate them). Domestic Service, General Service, and Streetlights will continue to be cross-subsidized—but to a lower extent than before, as shown by the reduced percentage gap from the overall return. Large Power and Secondary Voltage Power customers will cross-subsidize other customers—to a lower extent for Large Power customers, and to a greater extent for Secondary Voltage Power customers.

**Table 2-7: BL&P's Realized and Proposed Rate of Returns on Rate Base**

| Tariff category | Realized Rate of Return on Rate Base (percent) | Approved Rate of Return on Rate Base (percent) |
|---|---|---|
| Overall | 6.07% | 10.00% |
| Domestic Service (DS) | 2.58%<br>(-57.5% below overall) | 6.91%<br>(-30.9% below overall) |
| General Service (GS) | 4.02%<br>(-33.8% below overall) | 9.00%<br>(-10.0% below overall) |
| Secondary Voltage Power (SVP) | 6.12%<br>(0.8% above overall) | 10.79%<br>(7.9% above overall) |
| Large Power (LP) | 12.40%<br>(104.3% above overall) | 13.81%<br>(38.1 above overall) |
| Streetlights (LP) | -5.42%<br>(189.3% below overall) | 0.00%<br>(-100% below overall) |

Source: BL&P.

### 2.5.3 Monthly electricity bills

Based on the new tariff schedule approved by the FTC in February 2010, it is possible to estimate the electricity bill for the various types of customer categories:

- Domestic Service Customers—US$82.5, assuming a monthly consumption of 253kWh per month (the 2008 average for residential consumers—see Section 2.2.3), including a customer charge for the '151-500kWh per month' second block, an FCA calculated based on oil prices of US$100 per barrel, and 15 percent VAT

[53] BL&P, *Application for a Review of Electricity Rates*, 6 Mat 2009, page 6.

[54] FTC *Decision* of 28 January 2010 (see footnote 36), page 54.

- General Service Customers—US$988.9, assuming a monthly consumption of 2,707kWh per month (the 2008 average for non-residential consumers—see Section 2.2.3), including customer charge for the 'over 500kWh per month' third block, an FCA calculated based on oil prices of US$100 per barrel, and 15 percent VAT.
- Secondary Voltage Power Customers—US$911.1, assuming a monthly consumption of 2,707kWh per month, including the US$10 customer charge, an FCA calculated based on oil prices of US$100 per barrel, and 15 percent VAT.
- Large Power Customers—US$1029.8, assuming a monthly consumption of 2,707kWh per month, including the US$150 customer charge, an FCA calculated based on oil prices of US$100 per barrel, and 15 percent VAT.

#### 2.5.4 Analysis of impact of new tariffs on renewables and energy efficiency

Tariffs will affect customers decisions to invest in energy efficiency, and in distributed generation. Customers will have an incentive to invest in these measures whenever the reduction in their power bill more than offsets the cost of the investment. Therefore economic efficiency will be promoted when the tariff is cost-reflective.

In cost reflective tariffs, the charge per kWh hour (that is, the base energy charge plus the Fuel Cost Adjustment) should reflect the actual cost of generating power, grossed up for system losses. In Barbados' case, this is around US0.20 per kWh. Peak demand or time of day charges may be used to reflect the fact that supplying at peak costs more than off-peak. Other costs that do not vary with consumption should be recovered through a fixed monthly charge.

Looking at BL&P's tariff schedule we see that all customers will pay the Fuel Cost Adjustment Charge, which would be around US$0.18 per kWh with oil at $100 per barrel. In addition, all customers will pay a base energy charge of $0.045 or more. This means all customers will face a per kWh charge equal to or greater than the cost of supplying energy. This is good, since it means that—unlike many other countries—no customer will face inadequate incentives to investment in energy efficiency and distributed generation.

In fact, the BL&P tariff schedule is more likely to the generate the opposite problem—giving customers incentives to invest in energy efficiency and distributed generation even in cases where doing so will increase the total cost of power supply to the country. On the new tariffs, general services customers, and domestic consumers using over 150kWh per month, will face a charge per kWh of at least US$0.26 per kWh (assuming a US$100 per barrel oil price) while the actual marginal cost of supplying them with energy would be around US$0.21 per kWh. This means these customers would have an excessive incentive of around US$0.06 per kWh to invest in energy efficiency and distributed renewables.

In future, a way to overcome these problems would be to more fully disaggregate BL&P's tariff, and so make it more cost-reflective. This would involve creating a monthly connection charge to cover the cost of connection to the distribution system. There could be other charges for providing back up and peaking power capacity to customers who generate for themselves. The base energy charge could then be reduced so that recovered only the capital costs of generation.

The FTC has recently approved a 'Time-of-Use Tariff' (for Large Power customers) and an 'Interruptible Service Rider' (for Large Power and Secondary Voltage Power customers), both on a two-year pilot basis. These pilot tariffs will also contribute to energy efficiency broadly intended, and we recommend that a time-of-use tariff be considered for smaller consumers too.

## 2.6 Government Programs for Promoting Sustainable Energy

Current Government initiatives to promote a more sustainable energy sector include the following:

- The Public Sector Energy Conservation Program
- Tax and customs incentives
- The Caribbean Hotel Energy Efficiency Action Program.

Each of these is summarized below.

### 2.6.1 The Public Sector Energy Conservation Program

The Public Sector Energy Conservation Program (the Program) was started in 2006 to reduce the cost of energy in the public sector.[55] Table 2-8 summarizes its key provisions, including mandates to increase fuel efficiency in government vehicles, install energy efficiency lights and appliances, and do energy audits in Government buildings.

**Table 2-8: The Public Sector Energy Conservation Program**

| Component | Recommended Actions |
|---|---|
| Vehicles | ▪ Purchase gasoline vehicles with engine size below 1,600 cc<br>▪ Purchase diesel vehicles with engine size below 2,500 cc<br>▪ Purchase alternative power sources vehicles (natural gas, Liquefied Petroleum Gas (LPG), ethanol)<br>▪ Develop driver education courses for greater fuel efficiency in the public fleet<br>▪ Conduct audit of gas usage in the public sector |
| Air Conditioners | ▪ Purchase energy efficient A/C systems<br>▪ Seal air-conditioned rooms<br>▪ Schedule air conditioner use |
| Lighting | ▪ Maximize the use of daylight<br>▪ Turn off lights when leaving buildings and offices<br>▪ Replace incandescent light bulbs with compact fluorescent light bulbs<br>▪ Use solar PV technologies for exterior lighting |
| Electrical Appliances | ▪ Purchase energy efficient appliances<br>▪ Assess large appliances' energy consumption ahead of purchase, and consider more energy efficient alternatives |
| Government Buildings | ▪ Conduct energy audits for existing buildings<br>▪ Apply energy efficiency standards to new buildings<br>▪ Use solar power for emergency shelter back up |

Source: Public Sector Energy Committee, *Public Sector Conservation Program*, September 2006

[55] Source: Public Sector Energy Committee, Public Sector Conservation Program, September 2006.

The Program also envisions establishing energy conservation obligations for various public entities and departments, and enforcing penalties for non-compliance.

The Program is led by the "Energy Conservation and Renewable Energy Unit" (the Unit), which was originally established within the Ministry of Energy and Environment. In 2008 it became part of the Ministry of Finance, Investment, Telecommunications and Energy (MFIE). The Energy Conservation and Renewable Energy Unit is in charge of supervising the implementation of the Program, preparing public awareness initiatives, and advising on the purchase of efficient equipment.[56] It reports to the Public Sector Energy Conservation Committee.

The Program's budget is established yearly by the Government. The fiscal year for all Government entities goes from 1 April to 31 March.

Implementation of the program has been slower than expected. No obligations for Government entities are in place, and no penalties have been imposed. So far, the Program's main outputs have been limited to the preparatory stages for the retrofitting of Government buildings and for the installation of small renewable systems on Government property.

**Retrofitting of audited Government buildings has not begun**

Fifteen energy audits were conducted in various Government buildings between 2007 and 2008. In 2009-10 the Government allocated BB$1.4 million for retrofitting about 5 of these 15 buildings. The Unit has been drafting terms of reference to procure the retrofits under a performance contracting scheme. However, as of 3 June 2010 no procurement had been launched.

Management of the Unit stated[57] that the delay in implementation is because:

- Many of these buildings need major maintenance prior to retrofitting
- Some buildings are currently not in use (such as the Central Police Station, transferred to a temporary location)
- There is little clarity about who is in charge of launching the implementation of retrofits—whether the Unit, or each Government entity located in the various buildings
- There is insufficient coordination between various Government entities
- The Unit is understaffed compared to its responsibilities.

The budget for fiscal year 2010-2011 is under preparation as of 1 June 2010, and is expected to confirm funding for the retrofits. The exact amount allocated for retrofits for the next fiscal year is to be determined.

In May 2010, the Government confirmed one company (CASSE Engineering) to perform additional audits on selected public buildings under the SEF. The SEF Project Manager expects to give the company the go-ahead in June 2010, subject to a few final inputs from

[56] Conversation with the Energy Division of MFIE, 16 September 2009.

[57] Conversation with Management of the Energy Conservation and Renewable Energy Unit, 22 January 2010. Update with the SEF Project Manager, 3 June 2010, confirming implementation has not started yet.

the Finance Ministry. The agreed delivery is within 50 calendar days from the beginning of activities.[58]

**Small renewable energy systems for Government premises await updated tender and installation**

In the 2009-2010 fiscal year the Government allocated BB$1.3 million to the Unit for purchasing 11 small solar PV systems (2kW) and 11 small wind systems (2kW). The Unit published a tender for the procurement of the equipment in late 2009, and 11 bidders responded. However, after receiving the bids, the Unit decided that an updated tender should be published. The Unit's intention is to change and improve the technical specifications of the equipment procured, and require back-up batteries for the small systems. As of 3 June 2010, the Unit had not published an updated tender. [59]

The actual installation of the systems is a separate process that does not fall under the Unit's budget or responsibilities—the Unit's job for systems installation is simply to coordinate with other Government entities, which are directly in charge of deciding on, and paying for the installation of equipment purchased with Program budget. The Unit has tried to contact other government entities to identify adequate locations to install the systems, as well as the funding required to pay for installation services. The Barbados International Airport is considering small renewable generation systems for its premises, but has not made any decision as to installing them. The Barbados National Conservation Commission (NCC), the quasi-governmental entity that is in charge of the country's natural parks, has also expressed interest in the possibility of installing renewable energy systems on its premises (in addition to parks, the NCC controls up to 24,000 square feet of building space).[60] The Unit's efforts with the Ministry of Education to install systems in public schools have been unsuccessful.

The Unit is providing technical assistance to the Ministry of Public Works, which is installing a 16kW solar PV system (purchased under the Ministry's separate budget) on the rooftop of its headquarter's building. As of 22 January 2010, the system is being installed. The intention is that it will sell electricity to the grid once functioning, after power purchase and regulatory arrangements with BL&P are finalized.

### 2.6.2 Tax and customs incentives

There are a number of tax and customs duties incentives for energy efficiency and renewable energy. This section first describes the basic tax and custom duty system, and then the various deductions and waivers intended to promote renewable energy and energy efficiency.

Barbados has a fairly standard tax collection system involving income taxes, VAT and customs duties and other levies on improved items. Individuals and businesses are subject to income tax. Individual taxation ranges from 20 to 35 percent, while businesses are taxed at 25 percent. Both individuals and businesses benefit from deductions for specific expenses or investments. For individuals each deduction can go up to BB$10,000. Corporate deductions are usually expressed as a percentage of the total expense[61].

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[58] Communication with the SEF Project Manager, 28 May 2010.

[59] Conversation with Management of the Energy Conservation and Renewable Energy Unit, 22 January 2010. Update with the SEF Project Manager, 3 June 2010, confirming no progress has been made for the procurement.

[60] National Conservation Commission website http://www.nccbarbados.gov.bb/.

[61] Department of Inland Revenue Individual and Corporate Income Tax Return Forms 2008

Imports in Barbados are usually charged: (i) 20 percent customs duties[62], (ii) 1 percent environmental levy[63], (iii) 15 percent Value Added Tax (VAT), and (iv) an additional 6 percent on extra-regional imports. In 2006, the Government established tax and customs incentives for renewable energy and energy efficiency equipment. Table 2-9 shows these incentives as of 2009.

The incentives can be summarized as follows:

- **Tax incentives**—Households benefit of up to BB$17,500 deductions for RE and EE measures per year: up to BB$10,000 are for home improvements and include up to BB$2,000 for energy audits; up to BB$5,000 (for a maximum of BB$25,000 over 5 years) are for "environmentally preferred products"[64], and up to BB$2,500 are for retrofitting
- **Customs incentives—**All imported renewable energy systems and related equipment (including wind, solar photovoltaic and thermal, biomass, and hydro) are fully free of customs duties. CFLs, house and attic fans, ceramic coatings for roofs, and window tints pay duty at a reduced rate of five percent. No other energy efficient equipment is eligible for customs incentives.

The use of alternative transport fuels is also incentivized by a reduced excise tax (from 46.9 to 20 percent) for electric, hybrid, Liquid Petroleum Gas (LPG), and Compressed Natural Gas (CNG) vehicles and a reduced excise tax (from up to 120 percent to 46.9 percent) for diesel vehicles under 2,000cc and BB$45,000.

The Government does not have an estimate of the total value of waived tax and customs duties.

A problem in implementing tax incentives is that there is no clear definition of 'environmentally preferred product'. For now, the Inland Revenue Department seeks guidance on an *ad hoc* basis from the Energy Unit in the MFIE on which products comply. The Barbados National Standards Institute (BNSI) is preparing 'certificates' for air conditioners and refrigerators. These certificates will establish performance standards that will provide clarity on which of these appliances can be considered 'efficient' for purposes of tax incentives.

Another issues is that the Tourism Development Act of 2002 allows businesses operating in the tourism sector to import furniture, fixtures, equipment, and building materials free of duty[65] upon the approval of the Ministry of Tourism[66]. This means that importation of both efficient and conventional equipment—such as water heaters and air conditioners—is duty free for the tourism sector. The possibly unintended consequence of this is that the incentive

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[62] Some products are subject to higher customs duties ranging from 40 to 115 percent. The list includes: agricultural products (40), furniture (60), clothing (60), jewelry (60), motor cars (45), and t-shits (115)

Source: http://www.businessbarbados.com/index.php?RootSection=488&ParentSection=730&Section=731

[63] Some products such are motor vehicles are subject to a lump sum environmental levy.

[64] The IRD defines the products as "products that cause less harm to human health or the environment than alternative products that serve the same purpose: or products the consumption of which contribute to the preservation of the environment".

[65] The waiver includes customs duties, environmental levy, and VAT

[66] Source: http://www.barmot.gov.bb/tourism-development-act.html

the customs systems provides toward efficient equipment for others areas of the economy does not apply in the tourism sector.

**Table 2-9: Tax and Customs Incentives for EE and RE measures**

| | Energy Efficiency | Renewable Energy |
|---|---|---|
| Tax Incentives | ▪ Tax deduction for individuals of up to BB$10,000 for home improvements. EE measure fall in this category<br>▪ Tax deduction for the cost of household energy audits (up to BB$ 2,000 and as part of the BB$10,000 home improvement allowance)<br>▪ Tax deduction (up to BB$5,000 per year for a maximum of BB$ 25,000 over 5 years) for the cost of "environmentally preferred products". There are defined as "products that cause less harm to human health or the environment than alternative products that serve the same purpose: or products the consumption of which contribute to the preservation of the environment"<br>▪ Tax deduction for individuals (up to BB$2,500) for retrofitting with roof straps and window shutters<br>▪ Corporate tax deduction for environmental certifications (entire expenditure plus an allowance equal to 150 percent of the expenditure) | ▪ Tax deduction for individuals of up to BB$10,000 for home improvements. Distributed RE technologies such as solar PV fall in this category<br>▪ Corporate tax deduction for environmental certifications (entire expenditure plus 150 percent allowance) |
| Customs Incentives | Reduced customs duties rate of 5 percent for all the following products:<br>▪ CFLs<br>▪ House and attic fans<br>▪ Ceramic coatings for roofs<br>▪ Window tint | Full customs duty waiver for:<br>▪ Wind turbines<br>▪ Solar photovoltaic systems<br>▪ Solar thermal systems (including solar water heaters)<br>▪ Biofuel systems<br>▪ Hydropower systems<br>▪ Wave and tidal power systems<br>▪ Fuel cells systems<br>▪ Geothermal heat pump systems. |

Sources: Energy Conservation and Renewable Energy Customs Information, http://www.bajanpower.com/

Department of Inland Revenue Individual Income Tax Return Form 2008

### 2.6.3 The Caribbean Hotel Energy Efficiency Action Program (CHENACT)

The Government is developing the Caribbean Hotel Energy Efficiency Action Program (CHENACT) together with the IDB, the Caribbean Hotel Association (CHA), the Caribbean Alliance for Sustainable Tourism (CAST), the Caribbean Tourism Organization (CTO), and the United Nations Environmental Program (UNEP).

The CHENACT Program seeks to promote energy efficiency and phase out ozone depleting substances in the tourism industry in the Caribbean. Barbados is being used as a case study (a regional assessment of energy efficiency potential is also being done). The goal is to improve the competitiveness of small and medium hotels in the Caribbean region. Consultants were selected in October 2009 to launch the CHENACT activities, and are currently working on this assignment.

The CHENACT program has five components:[67]

1. Designing the CHENACT Program and developing an institutional strengthening plan. This component will determine the Program's eligibility criteria, guidelines for energy audits, and EE policy and legislation for the tourism sector. Pilot EE measures will be implemented in selected hotels on a cost-sharing basis
2. Assessing the capacity of Energy Services Companies (ESCOs) in the Caribbean. The aim is to measure ESCOs' ability to deliver a reliable, competitive and effective service to the tourism sector; and to prepare a strategy to enhance ESCO capabilities
3. Designing a model for increasing energy efficiency in hotels that could be replicated throughout the region
4. Assessing financial options to expand the implementation of CHENACT findings
5. Dissemination of the program's findings.

[67] Conversations with CHENACT program manager, 15 September 2009.

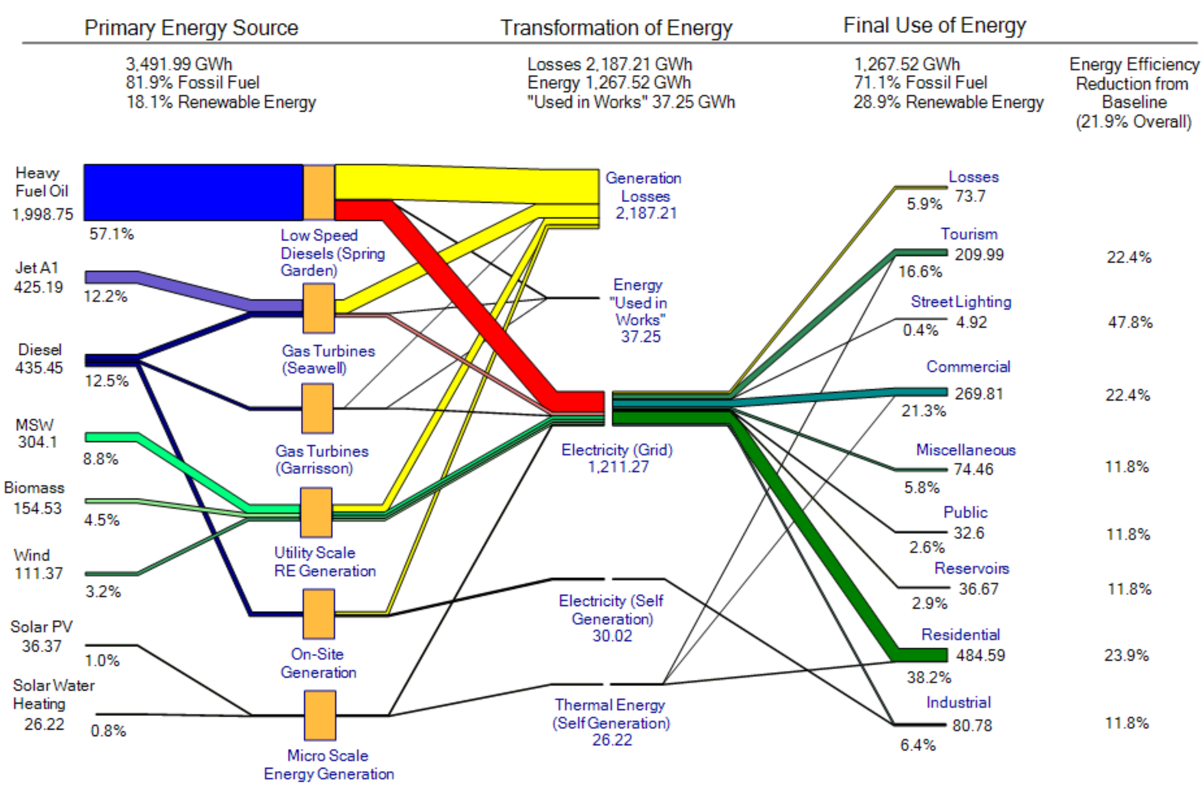
# 3 A Sustainable Energy Matrix for Barbados

The Sustainable Energy Matrix scenario is a snapshot of what energy generation and end-use could look like over the next 20 years, given the implementation of energy efficiency opportunities and renewable energy generation. In Section 3.2 we also show a preliminary estimate of an alternative Sustainable Energy Matrix including electricity generation with natural gas.

## 3.1 Barbados' Sustainable Energy Matrix

As shown in Figure 3-1, the Sustainable Energy Matrix indicates the primary energy sources used for power generation and water heating, the transformation of that energy into electricity and other forms (with the energy used in the transformation process shown), and the final use of the energy in various sectors.

**Figure 3-1: Barbados' Sustainable Energy Matrix (GWh)**




Source: Castalia and Stantec calculations.

Under the Sustainable Energy Matrix, 28.9 percent of energy in final use would come from renewable generation, and the remaining 71.1 percent of final use of energy would come from conventional fossil fuel-based resources.

Although consumption of electricity is anticipated to increase, the impact can be reduced by implementing energy efficiency measures. In the case shown in the Sustainable Energy Matrix, energy efficiency would account for a 21.9 percent reduction in energy consumption compared to a 'business as usual' scenario.

It is important to note that the increased levels of renewable energy and energy efficiency shown in the Sustainable Energy Matrix should be indicative targets, with the purpose of guiding policy and project implementation based on the economic viability of the underlying technologies. They should not be fixed targets to be achieved at any cost—this would be counter to the objectives of the Sustainable Energy Framework (see Section 1.1).

The following sections describe the sustainable energy matrix, and the detailed assumptions behind it, looking in turn at the primary energy sources, the transformation of energy, and energy end use and efficiency in consumption.

### 3.1.1 Primary Energy Source

The left hand column of the sustainable energy matrix indicates the various primary energies used in energy generation, and the type of generation plants. In the Sustainable Energy Matrix renewable energy represents 18.1 percent of primary energy sources, compared to around 1.6 percent of renewable primary energy now (see Section 3.3 below).

This increase in renewable generation is based on the analysis of which types of renewable generation are economically viable for Barbados with oil at or above US$100 per barrel (see section 4 for the analysis), and our estimates of the quantities that could be realistically deployed, given Barbados' resources and grid constraints. The Sustainable Energy Matrix is deliberately conservative, in that it only considers current proven technologies. However, it is also ambitious, in that it will be quite a stretch for the various players in the energy sector to increase generation by renewable energy from 3.2 to 18.1 percent.

The major renewable primary energy sources and technologies are discussed below, in the order in which they appear in the matrix (Appendix C describes all renewable energy technologies in more detail, and Appendix D analyzes various options for a waste to energy plant, and their environmental impacts).

#### Waste to Energy

The Sanitation Services Authority (SSA) is planning a municipal solid waste to energy plant (13.5MW capacity). Without commenting on the viability of this particular version of the technology, in our assessment a waste to energy plant of approximately this capacity will be viable for Barbados, provided proper allowance is made for the savings in landfill costs it allows. We therefore assume that such a technology can and should be implemented.

#### Biomass cogeneration

The Barbados Cane Industry Corporation (BCIC) is evaluating a plan for consolidating all sugar production at the Andrews factory and upgrading that factory. The proposed upgrade includes a new biomass cogeneration system of 20MW capacity, which would be designed to provide energy for the factory and to the grid throughout the year.

The cogeneration system is intended operate near full capacity for 20 weeks of the year when the sugar cane is harvested. The system would operate at one-half of the capacity for 16 weeks of the year using another source of biomass such as wood waste, which would be collected throughout the year. The remaining 16 weeks of the year the system will be off. The Sustainable Energy Matrix assumes this system becomes operational. Again, without commenting on the particular proposals put forward by BCIC, we are convinced that so long as Barbados has a cane industry, cogeneration from bagasse will be a viable part of the Sustainable Energy Matrix.

### Wind farms

BL&P has been planning on developing a 10MW wind farm for the past few years. BL&P expects the obstacles to obtaining approval from Town & Country Planning will be overcome and this wind farm will be developed. Following the first 10 MW wind farm another 10MW will likely be shortly behind. Following the success of these installations it can be reasonably projected that another 20 MW wind farm be installed. Since there is limited land available for wind farms it is likely these are either larger turbines brought to site via helicopter or an offshore wind farm.

### Distributed solar photovoltaics

In addition to the utility scale solar photovoltaic generation, we expect a significant increase in the use of distributed solar photovoltaic systems installed in Barbados. The government is currently moving forward with a number of small solar PV systems through both their own initiatives and the GEF Pilot Project.

The viability analysis in section 4 shows that solar photovoltaics are already commercially viable, in the sense that many electricity consumers would be able to reduce their total cost of power by installing such systems—that is, the lower power bill and sale of excess power to the grid under a new systems proposed by BL&P could more than justify the cost of the investment. The analysis also shows that these systems are not economically viable—that is, the cost of power from the system still exceeds the cost of centrally-generated efficient power (the wedge between commercial and economic viability is created by the fact the BL&P's tariff is not fully cost-reflective, as described in section 2.5.4). However, given the rate at which the costs of these systems are falling, we are fairly confident in predicting they will become economically as well as commercially viable (compared to thermal generation based on diesel or HFO) in the near future.[68]

A number of different types of photovoltaic systems will likely be installed, with the fixed thin film PV being the most prevalent since it currently is one of the more commercially viable PV systems. For the first few years, we expect minimal implementation of solar PV systems. Electrical contractors have to be trained on the technology, the installation, and the operation of these systems. Pilot projects also have to demonstrate the feasibility and the benefits of these systems.

Solar PV technology is still in development and increases in efficiency and decreases in cost will make it economically viable in the near future. As the demand increases, more companies will offer solar PV systems and we expect uptake to grow exponentially. In 20 years there could be several small scale and commercial scale solar PV installations in Barbados. These systems would vary in size and could total 20MW of micro-solar capacity.

### Solar water heaters

Solar water heaters are the final renewable energy component. These solar water heaters offset electricity from the grid that is typically used in electric water heaters. These systems have primarily been adopted by households. It is reasonable to assume that in twenty years 7 percent of all homes will use solar water heaters, while 15 percent of commercial buildings,

[68] See Dr. Travis Bradford, *Solar Revolution: The Economic Transformation of the Global Energy Industry*, 2006, page 191. This study estimates that the cost per Watt of installed PV will fall to about US$2.50 by 2020. The three solar PV systems that we included in the Sustainable Energy Matrix (analyzed in Section 4.2) are the ones with the lowest cost per Watt installed—between US$3.5 and US$4.7.

(primarily the high water consumers), and 50 percent of the tourism industry will use solar water heaters.

**Our assumptions regarding conventional plants**

The existing steam turbines at Spring Garden, which are shown in the Current Energy Matrix (section 3.3) and discussed in Section 2.3, are scheduled to be decommissioned in the next couple years. Therefore, we have removed them from the Sustainable Energy Matrix.

BL&P is considering acquiring Low Speed Diesel generators for electricity production in the future. These systems are anticipated to use heavy fuel oil (Bunker C). We assume these plants will be installed to make up the balance of the electricity production needs in conjunction with the other existing plants. Below in Section 3.2 we discuss the possibility of thermal generation with natural gas imported via pipeline from Trinidad and used in dual fuel plants.

### 3.1.2 Transformation of Energy

Of the approximately 3,492 GWh per year of primary energy, about 2,187 GWh per year is consumed in the generation of electricity. The majority of these losses is waste heat emitted from the generation process, with a small amount being converted to electricity and then used in the generation works. Around 1,267 GWh per year is converted into electrical energy for supply to the grid, as well as a small amount of electrical and water heating energy supplied directly at customers premises.

### 3.1.3 Final Use of Energy

The right side of the matrix indicates the final use of energy for Barbados. This Sustainable Energy Matrix includes the effect energy efficiency can have on the final end-use of the energy.

We made projections for a business as usual case in which we evaluated energy efficiency in three categories; Residential, Commercial (includes Tourism and Commercial businesses) and Industrial (Industrial, Street Lighting, Public Services, Reservoirs and Miscellaneous). We also assumed the relative composition within each of these sectors would be maintained.

We then evaluated the potential penetration in each sector of a number of energy efficiency technologies (these technologies are analyzed in Section 5 of this Report). The projected increase in energy efficiency as a result of this uptake was estimated at 23.9 percent for residential customers, 22.4 percent for commercial customers, and 13.3 percent for industrial customers (11.8 percent for all categories except street lights, for which we calculated a 47.8 efficiency assuming the introduction of magnetic induction lights). The overall result is a 21.9 percent reduction in electricity consumption, compared to the business as usual scenario. Appendix H contains a more detailed description of all energy efficiency technologies, and describes the assumptions we used for projecting the increases in energy efficiency across the various sectors.

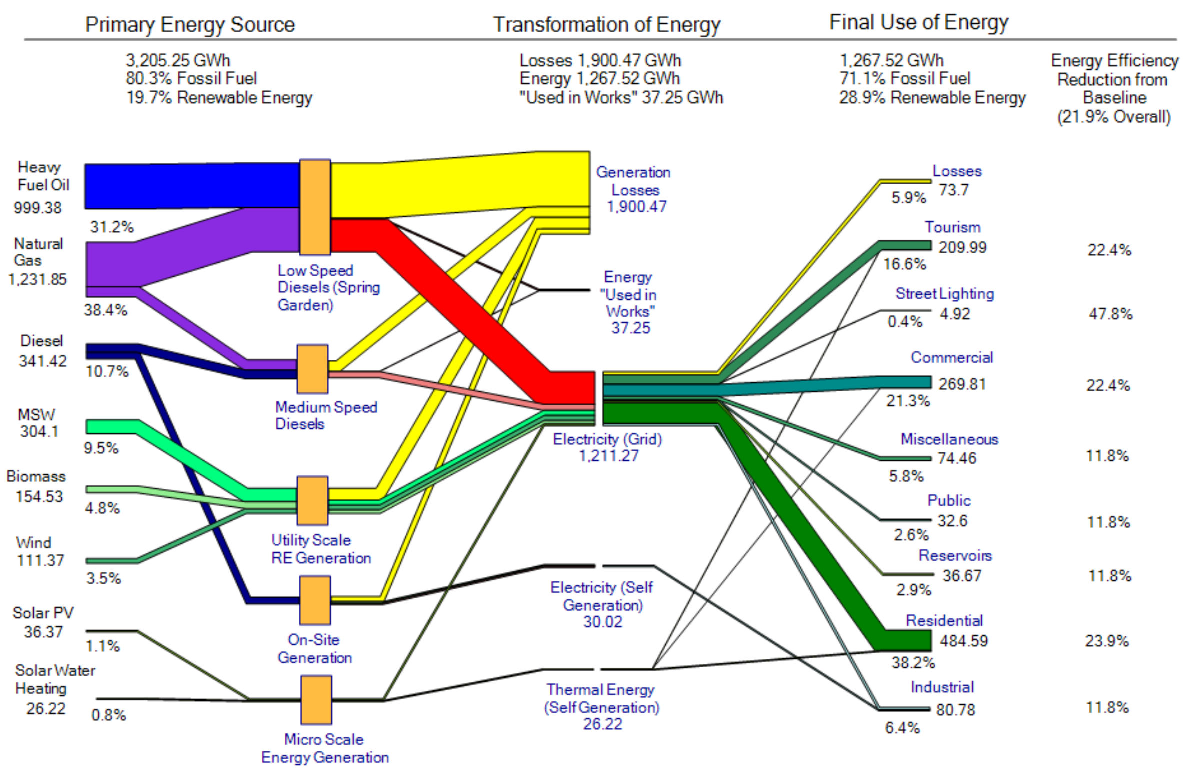
In addition to energy efficiency gains, electricity use is reduced by a further 1.0 percent with the increased penetration of solar water heaters, for a combined 22.9 percent reduction in electricity supplied from the grid in the Sustainable Energy Matrix, compared to the business as usual scenario.

## 3.2 An Alternative Sustainable Energy Matrix Including Natural Gas

As discussed above in Section 2.3.3, an Eastern Caribbean Gas Pipeline (ECGP) is being considered for exporting natural gas from Trinidad and Tobago to Barbados, although the actual realization of this project is still not certain. We also note that the Government of Barbados has obtained financing from the IDB to support "Studies for the Upgrade and Expansion of the Natural Gas Network"[69]—this study will assess the details of natural gas allocation for expanding residential and non-residential access to this resource.

In spite of these uncertainties, and subject to further information on the expansion of natural gas in Barbados that will emerge in the course of 2010 and 2011, in Figure 3-2 we show a conservative estimate of what Barbados' Sustainable Energy Matrix could look like including electricity generation with natural gas.

**Figure 3-2: Alternative Sustainable Energy Matrix including Natural Gas (GWh)**




Source: Castalia and Stantec, based on preliminary information on the expansion of natural gas in Barbados.

Note: This is a conservative estimate—if possible, all thermal generation should be converted to natural gas because this would be the lowest-cost generation option for Barbados, and it would allow maximizing the investment for the Eastern Caribbean Gas Pipeline.

It emerged from our discussions with BL&P that the intention is to use natural gas in Low Speed Diesel and Medium Speed Diesel dual fuel generators (although BL&P's updated expansion plan is apparently less likely to include MSD plants).[70] At peak use, we assumed a

[69] Request for Expressions of Interest published in the United Nations Development Business website, 20 May 2010.

[70] Conversation with BL&P management, 28 April 2010.

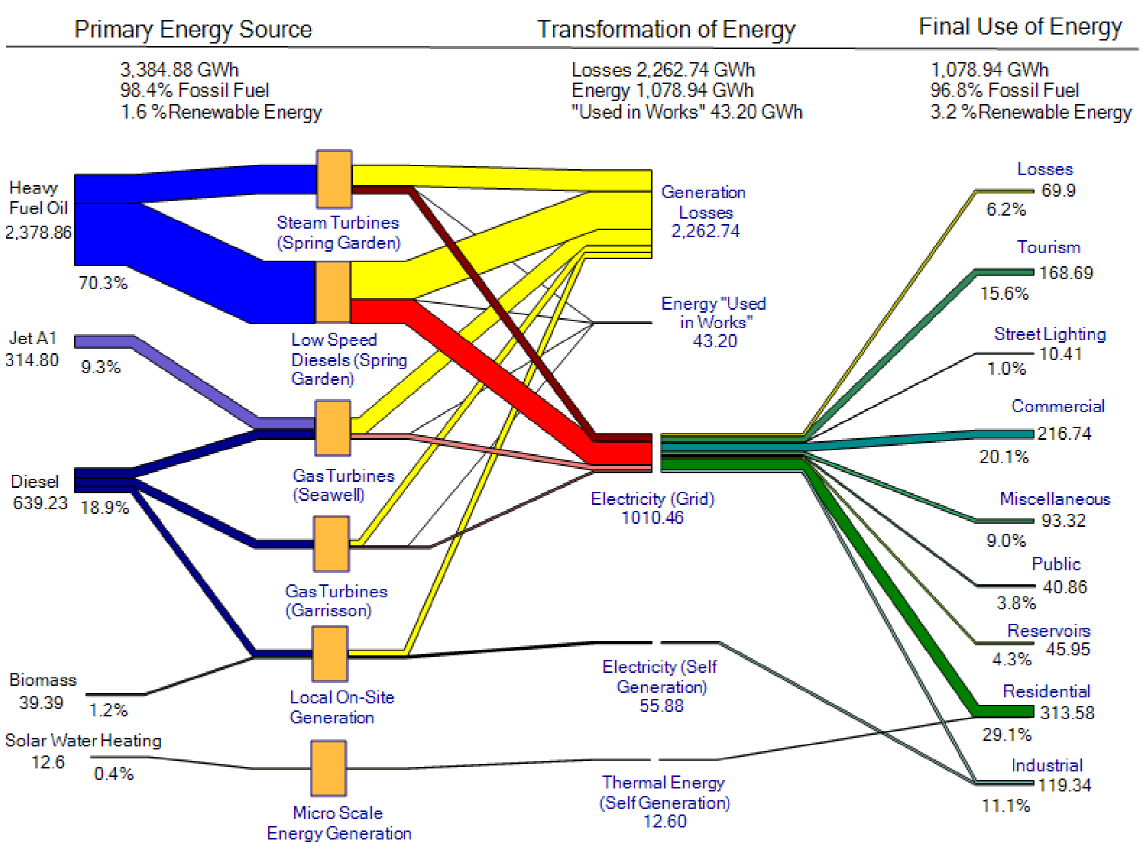
maximum ratio of 50 percent natural gas to other liquid fuels (HFO or diesel), and conversion of all generation plants to dual fuel, in addition to the twenty-year scenario of energy efficiency and renewable energy implementation. Given the very low cost of natural gas generation, it should replace—if possible—all other thermal generation technologies. This would allow maximizing the investment of the ECGP.

## 3.3 Barbados' Current Energy Matrix

The Current Energy Matrix is a snapshot of the energy generation mix and end-use today. As with the Sustainable Energy Matrix, the Current Energy Matrix indicates the primary energy source, then the transformation of energy into electricity and the final use of energy by end-use categories. BL&P provided the data for the Current Energy Matrix for 2008.

Currently only 3.2 percent of the energy generated either to the grid or direct to the end-use is from renewable energy, leaving the remaining 96.8 percent generated from fossil fuels. Moreover penetration of many of today's energy efficiency technologies is minimal in Barbados.

**Figure 3-3: Barbados' Current Energy Matrix (GWh)**




Source: Stantec elaboration based on data provided by BL&P and BL&P's 2008 *Annual Report*

### 3.3.1 Primary Energy Source

The primary energy source section of the current energy matrix indicates the various fuels used in energy generation and the type of generation plants. The Current Energy Matrix scenario indicates very little renewable energy technologies impact the energy mix.

The sugar cane industry accounts for the largest portion of renewable energy generation although the energy generated is only used by the sugar cane processing facilities and no excess electricity is produced for the grid. It is assumed the energy is generated for 20 weeks of the year when the sugar cane is harvested then nothing for the rest of the year. This results in excess bagasse. Based on the information provided by the BCIC, we estimate the capacity of electricity generated is 6.5MW.

The other renewable energy component is the solar water heaters. These offset electricity from the grid that is typically used in electric water heaters. These systems have made significant penetration into the residential market, primarily with high and middle income homes. The best available estimates are that 40 percent of the households use solar power for water heating.

The great majority of primary fuel consumed in the sector is in BL&P's conventional power plants. These include steam turbines at Spring Gardens, low-speed diesels at Spring Garden and Gas Turbines at Seawell and the Garrison as indicated in Section 2.3. These systems primarily use three types of fuel: Bunker C, Diesel and Jet A1. Natural Gas makes up less then 0.1 percent of the overall electricity production and therefore has not been included among the other fuels used for generation. Heavy fuel oil (or Bunker C) is the most used fuel representing 70.3 percent of the total fuel use (equivalent embodied energy).

There are a number of manufacturing customers who generate their own power because they can purchase diesel duty free. Information on the number of companies that are doing so is poor. Therefore, our estimate of this energy use is based on BL&P's estimate of 16MW. This estimate assumes a power factor of 0.85 since these companies are not as likely to monitor it as BL&P would. We also assume the efficiency of these plants is lower at 20 percent.

### 3.3.2 Transformation of Energy

Of the approximately 3.4 GWh per year of primary energy being used, around 2,302 GWh is expended as waste heat and own use in the generation process, with the remaining 1,079 GWh per year being supplied to the grid or for the customers own use at their premises.

### 3.3.3 Final Use of Energy

The right side of the matrix indicates the final use of energy for Barbados. This section divides the final use of the energy into the following categories; Transmission & Grid Losses, Tourism, Street Lighting, Commercial, Miscellaneous, Public Services, Reservoirs, Residential and Industrial. BL&P provided the breakdowns of energy use by category.

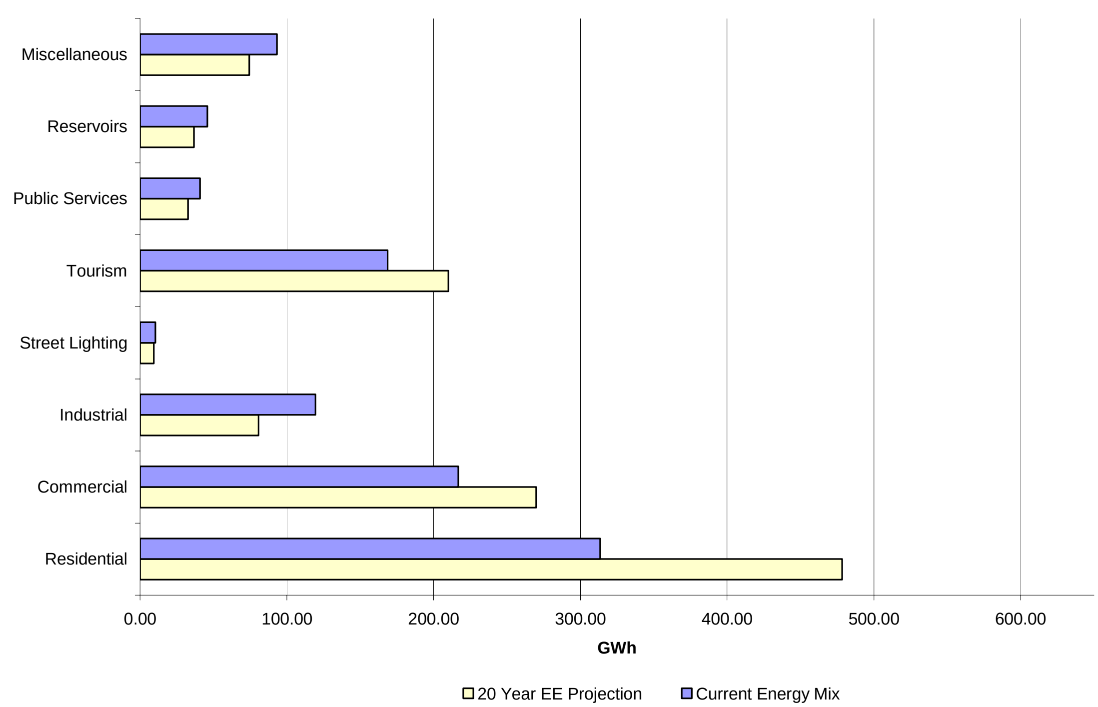
## 3.4 Gap Between the Current and the Sustainable Energy Matrix

In order to achieve the projections outlined in the Sustainable Energy Matrix both energy efficiency and renewable energy policies will need to be pursued. This scenario represents a high penetration rate for both renewable energy and energy efficiency.

Renewable energy uptake over this time period will have to be significant in order to achieve the desired results. Renewable electricity generation capacity totaling 94.7MW have to be put in place, compared to the estimate of 6.5MW of installed capacity. The utility scale plants that are being considered would provide a good start to achieving these goals.

Energy efficiency will have to increase by around 20 percent to shift from the business as usual to the Sustainable Energy Matrix. While 20 percent is a significant goal, experience shows that simply having an energy audit and following its recommendations can reduce energy consumption by 20 percent or more for many customers. Figure 3-4 indicates the sectors in which energy efficiency gains may be expected, with indicative figures for each sector showing estimated consumption under a business as usual scenario and under the Sustainable Energy Matrix.

**Figure 3-4: Electricity End-use Projection**




Source: Stantec Estimates.

# 4 Renewable Energy in Barbados' Current and Sustainable Energy Matrix

This section shows that renewable energy is economically and commercially viable in Barbados, but is not widely used. An inadequate regulatory framework is a key barrier to the uptake of renewable energy in Barbados. Here we provide the following eight key recommendations for increasing the use of renewable energy in the country:

- Create a consumer finance instrument to support small and commercial scale renewable energy technologies
- Provide electricity consumers with information about the renewable technologies that are new or have recently come down in cost
- Develop a standardized, technology specific approach for the planning and permitting process for renewable energy technologies
- Introduce new rules that allow households and businesses to sell power from distributed renewable generation to the grid, building on a Pilot Program proposed by BL&P for small wind and solar PV systems
- Require BL&P to show that its generation choices are least-cost solutions for Barbados
- Amend the Fuel Cost Adjustment mechanism to allow and encourage BL&P to use economically viable renewable technologies
- Revise BL&P's tariff schedule to encourage uptake of efficient distributed renewable generation, while discouraging customers from adopting those distributed generation solutions that could end up increasing the total cost of power to the country
- Provide incentives for the tourism sector consistent with the Government's use of tax and customs incentives for favoring renewable energy technologies over conventional ones—particularly solar water heaters over electric ones.

Below we review the current uptake of renewable energy, and then analyze the potential for and economic viability of various renewable energy technologies for Barbados (refer to Table 4-2 for a summary description of these technologies, and to Appendix C for a full description). We then look at the barriers that may have slowed their adoption. Finally we recommend possible solutions for overcoming the barriers identified (we present our recommendations in more detail in Section 6).

## 4.1 Current Uptake of Renewable Energy

The current uptake of renewable energy in Barbados is low. Residential solar water heaters are the only major renewable energy technology currently in use. Below we discuss the uptake of utility scale technologies in more detail, then that of distributed technologies.

### 4.1.1 Uptake of utility scale technologies

There is no utility scale renewable electricity generated in Barbados, despite the fact that it would be viable. By 'utility scale' we mean any technologies that need to be installed at a dedicated site and supply power over the transmission and distribution grids. There are some wind, biomass cogeneration, and waste-to-energy projects in the early stages of development, with wind being the most advanced.

### 4.1.2 Uptake of distributed generation technologies

Solar water heaters, with an estimated penetration of about 40 percent of households,[71] are the only significant distributed renewable energy supplies in Barbados. By 'distributed generation technologies' we mean small-scale technologies that are located in close proximity to the load being served[72]. We refer to these technologies as 'distributed generation' because they are distributed across the network at consumer premises. For the purposes of this assignment they include technologies such as the various types of solar photovoltaics and small-scale wind technologies.

Distributed renewable generation is almost non-existent in Barbados. There are a few small-scale wind units,[73] but these are used mostly for experimental purposes. Similarly, solar photovoltaic is limited to just a few installations.

BL&P proposed (as part of its application for a rate review to the FTC) a Pilot Program for introducing up to 1.6MW of distributed renewable energy systems. We discuss BL&P's proposal, which was approved by the FTC for starting in July 2010, in Section 4.2.3.

## 4.2 Renewable Energy Potential

In this section we analyze a range of renewable energy technologies for Barbados, present our conclusions on their viability,  describe BL&P's Pilot Program for distributed generation, and present a $CO_2$ abatement cost curve for the technologies.

### 4.2.1 Analysis of renewable energy technologies

Figure 4-1 shows our evaluation of the economic and commercial viability of potential technologies for renewable generation in Barbados. The figure shows the cost per kWh for a range of renewable energy technologies, and compares these against the fuel cost and all-in cost of conventional generation, as well as BL&P's retail tariffs. Fuels costs are shown for an oil price of US$100 per barrel because we need to use some estimate of future oil prices. A good source of these prices is the ten year oil futures contract, which is trading at about US$100 per barrel.[74]

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

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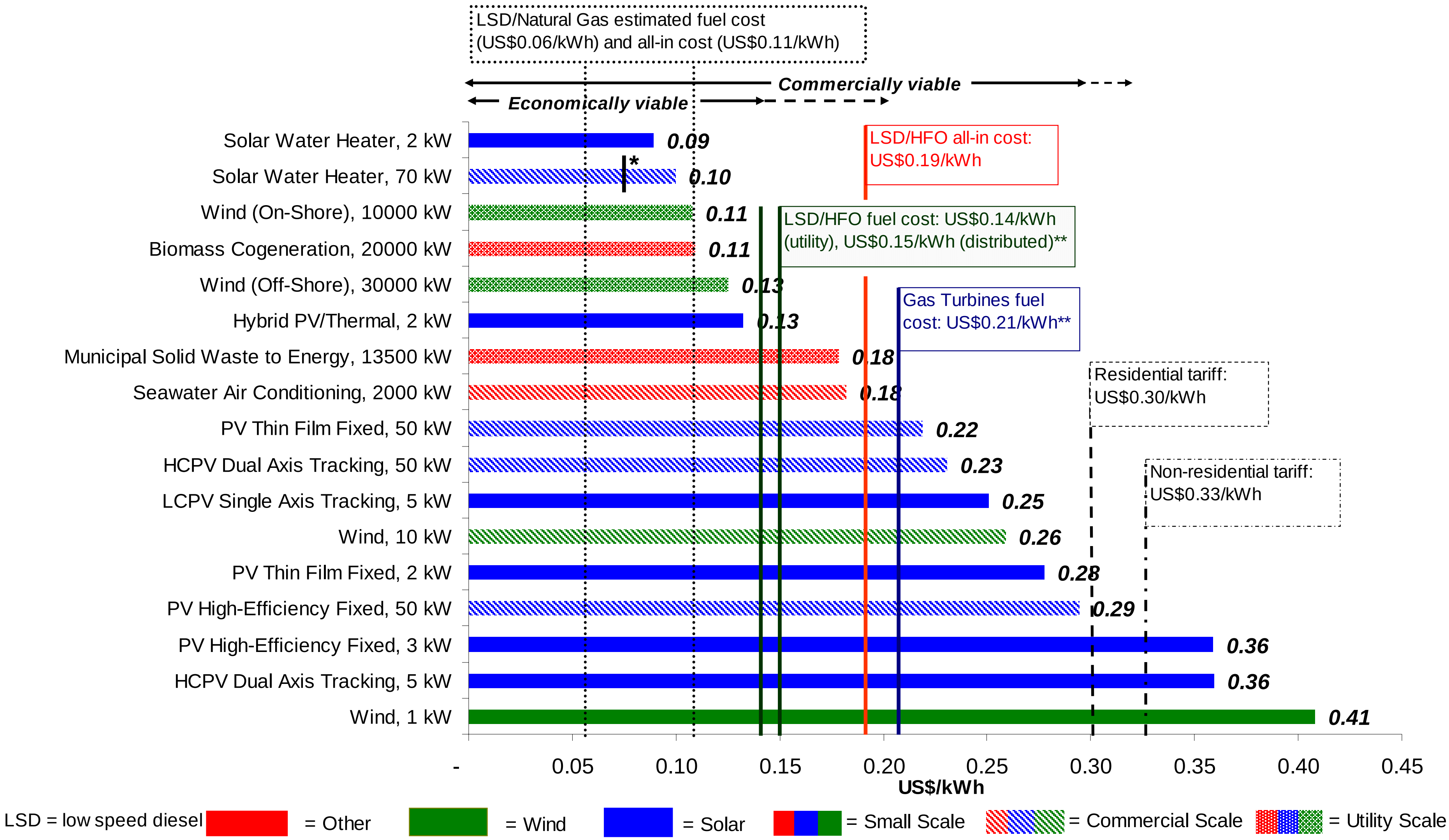
[71] Samuel Milton and Stephen Kaufman, *Solar Water Heating as a Climate Protection Strategy: The Role for Carbon Finance*, Green Markets International, Inc., Arlington, VA: 2005, page 17. Confirmed by conversations with MFIE officials, September-October 2009.

[72] 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).

[73] One small wind system (250W) is installed for a home office in Bridgetown; another of similar size is installed at the Barbados Public Workers Credit Union.

[74] Based on the price of ten-year futures for light sweet crude oil (WTI). See http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude.html

**Figure 4-1: Cost of Renewable Generation Technologies Compared to Avoided Cost of Conventional Generation (US$ per kWh)**




Source: Castalia and Stantec estimates

Note: * For "Solar water heater, 70kW" the comparator is fuel oil boiler heating (US$0.08 per kWh). ** 'Fuel costs' also include variable O&M costs; and are grossed up for losses (6.6%) for distributed technologies, but *not* for utility scale technologies. Generation costs and tariffs estimated based on oil prices of US$100 per barrel, and natural gas prices of US$7 per MMBTU. All-in cost of LSD with natural gas contingent on availability from the planned Eastern Caribbean Gas Pipeline.

**Viable technologies**

The analysis shows that there are six renewable energy technologies that are clearly economically and commercially viable in Barbados. These are:

- **Solar water heaters**, for homes. The cost per kWh for a residential solar water heater is around US$0.09 /kWh. This is considerably lower than the fuel cost of even the most efficient conventional plant (US$0.14 per kWh)
- **Wind at utility scale (on-shore and off-shore)**, is estimated to cost US$0.11 per kWh (on-shore) and US$0.13 per kWh (off-shore). Again, both costs come in under the fuel cost of the most efficient conventional plant (US$0.14 per kWh)
- **Biomass cogeneration**, on a large scale operated by the utility. This is estimated to cost US$0.11 per kWh. The biomass plant can provide firm power at less than the all-in cost of low speed diesel plant (US$0.19 per kWh)
- **Hybrid PV/thermal systems**, on a small scale. These systems are estimated to have a cost of US$0.13 per kWh, again lower than the fuel cost of the most efficient conventional plant (US$0.14 per kWh)
- **Municipal Solid Waste to Energy**, on a large scale operated by the utility. This technology can provide firm power at an estimated cost of US$0.18 per kWh, which is slightly less than the all-in cost of low speed diesel plant (US$0.19 per kWh)—the oil price breakeven point is US$94 per barrel, that is US$6 below the benchmark
- **Seawater Air Conditioning**, on a utility/district scale. This technology is commercially proven, and can provide cooling power at US$0.18 per kWh, effectively replacing conventional generation that costs US$0.19 per kWh. However, its realization is likely to be hampered by planning and approval difficulties, and for this we did not include it in the Sustainable Energy Matrix

These six technologies are also commercially viable. The customer saves money with residential solar water heating (or hybrid solar PV/thermal systems). BL&P could cut its generating costs with biomass cogeneration and wind generation. Provided oil costs on average more than US$94 per barrel, solid waste to energy will also reduce total generation costs.

**Technologies likely to be viable in the near future**

The following technologies are likely to become viable in the near future—their cost has been falling rapidly and consistently over the past few years, and is expected to fall further:

- **Certain types of small scale and commercial solar photovoltaic technologies**—thin film PV systems with fixed mounting (50kW), high concentration PV systems with dual axis tracking (50kW), and low concentration PV systems with single axis tracking are the most cost-effective PV technologies
- **Solar water heaters for commercial and industrial use**—the penetration of non-residential solar water heaters in Barbados is lower than that of residential ones, but it is increasing. As the scale of production increases (particularly for domestic manufacturers), the cost of these technologies is expected to fall.

Based on our expectation that the cost of these technologies will fall further in the near future, we included them in the Sustainable Energy Matrix for Barbados presented in Section 3.1. In that section, we also explain the basis for their estimated potential installed capacity.

**Only biomass cogeneration could be economically viable compared to potential future natural gas-based generation, which would be the cheapest option for Barbados**

Figure 4-1 also shows an estimate of generation costs using Low Speed Diesel (LSD) plants running on natural gas (US$0.11 per kWh for the all-in cost, and US$0.06 per kWh for the fuel only cost). LSD plants would not be the cheapest natural gas generation option (Gas Turbines and Combined Cycle Gas Turbines would have an all-in cost of US$0.09 and US$0.08, respectively), but they are the technology option we understand is being considered as the most realistic one by BL&P (see Section 2.3.3).

The cost estimate refers to a possible, but not yet certain scenario: it is contingent on the actual realization of the planned Eastern Caribbean Gas Pipeline (ECGP), and on a price of natural gas of US$7 per MMBTU, according to assumptions discussed above. Under this scenario, almost no RE technologies would be economically viable—biomass cogeneration as a firm technology would be just viable, but other non-firm technologies (such as solar and wind) would have to complete with a fuel-only cost of LSD plants using natural gas of around US$0.06. However, natural gas-based generation would still be a cleaner source of generation that HFO or diesel.

**Details on all the technologies**

Table 4-1 shows the cost, potential, and uptake of these technologies, as well as other renewable technologies that are not viable. Table 4-2 provides descriptions and underlying assumptions for each of these technologies. Appendix C contains a complete description of all renewable energy technologies we analyzed, and of the assumptions used.

**Table 4-1: Summary of Potential Renewable Energy Technologies in Barbados**

| RE Technology | Type | Scale | All-In Cost, US$ per kWh | Avoided Cost (benchmark), US$ per kWh | Cost Savings, US$ per kWh | Breakeven oil price (US$ per bbl) | Potential Installed Capacity (MW) | Installed Capacity as % of Current | Cost of Abatement (US$ per $tCO_2$) |
|---|---|---|---|---|---|---|---|---|---|
| **Economically and commercially viable** | | | | | | | | | |
| Solar Water Heater, 2 kW | Solar | Small | 0.09 | 0.21 | 0.12 | 40 | 14.5 | 0% | -133 |
| Wind (On-Shore), 10,000 kW | Wind | Utility | 0.11 | 0.14 | 0.03 | 74 | 10.0 | 0% | -53 |
| Wind (Off-Shore) 30,000 | Wind | Utility | 0.13 | 0.15 | 0.02 | 81 | 30.0 | 0% | -41.4 |
| Biomass Cogeneration, 20,000 kW | Other | Utility | 0.11 | 0.19 | 0.08 | 42 | 20.0 | 0% | -120 |
| Hybrid PV/Thermal | Solar | Small | 0.13 | 0.21 | 0.07 | 62 | N/A | 0% | -84.5 |
| Solid Waste to Energy, 13,500 kW | Other | Utility | 0.18 | 0.19 | 0.01 | 94 | 13.5 | 0% | -13 |
| Seawater Air Conditioning | Other | Commercial | 0.18 | 0.19 | 0.01 | 96 | 0.0 | 0% | -8 |
| **Likely to be viable in the near future** | | | | | | | | | |
| Solar Water Heater, 70 kW | Solar | Commercial | 0.10 | 0.08 | -0.02 | NA | 5.2 | 0% | 19 |
| PV Thin Film Fixed, 50 kW | Solar | Commercial | 0.22 | 0.21 | -0.01 | 105 | 11.8 | 0% | 12 |
| HCPV Dual Axis Tracking, 50 kW | Solar | Commercial | 0.23 | 0.21 | -0.02 | 111 | 2.5 | 0% | 25 |
| LCPV Single Axis Tracking, 5 kW | Solar | Small | 0.25 | 0.21 | -0.04 | 121 | 5.7 | 0% | 48 |
| **Not viable** | | | | | | | | | |
| Wind, 10 kW | Wind | Commercial | 0.26 | 0.15 | -0.11 | 174 | 0.0 | 0% | 163 |
| PV Thin Film Fixed, 2 kW | Solar | Small | 0.28 | 0.21 | -0.07 | 135 | 0.0 | 0% | 78 |
| PV High-Efficiency Fixed, 50 kW | Solar | Commercial | 0.29 | 0.21 | -0.09 | 143 | 0.0 | 0% | 96 |
| PV High-Efficiency Fixed, 3 kW | Solar | Small | 0.36 | 0.21 | -0.15 | 175 | 0.0 | 0% | 168 |
| HCPV Dual Axis Tracking, 5 kW | Solar | Small | 0.36 | 0.21 | -0.15 | 176 | 0.0 | 0% | 169 |
| Wind, 1 kW | Wind | Small | 0.41 | 0.15 | -0.26 | 277 | 0.0 | 0% | 392 |

Note: PV= Photovoltaic, HCPV = High-Concentration Photovoltaic, LCPV = Low-Concentration Photovoltaic. The potential installed capacity of Hybrid PV/Thermal systems is included in that of solar water heaters and solar PV systems. We assumed no seawater air conditioning installation in Barbados in the Sustainable Energy Matrix (in spite of its viability) due to practical difficulties in obtaining approval for construction.

## Table 4-2: Description of Potential Renewable Energy Technologies

| Short name | Full name and description | Scale | Distributed or Dedicated Site? | Size | Potential Installed Capacity (MW) | Capital Cost per Unit (US$) | O&M Costs per Unit (US$/year) | Lifetime (years) |
|---|---|---|---|---|---|---|---|---|
| **Solar** | | | | | | | | |
| Solar water heater, 2 kW | Domestic solar water heaters | Small | Distributed | 2kW | 14.5 | 2,500 | 40 | 20 |
| Solar water heater, 70 kW | Commercial and industrial solar water heaters, using evacuated tube technology | Commercial | Distributed | 70 kW | 5.2 | 112,000 | 1,680 | 20 |
| Hybrid PV/thermal | Hybrid solar systems for electricity and heating | Small | Distributed | 2kW | N/A | 3,360 | 63 | 20 |
| PV thin film, fixed, 2 kW | Thin film solar photovoltaic panels with fixed mounting | Small | Distributed | 2kW | 0.0 | 10,000 | 120 | 20 |
| PV thin film, fixed, 50 kW | Thin film solar photovoltaic panels with fixed mounting | Commercial | Distributed | 50kW | 11.8 | 200,000 | 2,100 | 20 |
| PV high efficiency fixed, 3 kW | High-efficiency solar photovoltaic panels with fixed mounting | Small | Distributed | 3kW | 0.0 | 18,000 | 180 | 20 |
| PV high efficiency fixed, 50 kW | High-efficiency solar photovoltaic panels with fixed mounting | Commercial | Distributed | 50kW | 0.0 | 250,000 | 2,100 | 20 |
| LCPV single axis tracking, 5 kW | Low-concentration solar photovoltaic panels with single axis tracking | Small | Distributed | 5kW | 5.7 | 23,750 | 400 | 20 |
| HCPV dual axis tracking, 5 kW | High-concentration solar photovoltaic panels with dual axis tracking | Small | Distributed | 5kW | 0.0 | 32,250 | 400 | 20 |
| HCPV dual axis tracking, 50 kW | High-concentration solar photovoltaic panels with dual axis tracking | Commercial | Distributed | 50kW | 2.5 | 172,500 | 3,700 | 20 |
| **Wind** | | | | | | | | |
| Wind, 1 kW | Wind turbines for electricity generation | Small | Distributed | 1kW | 0.0 | 9,400 | 110 | 20 |
| Wind, 10 kW | Wind turbines for electricity generation | Commercial | Distributed | 10kW | 0.0 | 55,000 | 1,100 | 20 |
| Wind, 10,000 kW (On-Shore) | On-shore wind turbines for electricity generation | Utility | Dedicated | 10MW | 10.0 | 18.6 million | 372,000 | 20 |
| Wind, 30,000 kW (Off-Shore) | On-shore wind turbines for electricity generation | Utility | Dedicated | 30MW | 30.0 | 85.5 million | 1.7 million | 20 |
| **Other** | | | | | | | | |
| Biomass, 20,000 kW | Cogeneration (generation of heat and power) through combustion of biomass | Utility | Dedicated | 20MW | 20.0 | 59.5 million | 1.5 million | 20 |
| Seawater Air Conditioning | Use of ocean temperature for cooling | Commercial | Dedicated | 2MW | 0.0 | 8.3 million | 331,200 | 20 |
| Waste to energy, 13,500 kW | Use of solid waste (various technologies) to generate electricity | Utility | Dedicated | 13.5MW | 13.5 | 150 million | -1.1 million (savings) | 20 |

**Analyzing economic viability for each technology**

In Figure 4-1 the viability of each technology can be seen by comparing the cost of the technology (shown by the horizontal bar) with the relevant benchmark for that technology (shown by the line to the right or left of the end of the bar). We use different benchmarks for economic viability depending on the type of conventional generation that the renewable technology will displace.

- **Biomass, Waste to Energy, and Seawater Air Conditioning** technologies are benchmarked against the all-in cost of low speed diesel plant because these are "firm" technologies; they can be depended on to generate electricity at any time, just like a conventional generation unit. We use the all-in cost of low speed diesel generators as the benchmark for the economic viability of firm generation because it is the least-cost conventional technology for providing base-load electricity in Barbados. In other words, this is the technology that firm renewable technologies would displace

- The **solar photovoltaic** technologies are "non-firm"; they cannot be switched on at will.[75] This means that there needs to be a conventional generator on standby that is used as "firming" supply when the sun is not shining. Every unit of energy generated by a solar technology will save the fuel cost of the marginal plant on the system, but it will not save the fixed costs of capacity (because the firming technology capacity is also needed). In Barbados, the most efficient firming technology to use for solar are gas turbine generators because they have the lowest capital cost. The lower capital cost makes these generators more efficient, even though they have higher fuel costs than low speed diesel engines, because solar is reasonably dependable during the day, so the gas turbines only need to be operated intermittently. Therefore, for solar photovoltaic technologies, the benchmark for economic viability is the fuel cost (including variable O&M) of the gas turbines. This fuel cost is grossed up for transmission and distribution losses (6.6 percent)[76] because distributed technologies—being located close to the load served—would also avoid those losses

- The **solar water heater technologies** can store heat, so they are far less intermittent than solar photovoltaic technologies—and actually almost comparable to a firm technology. The benchmark we use for domestic solar water heaters is the all-in cost of low speed diesel generators, but not grossed up for losses, to compensate for not storing all heat produced. For commercial and industrial solar water heaters, the relevant benchmark is fuel oil boiler heating—which costs about US$0.08 per kWh—and not electric heating like domestic ones

- The **wind** technologies are a similar to solar photovoltaic technologies, except that wind is typically less reliable and therefore the firming technology will operate more often. We use the fuel cost (including variable O&M) of low speed diesel as the benchmark for wind because it is a more efficient choice of firming

[75] Technologies are being developed that allow traditionally non-firm technologies to become firm through storage in batteries. Although some technologies already exist, they are not yet economically viable on a relatively small scale such as Barbados (see *Battery energy storage technology for power systems-An overview*, K. C. Divya, Jacob Østergaard, Electric Power Systems Research, Vol. 79, No. 4. (April 2009), pp. 511-520).

[76] This figure does not include a small amount of electricity losses in works (see Section 3.1.2).

technology—it will be used regularly and has a lower fuel cost. This cost is grossed up for transmission and distribution losses (6.6 percent) for distributed wind technologies, as explained above for solar PV. It is not grossed up for utility scale wind, as it is not for biomass and waste to energy—generation from utility scale renewable technologies is subject to losses, just like for conventional plants

We do not use steam turbine generators as the benchmark for solar or wind for two main reasons. First, steam turbines take longer to heat up or cool down, so cannot respond quickly or efficiently enough to the unreliable supply of renewable technologies. Secondly, steam turbines have higher capital and operating costs than other types of generation. They are a legacy system and should be replaced by viable renewable technologies or low speed diesel engines. It would overstate the viability of renewable technologies to compare them to steam turbines.

A complex analysis could factor in the exact mix of generators displaced for different types of renewable technologies, in different locations and of varying capacity. But it would be of limited value given that our benchmarks for viability are heavily dependent on an uncertain fuel price and can quickly change significantly. It is enough to conclude that some technologies are clearly viable, while others are border-line viable, and will become clearly so if fuel costs rise or the costs of the technologies drop.

**Explaining our calculations of generating costs and benchmarks**

We used the following assumptions for calculating the costs of each generating technology (US$ per kWh):

- *Yearly output in kWh per year*—this involved making assumptions regarding the output each renewable generation technology could would produce. This would include resource availability (for example available solar energy, wind speed profile, and conversion efficiency of the technology)
- *Capital costs, in US$*—we estimated capital costs based on our local team's knowledge of market conditions in Barbados, quotes from Caribbean equipment providers, and our experience of the North American renewable generation market
- *Operation and maintenance (O&M) costs, in US$*—we estimated O&M costs based on our local team's knowledge of market conditions in Barbados, quotes from Caribbean equipment providers, and our experience of the North American renewable generation market
- *Lifetime, in years*—we estimated the lifetime of renewable generation equipment based on our experience of renewable generation technologies, in all cases 20 years being a reasonable approximation (some solar PV technologies have the potential for 25 year lifetime, so this assumption equates to a conservative basis in those cases)
- *Discount rate*—for the distributed (small scale) options we assumed a discount rate of 6 percent. For the utility scale options we assumed a discount rate of 12 percent. The reason for the difference is that we expect that small scale equipment will be able to attract financing from development agencies such as the IDB at rates of no more than 6 percent. However, large scale equipment will

likely have to be commercially financed, and so we used a higher discount rate. We also used the 12 percent discount rate to calculate the capital costs of conventional generation.

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

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

- *Hot Water Heating*—for this technology, we estimated the cost per kWh of electricity consumption saved
- *Tariff and conventional energy costs*—these are the same figures as were used in Section 4, and include an estimated Fuel Clause Adjustment component at US$15.8 cents per kWh including the 15 percent Value Added Tax.

For this Report, we based our evaluation on available data provided by BL&P for a utility-scale wind farm. For municipal solid waste to energy, we based our evaluation on information from the Sanitation Services Authority (SSA), but we also took into consideration significant O&M cost savings from reduced landfill costs—the net effect is that municipal solid waste to energy has negative O&M costs.[77] For biomass, we based our evaluation on information provided by the Barbados Cane Industry Corporation (BCIC).[78] Upgrades include a new cogeneration plant. For other technologies—solar photovoltaic, small wind, solar water heaters, hybrid PV/thermal, and seawater air conditioning—on quotes obtained from technology vendors and on our experience of the renewable energy market. Refer to Appendix C for a full description of technologies and assumptions. (Appendix E and F describe two technologies that are promising for Barbados, but that are not commercially proven yet—Ocean Thermal Energy Conversion, and Ocean Wave Energy Conversion. According to our discussions with the Government, we only included in the Sustainable Energy Matrix technologies that are commercially proven.)

### 4.2.2 Conclusions about the Viability of Technologies for Renewable Energy

Table 4-3 summarizes our general conclusions about the economic and commercial viability of renewable energy technologies in Barbados. In this section we draw broad conclusions by grouping similar renewable technologies together. In Section 4.2.1 above we give a detailed evaluation by specific technology.

[77] O&M costs, net of landfill cost savings, are US$-79.7 per kW per year. Estimate based on Stantec Consulting International Ltd. (in association with Consulting Engineers Partnership, Barbados), *Barbados Integrated Solid Waste Management Programme Prepared for: Government of Barbados, Sewerage and Solid Waste Project Unit, Ministry of Health*, December 1999 Final Revision/Update.

[78] Barbados Cane Industry Corporation, *Draft Final Design Report, Refurbishment and Upgrade of the Andrews Sugar Factory*, December 2009.

## Table 4-3: Conclusions about the Viability of Renewable Energy Technologies

| Technology | Scale | Economic viability with oil at US$100/bbl | Likely economic viability in near future | Commercial viability | Explanation |
|---|---|---|---|---|---|
| Biomass cogeneration | Utility | ✓ | ✓ | ✓ | Biomass cogeneration is likely to produce power at around US$0.11 per kWh. This is below current fuel costs—the breakeven oil price is US$42 per barrel. Moreover, biomass cogeneration can provide firm power if arrangements are made for supply of biomass year round. This can be possible if the biomass is stored for use out of the crop season, or if other biomass (such as wood briquettes) is imported for use out of the crop season. The relevant benchmark in that case would be the all-in cost of power generation, suggesting that at current fuel prices, use of biomass cogeneration could lower the cost of power by around US$0.08 per kWh for each kilowatt hour generated. Of course, the conclusion that biomass cogeneration is economically justified is subject to the results of the assessment of the viability of biomass cogeneration in Barbados, which will be completed in the course of 2010. |
| Municipal solid waste to energy | Utility | ✓ | ✓ | ✓ | The estimated all-in cost of a solid waste to energy plant is US$0.01 less than the all-in cost of low speed diesel generators. This estimate considers the cost savings that the construction of the SSA plant would have for landfill management, as we explain in detail in Appendix C. This technology is viable with oil prices of at least US$94 per barrel—US$6 per barrel less than our benchmark—and its viability will of course increase if the cost of the technology decreases. |
| Wind (On-Shore and Off-Shore) | Utility | ✓ | ✓ | ✓ | Utility scale wind power has an all-in cost of around US$0.11 per kWh (On-Shore) and US$0.13 per kWh (Off-Shore). At oil prices of US$100 per barrel, wind generation allows for net savings of about US$0.01-0.03 per kWh over the fuel costs of gas turbines. This makes it economically and commercial viable to the utility. This conclusion is subject to the assumptions used for turbine cost and capacity factor remaining valid. In calculating the cost of utility scale wind power, we used a capacity factor of 30 percent, provided by BL&P for the Lamberts wind site, and a unit capital cost of US$1,860 per kW installed also provided by BL&P. For off-shore wind, we used a capital cost of US$2,850 per kW installed and a capacity factor of 40 percent, based on estimates from the European Wind Energy Association (EWEA). |
| Seawater Air Conditioning | Commercial | ✓ | ✓ | ✓ | This technology is commercially proven and viable, but in practice its realization is very difficult—it would need agreement on a piping network linking at least six large users (such as hotels) close to the coast, and likely require a difficult planning and approval process. For this, we did not include it in the Sustainable Energy Matrix—but a strong action from the Government could overcome the practical difficulties in constructing it. |

| Technology | Scale | Economic viability with oil at US$100/bbl | Likely economic viability in near future | Commercial viability | Explanation |
|---|---|---|---|---|---|
| Wind | Commercial and Small Scale | X | X | ✓ | The capital costs of wind turbine technology, although decreasing in recent years, is still too expensive to make it viable in Barbados on a commercial (10 kW) or small (1 kW) scale. As we discuss below, there is a problem that commercial scale wind turbines have a lower cost than the tariff, making them commercially viable even though they are not a least-cost solution for Barbados. |
| Solar Water Heaters | Commercial and Small Scale | ✓ | ✓ | ✓ | Small scale solar water heaters are clearly economically and commercially viable, reflected by the fact that about 40 percent of households already have them installed. Commercial scale water heaters are different. Our analysis shows that on average they are not viable in comparison to fuel oil boilers, by about U$0.03 per kWh, but the actual efficiencies of the alternative technologies will vary significantly between the sites and applications where they are used, so we would expect commercial scale solar water heaters to be viable in some but not all cases. Where the commercial solar thermal is replacing electric water heaters, it will be clearly economically and commercially viable. |
| Hybrid PV/Thermal | Small Scale | ✓ | ✓ | ✓ | This technology, at US$0.13 per kWh, is viable. We considered its potential installed capacity in Barbados as part of the Solar Water Heaters and the PV systems close to viability. |
| Solar PV | Commercial and Small Scale | X | ✓ | ✓ | The viability of PV varies significantly by the specific type of technology – thin film, single/dual axis, or high efficiency fixed. All solar PV technologies have come down significantly in cost in recent years. However, at oil prices of US$100 per barrel none are clearly economically viable in Barbados. There are three specific types that are close to viability (with gaps between US$0.01 and US$0.04 per kWh) and are likely to become viable in the near future as costs continue to come down (see Table 4-1). These are (i) PV thin film fixed at a commercial scale (50 kW), (ii) HCPV dual axis tracking at a commercial scale (50 kW), and (iii) LCPV single axis tracking at a small scale (5 kW). If commercial scale PV technologies do become viable, it would be possible to install a series of facilities at a dedicated site where they would be operated at a utility scale. |

**The problem of technologies that are commercially but not economically viable**

Technologies that are commercially but not economically viable are a problem because they mean that customers have incentives to install technologies that are not least-cost solutions for Barbados.

As shown in Figure 4-1 the following technologies are commercially but not economically viable:

- ***Wind, commercial scale (10kW)***—new technologies for wind turbines of about 10kW in capacity allow electricity to be generated at a cost of US$0.26 per kWh. This is less than both the residential and non-residential tariffs (US$0.30 and US$0.32 per kWh, respectively). Therefore, these units will appeal to customers with steady loads of around 10kW or more at a single location, saving them between US$0.04 and US$0.06 per kWh. This technology is not economically viable and will unnecessarily incur a cost of US$0.11 per kWh more than the least-cost alternative (low speed diesel fuel cost, including losses)
- ***Solar PV, commercial and small scale***—almost all of the solar PV technologies (either using fixed thin film or high efficiency silicon with dual axis tracking and solar concentrators), which range from US$0.22 to US$0.29 per kWh in cost, are cheaper than the residential and commercial tariffs. (The exceptions are small scale "PV high-efficiency fixed" and "HCPV dual axis tracking" that have costs as high as US$0.36 per kWh.) While PV technologies may become economically viable as the cost of panels continues to fall, there is a risk that electricity consumers in Barbados will have incentives to install them well before they are economically viable. At current costs, installing solar PV technologies is potentially as much as US$0.09 per kWh more expensive than the least-cost alternative (gas turbine fuel cost including losses).

This problem of technologies that are commercially viable but not economically viable arises in Barbados because most electricity consumers face a per kWh charge that covers not only the cost of generation, but also the costs of the distribution grid, and the stand-by capacity the utility has invested in. This means that a customer who installs non-firm renewable generation, and so only uses electricity from the grid occasionally, does not pay the full cost of the connection to the network. If such customers were charged a monthly connection fee that reflected the true cost of their connection, and faced a correspondingly lower per kWh charge, the non-firm renewable generation would no longer be commercially viable.

We recommend rebalancing BL&P's tariff so that it provides more cost-reflective signals. The utility needs to be allowed to split its tariff into a fixed charge to cover distribution costs and back-up services, and a variable charge that more closely reflects generation costs (see Section 6.2 for details on this recommendation).

### 4.2.3 BL&P's Pilot Program for small wind and solar PV systems

BL&P has developed a pilot program for distributed generation, included in its application to the FTC for a revision in its rate structure. The FTC approved this program together with other pilot tariffs for a period of only two years starting on 1 July 2010. This program represents a useful first step towards establishing a framework for efficient use of renewable distributed generation—however, two years are much less than the useful lifetime of the systems that would benefit from it (20 years), and this could limit the program's success.

BL&P's pilot program aims at allowing its customers to connect small solar PV and wind systems to the grid under a three-year interconnection agreement. Residential systems will have a maximum capacity of 5kW, while non-residential systems will have a maximum capacity of 50kW. BL&P proposed that customers who install such systems sell excess energy to the grid at a rate—the "Rider for Renewable Energy"—equal to BBD 31.5 cents, or 1.8 times the Fuel Clause Adjustment (the fuel cost component of the tariff), whichever is greater. The pilot would have a ceiling of 1.6MW or 200 projects, whichever was reached first.

BL&P proposed that the 'Rider' be 1.8 times the FCA, because 1.8 is the result of the ratio of the following two elements used to calculate it:[79]

- The average cost of generation that would be avoided if a combination of renewable technologies (1.6MW of capacity, 90 percent solar and 10 percent wind) sells electricity to the grid. This avoided average cost of generation is based on BL&P's load profile, and therefore considers the varying costs of generation at different times of the day. Solar PV is assumed to peak between 11am and 1pm, and wind is assumed to provide a constant load
- The average cost of fuel over the day.

The methodology used by BL&P to calculate the 'Rider' for its Pilot Program is sound. The Pilot Program will be useful to test how efficient distributed generation can be introduced in Barbados. The experience developed and the lessons learned in the Pilot Program will provide a good basis to develop a comprehensive framework beyond the initial 1.6MW or 200 systems—as shown in Table 4-1, we estimate that up to 20MW of distributed solar PV technologies could be installed in Barbados.

#### 4.2.4 The Cost of additional $CO_2$ Abatement

Our analysis above focuses on the economic and commercial viability of technologies on the basis of cost alone. In this section we calculate the cost of introducing technologies that are not least-cost but are environmentally friendly—we calculate the additional cost per ton of $CO_2$ abated for all renewable technologies considered.

Figure 4-2 below shows the $CO_2$ abatement curve—what it costs to abate an additional ton of $CO_2$ by implementing each technology. The figure shows that after the renewable technologies that are economically viable (those with a negative cost of abatement) are exhausted, the cost of reducing one ton of $CO_2$ begins at around US$12 (for solar PV thin film fixed systems) and increases to over US$390 (for very small scale wind power).

The figure also shows the current price for Certified Emission Reductions (CERs)—US$16 for December 2010 delivery.[80] The CER price is the price currently being paid to reduce global carbon emissions. If the Government wants to reduce global $CO_2$ emissions, it should not consider technologies that have an abatement cost above the CER price—it could just buy CERs instead.

We calculate the cost of $CO_2$ abatement through the following steps:

[79] Conversation at BL&P, Bridgetown, 1 December 2009.

[80] Source: PointCarbon www.pointcarbon.com, 3 June 2010.

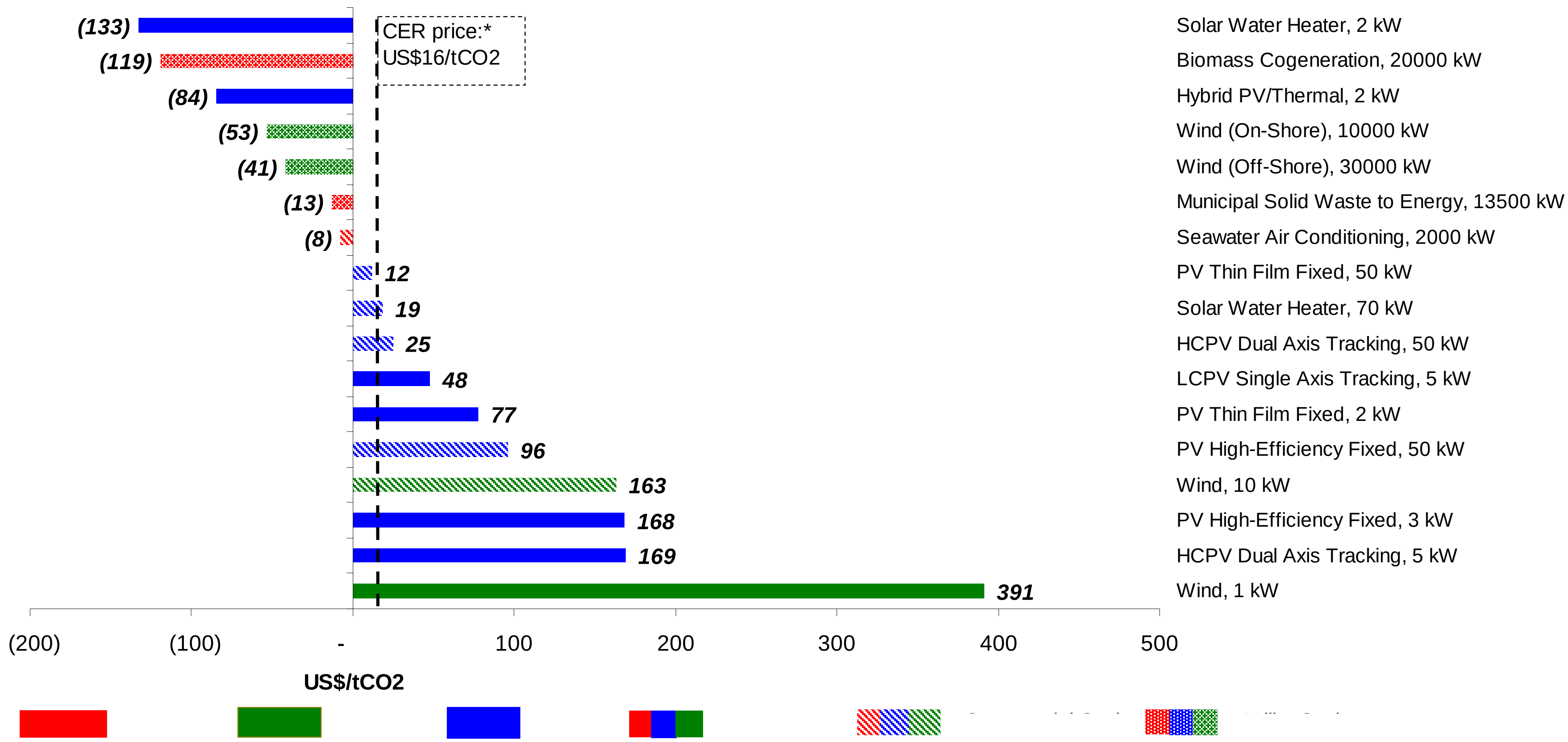
- *Emission factors*—we calculate emission factors for each plant type based on the carbon content of the fuel they use (heavy fuel oil or diesel), according to the guidelines of the Intergovernmental Panel on Climate Change (IPCC).[81] We use thermal efficiency factors (the percentage of the fuels' energy content that is transformed in electricity) for the plants as provided by and discussed with BL&P[82]
- *Avoided emissions*—we calculate the avoided emissions of each renewable technology (tons of $CO_2$ per kWh) based on the conventional technology each displaces (the generation benchmark used for calculating economic viability)
- *Cost of abatement*—we divide the cost savings (US$ per kWh) of each technology compared to its conventional benchmark (see Table 4-1) by the avoided emissions. Cost savings are calculated by considering transmission and distribution losses in the generation benchmark for distributed technologies. We use the following formula:

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

[81] 20kg of carbon per GJ for heavy fuel oil, and 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).

[82] 0.2 for steam plants (heavy fuel oil), 0.4 for low speed diesel plants (heavy fuel oil), and 0.28 for gas turbines (diesel fuel). Provided by BL&P management, September 2009.

**Figure 4-2: $CO_2$ Abatement Cost Curve**




Note: * Price of a December 2010 CER (Certified Emission Reduction) as of 3 June 2010. Source: PointCarbon www.pointcarbon.com

## 4.3 Barriers and Solutions to the Uptake of Technologies for Renewable Energy

In this section we assess the barriers to the uptake of renewable technologies, focusing on those technologies that are economically viable, as we established in Section 4.2.2 above. For each barrier, we propose solutions that will encourage the uptake of renewable energy in Barbados.

### 4.3.1 Barriers to Renewable Energy Technologies

The barriers to the uptake of renewable energy projects in Barbados are summarized in Table 4-4 below.

**Table 4-4: Summary of Barriers to Renewable Energy in Barbados**

| RE technology | Scale | No Commercial Viability | Limited Access to Capital | Incomplete Information | Planning and Permit Problems | Lack of Grid Connection Rules | Economic Regulatory Distortion |
|---|---|---|---|---|---|---|---|
| Biomass cogeneration | Utility | _ | _ | _ | B | B | B |
| Municipal solid waste to energy | Utility | _ | _ | _ | B | B | B |
| Wind | Utility | _ | _ | _ | B | _ | B |
| | Commercial and small | B | B | B | B | B | _ |
| Solar Water Heaters | Commercial and small | _ | B | B | _ | _ | _ |
| Solar PV | Commercial and small | _ | B | B | _ | B | B |
| Hybrid PV/Thermal | Small | _ | B | B | _ | _ | _ |
| Seawater Air Conditioning | Commercial | _ | _ | B | B | _ | _ |

Note: B = barrier.

Below we discuss the barriers to the uptake of renewable energy technologies in more detail, first discussing the barrier to utility scale technologies, then the distributed (commercial and small scale) technologies. We also describe planning and permitting barriers, which apply to both utility scale and distributed technologies—in particular, we address concerns on the effects of wind turbines that have contributed to the delay in developing this technology in Barbados.

**Barriers for utility scale technologies**

There are two main barriers to utility scale technologies in Barbados—both relate to a lack of incentives to adopt renewable energy in the regulatory regime under which BL&P operates:

- ***BL&P has not been required to show that its choice of generation investment is likely to lead to the lowest cost power for the country***. This means it has not been required to consider renewable technologies, and to adopt these technologies if they offer lower cost power than conventional generation
- ***The design of the Fuel Clause Adjustment (FCA) provides a disincentive to BL&P to use renewable technologies***. That is, BL&P may be able to lower the total cost of power generation by using renewables, but still not be able to recover all of that lower cost. In contrast, with conventional generation, BL&P can be more certain of recovering the cost of generation. This is not to argue against a fuel cost adjustment mechanism, but simply to point out that the particular design used for the FCA has reduced incentives for the use of renewables, even when they are lower cost.

**Barriers for distributed technologies**

The barriers to the uptake of distributed technologies for renewable energy are:

- ***Customers are not allowed to connect their systems or sell to the grid***—there are no rules that allow households and businesses to sell excess capacity of their distributed technologies back to BL&P, or that require BL&P to purchase that power even if it saves cost. (BL&P's Pilot Program, with the Rider for Renewable Energy approved by the FTC, is a useful first step towards doing this, although on a small scale and for a limited period of time—two years starting on 1 July 2010—which is less than the lifetime of the systems—this might limit the program's success). This means that if a householder or business does not require the full capacity of a renewable generation unit, it has no way of fully using that capacity so it becomes more costly[83]
- ***Distributed technologies have a high upfront cost***—many households in Barbados 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
- ***Customers are unfamiliar with distributed renewable technologies***—these technologies are relatively new and unknown to the public. Familiarity with the true costs and benefits of solar water heaters—thanks to Government programs—has been essential to their high penetration in Barbados. Other technologies—particularly solar PV—are more complex, and customers will be

[83] More broadly, any industry requires the development of a market in order to grow. See Dr. Travis Bradford, *Solar Revolution: The Economic Transformation of the Global Energy Industry*, 2006, pages 193-194: "(…) Achieving growth in any industry depends on more than availability and cost-effectiveness. Growth also requires the development of markets and businesses to deliver the solutions. In the case of solar energy, the supply chain requires manufacturing capability, distributors, integrators, and installers. Market development also requires financing, rationalized building codes, interconnection agreements, and certification and training programs. The growth of the PV market requires that people-consumers, architects, builders, installers, services, and utility executives-all become comfortable with PV technology."

slow to adopt technologies they do not know.[84] Costs and performance of solar PV technologies have improved significantly only in recent years, and customers may not be convinced of their commercial viability[85]

- ***Incentives for the Tourism sector may end up working against solar water heaters***—the Government intends to use tax and customs incentives to promote sustainable energy technologies. However, incentives for the tourism sector have the unintended consequence of removing the preference given to these technologies over conventional ones. The Tourism Development Act allows tourism operators to obtain tax and customs incentives.[86] An operator can obtain duty free import of building material, equipment, and supplies for refurbishment of tourism sites—including electric water heaters, which directly compete against solar water heaters. This means there is no duty preference for renewables in the tourism sector.

**Permitting and planning barriers for utility scale and distributed technologies**

A common barrier for renewable energy development in Barbados is the permitting and planning process. The Barbados Town and Country Development Planning Office (TCDPO)[87] is in charge of managing the permitting and planning process. Its task is to balance the requests of developers with the safety, security, and rights of the public.

The permitting and planning process is not well suited for renewable generation projects. For conventional developments that have been done many times through the TCDPO, the submittal requirements, public consultation process, and approval processes are clearly defined and the process is reasonably streamlined. Introducing renewable energy technologies, on the other hand, requires the planning process be developed from first principles. As a result, the timeframe for permitting is excessively long, and the process is excessively complex—each technology's environmental, social, and aesthetic implications must be formally addressed through public hearings, with no clear rules set out in advance.

For renewable energy developments, the TCDPO often receives a wide range of health and safety concerns brought to its attention through the public consultation process. As the TCDPO is not equipped to evaluate these technical and environmental concerns, it must pass these concerns on to the agency that has jurisdiction—this may be the Ministry of Environment, the Barbados Coastal Zone Management Unit,[88] the Barbados Water Authority (BWA), or all of the above, depending on the concern being raised. The respective

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[84] The Pine Hill Dairy is using steam for process heating, producing the steam in boilers using fuel oil number 6. During our survey of the facility the management indicated their general desire to preheat the boiler's feed water with solar collectors, but was not familiar enough with evacuated tube technology to know which next steps to take.

[85] See Dr. Travis Bradford, *Solar Revolution*, pages 155-156: "Beyond the cash costs of installation, maintenance, and financing that are included in the economic calculation of cost per kWh delivered, switching to a new and unfamiliar technology creates additional noncash costs for PV system purchasers in time and effort to evaluate such a system-that is, information costs. (…) As more PV systems are installed, each new user increases aggregate market awareness, thereby reducing information costs for future systems, and this adoption trend gains steam until a technology becomes mainstream and information costs become a small portion of an adopter's total cost-via implementation of standardized solutions and through a general sharing of awareness and technical knowledge."

[86] Tourism Development Act, 2002-7, 31 August 2002, http://www.barmot.gov.bb/tourism-development-act.html. Also see Barbados Tourism Investment, Inc. http://www.barbadostourisminvestment.com/legislation_and_incentives.cfm.

[87] Town and Country Development Planning Office, http://www.townplanning.gov.bb/.

[88]Website of the Barbados Coastal Zone Management Unit: http://www.coastal.gov.bb/.

agency must then initiate a technical review giving its opinion on the issue and providing a recommendation for approval, resubmission, or denial to the application. In many cases, this process is repeated during a second round of public consultation, to allow the public time to transmit to the various agencies their initial responses and then clarify their concerns.

A standard permitting process for each renewable technology would streamline approvals and overcome the majority of permitting delays, while still providing the necessary planning and environmental checks (see Section 6.3).

### 4.3.2 Proposed Solutions to Barriers

Table 4-5 shows our proposed solutions to removing the barriers to the uptake of renewable technologies in Barbados. We discuss our proposed solutions in detail in Section 6.

**Table 4-5: Proposed Solutions to Barriers**

| Barrier | Proposed Solution |
|---|---|
| No commercial viability | None. Renewable technologies that are not commercially viable are not economically viable, and therefore should not be implemented. |
| Limited access to capital | Create a consumer finance instrument within the proposed "Smart Fund", consisting of a subsidized hire purchase scheme for economically viable distributed renewable generation technologies. |
| Incomplete information | Promote renewable technologies that are economically viable. Provide information on their costs, how to purchase and install them, and their environmental benefits. |
| Planning and Permit problems | Direct the Town and Country Development Planning Office to move to a standardized, technology specific approach for the planning and permitting process that streamlines the development of viable renewable energy technologies. |
| Lack of Grid Connection Rules | Introduce new rules that allow electricity consumers to sell excess capacity to the grid, based on the experience that will be gained under the BL&P Pilot Program for renewables. These rules will need to cover the technical and safety aspects of connection to the grid, metering arrangements, and the price to be paid for power. Provisions also need to be made to prevent grid-stability problems in the face of large amounts of intermittent generation. |
| Economic Regulation Distortions | Require BL&P to prove that its choice of generators is the most economically efficient for Barbados. Amend the fuel cost adjustment mechanism so that it allows for both utility scale and distributed renewable technologies to recover their costs provided these are below BL&P's avoided cost. Disaggregate the electricity tariff structure to make it more cost reflective, and thus promote efficient energy efficiency and distributed generation investments, while discouraging economically inefficient investments. Make incentives under the Tourism Development Act consistent with the Government's intention to use tax and customs incentives to favor sustainable energy technologies over conventional ones—particularly solar water heaters over electric ones. |

# 5 Energy Efficiency in Barbados' Current and Sustainable Energy Matrix

In this section we show that there is great potential for increased use of energy efficiency (EE) technologies in Barbados. Table 5-1 lists the technologies of interest, and indicates which have real potential for Barbados. (Refer to Appendix H for a detailed description of each of these technologies, and of typical baseline technologies they replace or improve.)

**Table 5-1: Energy Efficiency Potential by Technology Type**

| EE Technology | Description | Potential |
|---|---|---|
| Compact Fluorescent Lamps (CFLs) | Efficient light bulbs that replace conventional incandescent ones. More efficient (more power converted to light, less to heat), more luminous for any given installed capacity, and up to 10-20 times more long-lasting. | High |
| Power Monitors | Handheld devices that provide real-time information on energy consumption and expenditure. Their use increases awareness on energy efficiency, and achieves behavioral changes for a more efficient consumption of energy. | High |
| Magnetic Induction Street Lighting | High-efficiency street lights that replace conventional ones and provide higher efficiency, better luminosity, longer lifetime, and lower costs | High |
| Premium Efficiency Motors | Efficient motors that replace conventional motors. Higher actual power for the same electrical motor load and rated power. | High |
| Efficient Window Air Conditioning Systems | A/C systems for window installation that are more efficient than conventional ones. Same or better performance, lower electrical load. | High |
| Variable Frequency Drives | Add-on device that adjusts motor speed to make motor output meet actual demand (no unnecessary extra output). | High |
| Efficient Split Air Conditioning Systems | A/C systems with indoor unit for air emission separate from outdoor condensing unit, more efficient than conventional systems. One system can cool multiple rooms. Same or better performance, lower electrical load. | High |
| T8 Fluorescent Lamps with Occupancy Sensor | Efficient fluorescent lights for offices that replace older fluorescent lights, achieving better lighting with lower energy consumption. Occupancy sensors turn lights on or off based on detecting people in a room, reducing 'on' time. | High |
| Efficient Chillers | Industrial cooling devices with efficient compressors incorporating VFD technology. They replace conventional chillers with traditional compressors operating at constant speed. | High |
| T5 High Output Fluorescent Lamps | Lighting fixtures for indoor applications, mostly in the industrial sector. They replace conventional metal halide bulbs. Brighter and higher quality light with lower energy consumption. | High |
| LCD Computer Monitors | Liquid Crystal Display monitors that replace conventional Cathode Ray Tube (CRT) monitors for computers. | Medium |
| Efficient Residential Refrigerators | Efficient fridges for homes that replace conventional ones. Lower power draw, and better insulation. | Low |
| Efficient Retail Refrigerators (Condensing Unit) | Condensing units with more efficient cooling performance for commercial refrigerators used in stores, supermarkets, and restaurants. Replacement is limited to the condensing unit to contain costs. | Low |
| LED Street Lighting | Light Emitting Diode street lights that replace conventional street lights, and also provide maintenance cost savings. Higher efficiency, but very high cost of installation. | None |
| Solar LED Street Lighting | LED street lights for new off-grid installations (no replacement of baseline technology), with solar PV collectors and a battery. Very high cost of installation. | None |

Despite the clear potential to save money, benefit the economy, and improve the environment that many of these technologies offer, their adoption in Barbados currently is limited. The key barriers to the uptake of viable energy efficiency technologies are limited access to capital, limited and uncompetitive equipment supply, incomplete information, and agency problems.

We make the following six recommendations to increase the uptake of viable energy efficiency technologies:

- Establish a consumer financing instrument (a subsidized hire purchase pilot scheme) in the Smart Fund for viable EE technologies on terms that make them attractive
- Establish instruments in the Smart Fund that will create a critical mass for key equipment on the supply side, and jump-start the market for them: (i) grants for CFLs, (ii) a 'cash for clunkers' program for efficient air conditioners, and (iii) low-interest retrofit loans for non-residential buildings (industrial and commercial businesses), starting with those audited under the SEF
- Develop information campaigns for all incentives described above for the Smart Fund, under an integrated approach that addresses both supply of and demand for energy efficient technologies
- Establish technical standards for key technologies, and use them to (i) ban the import and sale of substandard equipment—this can be done in a way that phases out incandescent light bulbs, (ii) establish eligibility for tax and customs incentives, and (iii) provide information that orients the purchase of equipment towards efficient technologies
- Implement retrofits for the Public Sector Energy Conservation Program under a performance contracting scheme
- Mandate energy efficiency in the building code for new construction.

The rest of this section describes current uptake of energy efficiency technologies in Barbados, and then shows which technologies are likely to be economic and commercially viable. It then analyses why uptake of these technologies is limited, and recommends options for increasing investment in energy efficient technologies in Barbados.

## 5.1 Current Uptake of Energy Efficiency

Table 5-2 provides estimates of the current uptake of EE technologies in the country, by sector.

## Table 5-2: Estimated Current Uptake of EE Technologies in Barbados

| EE Technology | Econ. Viable? | Uptake by Sector | | | Comment |
|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial & Public | |
| Compact Fluorescent Lamps (CFLs) | Yes | 5% | 5% | 5% | CFLs are the cheapest and most cost-effective energy efficiency technology. In spite of these benefits and the increasing availability of CFLs in stores, most residential customers—and many non-residential ones—still use incandescent bulbs. |
| Power Monitors | Yes | 0% | N/A | N/A | We saw no power monitors in use or on sale in Barbados. |
| Magnetic Induction Street Lighting | Yes | N/A | N/A | 0% | There are no magnetic street lights in Barbados. This technology is economically viable, as we discuss below. |
| Premium Efficiency Motors | Yes | N/A | N/A | 0% | All motors we observed during our field visits were standard efficiency motors. In some cases, motors had been rewound after failure—this results in even lower operating efficiency. At industrial sites, many motors have long run hours and are under maintained. Replacement of these motors will be more cost-effective than doing overdue maintenance. |
| Efficient Window Air Conditioning Systems | Yes | 5% | N/A | N/A | Almost no window A/C systems installed in low- and middle-income households (most of which don't have any A/C) are of an efficient type. Few efficient A/C systems are installed in higher income households—but these are the minority. |
| Variable Frequency Drives | Yes | N/A | N/A | 0% | We saw no VFDs in sites we visited. In particular, water pumping represents a large part of Barbados' energy use,[89] but no VFDs are used in water pumping. |
| Efficient Split Air Conditioning Systems | Yes | 5% | 5% | 5% | Split A/C systems are the most common type of A/C system in Barbados. Most that we observed are obsolete. There is significant scope in retrofitting them. The systems' configuration could also be improved at many sites by having one system serve several rooms, instead of using one system per room as now. |
| T8 Fluorescent Lamps with Occupancy Sensor | Yes | N/A | 10% | 10% | Many offices have T12 fluorescent lamps that can be retrofitted with T8 lamps. Customers who have already completed a retrofit with T8s use 32W lamps, which should be replaced with 25W ones—but these have apparently not been introduced into the market. We saw virtually no occupancy sensor controls. |
| Efficient Chillers | Yes | N/A | N/A | 5% | We saw no efficient chillers at premises we visited, but were told there are a few |

[89] According to BL&P's DSM study of 2000, almost 40 percent of the industrial sector's consumption.

| EE Technology | Econ. Viable? | Uptake by Sector | | | Comment |
|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial & Public | |
| | | | | | installed in Barbados. Central chiller plants are not common, and are typically only found in large buildings with central ventilation, or used in industrial processes. |
| T5 High Output Fluorescent Lamps | Yes | N/A | N/A | 0% | We saw no T5 fixtures in premises we visited. |
| LCD Computer Monitors | Yes | 30% | 30% | 30% | This is the only energy efficiency technology that has a significant uptake. Many offices and homes we visited have LCD monitors—older cathode ray tube (CRT) monitors, which consume about three times as much energy, are rapidly disappearing from premises and store shelves. |
| Efficient Residential Refrigerators | No | 10% | N/A | N/A | Inefficient refrigerators are a major component of residential load. New refrigerators are typically more efficient then the refrigerators they replace—but in spite of achieving commercial savings for customers, efficient refrigerators are not economically viable in Barbados, because they are designed to perform efficiently under different conditions (see Section 5.2.2). |
| Efficient Retail Refrigerators (Condensing Unit) | No | N/A | 0% | N/A | We saw no efficient retail refrigerators. Most units are obsolete and inefficient. |
| LED Street Lighting | No | N/A | N/A | 0% | There are currently no LED street lights in Barbados. As we show in the next section, this technology is too expensive—unless prices come down significantly, we expect that LED street lighting will have no uptake in Barbados. |
| Solar LED Street Lighting | No | N/A | N/A | 0% | There are no Solar LED street lights in Barbados—as we show in the next section, adding a solar panel and a battery makes LED street lights even more expensive and less cost-effective. Since these are off-grid installations, this technology is also not useful in Barbados, which has virtually complete electricity service coverage. |

Source: Stantec estimate based on site visits in September-October 2009.

Note: N/A indicates that the technology would have negligible applicability in the sector.

For each technology, the table first indicates whether or not the technology is viable—that is, whether the energy savings more than offset the upfront cost (see following section for these calculations). The table then shows the penetration of that technology in the household, commercial, industrial, and public sector establishments, as well as comments on the overall findings.

Uptake estimates are based on the field visits made in September and October 2009[90] to a small sample of residential, commercial, industrial, and public premises, and remote follow-up with stakeholders throughout our assignment. The latest comprehensive study on EE uptake and opportunities in Barbados is BL&P's Demand Side Management (DSM) Study[91] of 2000. More information on uptake levels will emerge from energy audits of a larger sample of facilities, planned under the SEF program. These audits should start in June 2010,[92] and will follow guidelines set by the Consultancy Team. Our assignment does not cover the tourism sector (in particular hotels), which is addressed under a separate assignment—the Caribbean Hotel Energy Efficiency Action Program (CHENACT)—described in Section 2. Overall, the data shows that, of all the energy efficiency technologies reviewed, only LCD computer screens have been widely adopted. There is little or no use of energy efficiency bulbs, air-conditioners or fridges in Barbadian households or offices. In industry, electric motors are mostly inefficient and under-maintained, and chillers are inefficient. Street lighting uses conventional lights.

## 5.2 Economic and Commercial Viability of Energy Efficiency Technologies

Figure 5-1 summarizes the viability of energy efficiency technologies in Barbados. To read the figure, note that the blue bars indicate the cost per kWh saved by each technology. The cost of saving a kWh is compared with the cost of generating that kWh, shown as a continuous line. Technologies that can save electricity for less than it costs to generate the electricity are considered 'economically viable'.

As the figure clearly shows, almost all the energy efficiency technologies reviewed are economically viable. In fact, the only technologies that are not economically viable are efficient refrigerators, and LED street lighting (with or without a solar panel). LCD computer screens are just viable at US$0.19, and as noted they are the only energy efficiency technology with a significant uptake in the country—in addition, they offer space saving and convenience benefits. Figure 5-1 also shows the tariffs customers face, shown as dotted lines. For customers, energy efficiency technologies are viable if they save the customer money—the customer's benchmark is not avoided generation cost, but the tariff the customer avoids paying. Any technology with a cost per kWh saved less than the tariff will save the customer money. We refer to these technologies as 'commercially viable'. The analysis shows that all the technologies except for LED street-lighting (with or without solar panels) are commercially viable.

The following sections set out the analysis and assumptions in detail, and also assess the cost of reducing $CO_2$ emissions using EE technologies.

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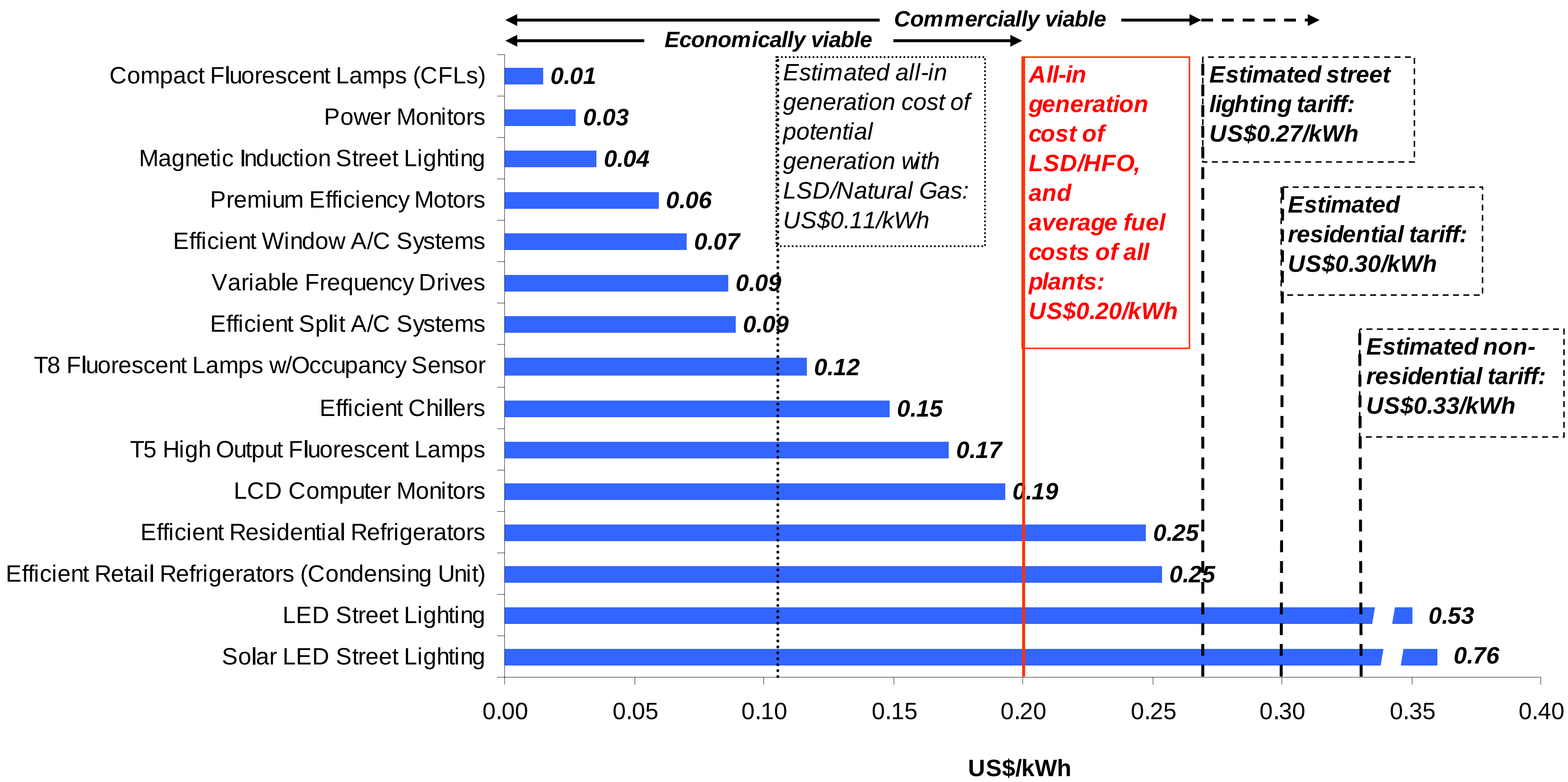
[90] The list of our September-October 2009 visits is reproduced in Appendix D of Preliminary Report I.

[91] B.C Hydro International and Marbek Resource Consultants Ltd., *DSM Strategy, Business Case, and Preliminary Plan*, 2000.

[92] Communication with the SEF Project Manager, 1 February 2010.

**Figure 5-1: Viability of Energy Efficiency Technologies in Barbados**




Source: Castalia and Stantec estimates.

Note: LSD = Low Speed Diesel plants, and HFO = Heavy Fuel Oil. LSD plants currently use HFO. All-in cost of LSD plants using natural gas estimated and contingent on availability of pipelined natural gas from the planned Eastern Caribbean Gas Pipeline. Generation costs and tariffs estimated based on an assumption of oil prices of US$100 per barrel, and natural gas prices of US$7 per MMBTU. All generation costs are grossed up for losses (6.6%).

The Figure also shows an estimate of generation costs using Low Speed Diesel (LSD) plants running on natural gas (US$0.11 per kWh). LSD plants would not be the cheapest natural gas generation option (Gas Turbines and Combined Cycle Gas Turbines would be US$0.09 and US$0.08, respectively), but they are the technology option we understand is being considered as the most realistic one by BL&P (see Section 2.3.3). The estimate refers to a possible, but not yet certain scenario: it is contingent on the actual realization of the planned Eastern Caribbean Gas Pipeline (ECGP), and on a price of natural gas of US$7 per MMBTU, according to assumptions discussed above. Under this scenario, less EE technologies would be economically viable—but many key ones would still be, including CFLs, power monitors, magnetic induction street lights, premium efficiency motors, all air conditioners, and variable frequency drives.

### 5.2.1 Defining the 'viability' of EE technologies

We evaluate the viability of EE technologies based on their **savings cost**. We define the 'savings cost' of a technology as the cost to save one kilowatt hour using that technology. The savings costs is calculated by turning the upfront cost of the technology installation into an annual capital cost, and then dividing the annual capital cost by the number of kilowatt hours the technology would save in a year. The annual capital cost figure is calculated the same way that an annual hire-purchase payment would be calculated, and assumes a cost of capital (interest rate) of 6 percent. (See Appendix L on the Smart Fund design for cost of capital in Barbados.)

A technology is **economically viable** if it reduces the overall cost of supplying electricity in Barbados. Specifically, an EE technology is defined, for the purposes of this study, as being economically viable when its savings cost is less than the cost of electricity generation at an oil price of US$100 per barrel. This means that, with oil at US$100 per barrel, it would cost less to implement the EE technology than to generate electricity.[93]

The relevant estimate of the cost of electricity generation depends on whether we adopt a short term or a medium term perspective:

- Short term, what matters is the fuel cost savings. The average fuel cost on BL&P's system—grossed up for 6.6 percent transmission and distribution losses, and including variable O&M costs—is US$0.20 per kWh. We consider system losses in assessing all energy efficiency technologies, because they are technologies for reducing electricity consumption—therefore, what matters is the cost to generate supply electricity to the customer premises. This includes the cost of system losses
- Medium term, lower demand will lower the need for investment in new capacity, as well as fuel costs. The main conventional technology BL&P will use in the future is likely to be low speed diesel units. Coincidentally, the all-in cost of low speed diesel units (grossed up for losses) is also US$0.20 per kWh. (The reason this number is the same as short term fuel costs is that these plants are more fuel efficient than the average plant on BL&P's system now. The greater fuel efficiency offsets the capacity cost that is factored into the medium-term generation cost benchmark).

[93] Based on the price of ten-year futures for light sweet crude oil (WTI). See http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude.html

The simple conclusion is that an energy efficiency technology should be considered economically viable if its cost per kilowatt hour saved is less than US$0.20 per kWh (not considering the possible, but not yet certain, future generation with pipeline natural gas).

A technology is '**commercially viable'** if a customer can save money by using it. To put it more precisely, for the purposes of this study, a technology is commercially viable when its savings cost is less than the electricity tariff at oil prices of US$100 per barrel—this means that, at that oil price level, it costs the customer less to implement the EE technology than to buy electricity. The relevant benchmark for the electricity tariff depends on the sector that the customer implementing an EE technology belongs to—residential, non-residential, or street lighting. We assume

- A residential tariff of US$0.30 per kWh
- A non-residential tariff of US$0.32 per kWh
- A street lighting tariff of US$0.27 per kWh.

Table 5-3 shows, for each technology: the savings cost, and whether the technology is economically viable. The table also shows:

- The breakeven oil price for economic viability—this is the oil price at which the technology in question would be just viable. For example, we see that premium efficiency motors in industry would save money even if oil prices fell to US$7.0 per barrel. On the other hand, efficient refrigeration technology for households, which is not viable with oil at US$100 per barrel, would become viable if oil rose above US$137.5 per barrel on a sustained basis
- The estimated potential uptake by sector—this estimated potential uptake is the one we refer to for the Sustainable Energy Matrix (see Section 3), and that can be reached under the SEF program over a 20-year period (see projected benefits of the SEF in Section 7). Our estimate is based on assumptions regarding the current uptake of the technologies we analyzed, and the additional uptake that each technology could have in applicable sectors (residential, commercial, industrial, and public) under a 'high energy efficiency scenario' as described in Section 7. We then turned the overall estimated uptake in annual incremental percentage reductions in consumption. Finally, we validated our assumptions by comparing them with historical annual percentage reductions in consumption. In Appendix H we explain in more detail how we estimated potential uptake of EE by sector, and in Appendix I we list the site visits we did to help understand current and potential uptake.

## Table 5-3: Efficiency Technologies—Savings Costs, Viability, Breakeven Oil Price, and Estimated Potential Penetration

| EE Technology | Savings cost (US$ per kWh) | Benchmark for economic viability | Economically viable with oil at US$100 per bbl | Breakeven oil price for economic viability (US$ per bbl) | Estimated potential uptake by sector (%)** |
|---|---|---|---|---|---|
| Compact Fluorescent Lamps (CFLs) | 0.01 | Short term: average fuel-only generation cost of all plant types (US$0.20/kWh) Long term: all-in generation cost of low speed diesel plants (US$0.20/kWh) | Yes | 0.0* | 70% (R, C, I, P) |
| Power Monitors | 0.03 | | Yes | 0.0* | 30% (R) |
| Magnetic Induction Street Lighting | 0.04 | | Yes | 0.0* | 100% (P) |
| Premium Efficiency Motors | 0.06 | | Yes | 7.0 | 50% (I, P) |
| Efficient Window A/C Systems | 0.07 | | Yes | 14.5 | 50% I |
| Variable Frequency Drives | 0.09 | | Yes | 23.5 | 50% (I, P) |
| Efficient Split A/C Systems | 0.09 | | Yes | 27.0 | 50% I, 70% (C, I, P) |
| T8 Fluorescent Lamps with Occupancy Sensor | 0.12 | | Yes | 48.5 | 70% (C, I, P) |
| Efficient Chillers | 0.15 | | Yes | 68.5 | 50% (I, P) |
| T5 High Output Fluorescent Lamps | 0.17 | | Yes | 84.0 | 50% (I, P) |
| LCD Computer Monitors | 0.19 | | Yes | 99.0 | 100% (R, C, I, P) |
| Efficient Residential Refrigerators | 0.25 | | No | 137.5 | 80% I |
| Efficient Retail Refrigerators (Condensing Unit) | 0.25 | | No | 141.5 | 70% I |
| LED Street Lighting | 0.53 | | No | 334.0 | 0% (P) |
| Solar LED Street Lighting | 0.76 | | No | 495.0 | 0% (P) |

*R=Residential, C=Commercial, I=Industrial, P=Public*

Source: Castalia and Stantec estimates.

Note: *At oil prices of US$0 per barrel, low speed diesel all-in generation cost is US$0.05 per kWh. **Refer to Appendix H for an explanation of our estimate.

The savings cost calculations in Table 5-3 are calculated from estimates of: typical installed capacity, life, capital cost, O&M costs, and yearly energy savings for each type of technology. These estimates are presented in Table 5-4. That table also provides an estimate of the savings that a customer would get for each unit of the technology installed.

**Table 5-4: Energy Efficiency Technologies—Key Data**

| EE Technology | Installed capacity (kW) | Lifetime (years) | Capital cost (US$) | O&M costs* (US$) | Yearly energy savings (kWh/yr) | Yearly financial savings** (US$/yr) | Savings over baseline (%) |
|---|---|---|---|---|---|---|---|
| Compact Fluorescent Lamps (CFLs) | 0.015 | 5 | 5 | 0 | 82.1 | 24.9 | 75% |
| Power Monitors | NA | 20 | 100 | 0 | 315.6 | 95.6 | 10% |
| Magnetic Induction Street Lighting | 0.030 | 20 | 450 | -35 | 120.5 | 32.2 | 48% |
| Premium Efficiency Motors | 9.846 | 20 | 1,500 | 0 | 2,191.2 | 703.7 | 5% |
| Efficient Window Air Conditioning Systems | 1.000 | 15 | 500 | 0 | 730.0 | 221.2 | 33% |
| Variable Frequency Drives | 7.178 | 10 | 7,000 | 60 | 11,687.2 | 3,753.4 | 27% |
| Efficient Split Air Conditioning Systems | 1.846 | 15 | 2,000 | 0 | 2,308.0 | 741.2 | 38% |
| T8 Fluorescent Lamps with Occupancy Sensor | 0.048 | 19 | 150 | 0 | 116.0 | 37.3 | 60% |
| Efficient Chillers | 14.064 | 20 | 40,000 | 0 | 23,439.8 | 7,527.7 | 40% |
| T5 High Output Fluorescent Lamps | 0.352 | 16 | 550 | 0 | 318.0 | 102.1 | 23% |
| LCD Computer Monitors | 0.040 | 15 | 300 | 0 | 160.0 | 51.4 | 67% |
| Efficient Residential Refrigerators | 0.105 | 12 | 1,000 | 0 | 481.8 | 146.0 | 34% |
| Efficient Retail Refrigerators (Condensing Unit) | 0.525 | 15 | 2,000 | 0 | 812.0 | 260.8 | 15% |
| LED Street Lighting | 0.035 | 20 | 1,000 | -35 | 98.6 | 26.4 | 39% |
| Solar LED Street Lighting | 0.000 | 20 | 2,500 | -26 | 251.9 | 67.4 | 100% |

Source: Castalia and Stantec estimates

Notes: *Operations and Maintenance (O&M) costs only considered when different from the O&M costs of the baseline—Magnetic Induction and LED Street Lights achieve cost savings, and only VFDs have additional O&M costs. **Financial savings calculated based on the tariff schedule entered into force on March 1 (see Section 2.5), and based on the assumptions described below in Section 5.2.3.

### 5.2.2 Assessing the economic and commercial viability of EE technologies

As shown in Figure 5-1, we find that—with oil at US$100 per barrel—the following technologies are ***economically and commercially viable***:

- CFLs (US$0.01 per kWh)
- Power Monitors (US$0.03 per kWh)
- Magnetic Induction Street Lighting (US$0.04 per kWh)
- Premium Efficiency Motors (US$0.06 per kWh)
- Efficient Window A/C Systems (US$0.07 per kWh)
- Variable Frequency Drives (US$0.09 per kWh)
- Efficient Split A/C Systems (US$0.09 per kWh)
- T8 Fluorescent Lamps with Occupancy Sensor (US$0.12 per kWh)
- Efficient Chillers (US$0.15 per kWh)
- T5 High Output Fluorescent Lamps (US$0.17 per kWh)
- LCD Computer Monitors (US$0.19 per kWh).

The following technologies are ***commercially viable, but not economically viable***:

- Efficient Residential Refrigerators (US$0.25 per kWh)
- Efficient Retail Refrigerators (Condensing Unit) (US$0.25 per kWh).

Only two technologies are ***not viable***—LED Street Lighting (US$0.53 per kWh) and Solar LED Street Lighting (US$0.76 per kWh)—both economically and commercially.

The breakeven oil prices shown in Table 5-3 suggest that even at lower oil prices—in particular, current oil prices of about US$74[94] as of 1 June 2010—the viability of standard EE technologies in Barbados remains high. Almost all technologies that are economically viable with oil prices of US$100 per barrel—except T5 High Output Fluorescent Lamps, and LCD Computer Monitors—are viable even at current oil prices.

Our key findings by main technology types show that:

- ***All lighting technologies for residential, commercial, and industrial customers are viable***. CFLs are the most cost-effective measure to save energy—they would be economically viable even if oil were free (with an oil price of US$0 per barrel, the all-in generation cost of low speed diesel plants is US$0.05 per kWh). Other more sophisticated lighting measures cost more, due to more complex installation, but are still effective compared to the cost of generating electricity—T8 lamps (with occupancy sensors, which increase their efficiency) have a breakeven oil price of US$48.5 per barrel. T5 lamps need a higher oil price to be economically viable (at least US$84 per barrel), but this is still lower than the US$100 per barrel benchmark

[94] West Texas Intermediate: US$73.97, *The Financial Times*, 1 June 2010.

- ***Magnetic Induction Lights are a viable option for Street Lighting, but LED (with or without solar panels) are not.***[95] Barbados should consider magnetic induction technology for street lighting. LED technology is still cost-prohibitive for municipal street lighting. With a breakeven oil price of US$334 per barrel, it is clear that considerable advances in the technology will be needed before LED street lighting should be seriously considered. Solar LED street lights are even less viable (a breakeven oil price of US$495 per barrel) and not really useful in Barbados—they are off-grid installations, but there are virtually no non-electrified areas in the country
- ***Power monitors are a strong awareness tool for saving electricity***. Power monitors show real-time electricity consumption and expenditure, and can induce long-lasting behavioral changes that save energy across all end uses of a customer. Estimated savings of 10 percent (based on existing studies referenced in Appendix H) are a reasonable estimate, and make these devices a very cost-effective measure (savings cost of US$0.03 per kWh). The SEF Pilot Program includes distribution of power monitors to households
- ***All mechanical technologies are viable***. As long as oil prices remain above US$68.5, Premium Efficiency Motors, Variable Frequency Drives, and Efficient Chillers can all deliver savings, particularly for industrial customers
- ***All Air Conditioning technologies are highly viable***. Efficient A/C units for residential use (mostly window systems) and commercial use (mostly split systems) are very cost effective. They start saving money with oil prices of US$14.5 and US$27.0 per barrel, respectively
- ***LCD monitors for computers are just viable***—but as mentioned they already have a high uptake in Barbados.
- ***Refrigeration technologies can save customers money, but they are not economically viable***. Efficient residential and retail refrigerators have a high savings cost (both about US$0.25 cents per kWh) and need oil prices of at least US$137.5 and US$141.5 per barrel, respectively, to be economically viable. However, they are commercially viable, given residential and non-residential tariffs.

The result for refrigerators is surprising—but can be explained by considering the type of efficient refrigerators imported in Barbados. We examined a small sample of refrigerators, and connected a power meter to them. Most refrigerators are North American models, and are designed for 60 hertz frequency, as opposed to the 50 hertz frequency that is available in Barbados. This results in reduced efficiency—the appliances will not meet design performance. Efficiency is further reduced in households without air conditioning. Imported North American refrigerators were never designed to operate efficiently at temperatures over 30°C—but premises in Barbados that are not air conditioned easily reach these temperatures.

[95] Solar Street Lights are a renewable energy measure, and have even higher costs.

### 5.2.3 Explaining the assumptions used to assess the viability of EE technologies

The viability of any EE technology is highly site-specific—it depends on how five key parameters of an EE technology compare to those of the particular baseline situation that it addresses:

1. Cost (capital, and operations and maintenance)
2. Lifetime
3. Time of energy use
4. Installed capacity
5. Energy consumption.

An accurate estimate of the viability of EE technologies can come from an energy audit of the specific facility where an EE project takes place. For our analysis, we made assumptions for the parameters of EE technologies and for those of typical baseline situations they address on the basis of current market data, our experience, and our field visits in Barbados in September-October 2009. Below we explain the assumptions we used to calculate savings costs, electricity generation benchmarks, and tariff benchmarks.

**Savings costs**

We calculated the savings cost of each EE technology on a Net Present Value (NPV) basis, using the following assumptions:

- *Capital costs, in US$*—we estimated capital costs based on our local team's knowledge of market conditions in Barbados, our site visits to equipment providers in Barbados, and our experience of the North American EE market
- *Operations and maintenance (O&M) costs, in US$*—we only considered O&M costs of an EE technology when different with respect to the baseline. Most EE technologies replace equivalent conventional equipment, and therefore do not require additional O&M
- *Lifetime, in years*—we estimated the lifetime of EE technologies based on our experience, and equipment sold on the North American market
- *Yearly energy savings, in kWh per year*—we assumed installed capacity, daily running time, and days of operation per year of each EE technology and the typical baseline situation it would replace or improve
- *Discount rate of 6 percent*—we use this discount rate because we understand that the loans from the IDB to the Government will be at a slightly lower rate (4-5 percent).

The formula we used to calculate each measure's savings cost is the following:

$$\text{Cost of each measure to achieve a 1kWh saving (US\$ per kWh saved)} = \text{Annualized capital cost per kWh (discounted at 6 percent over lifetime)} + \text{Annual O\&M costs per kWh}$$

The average savings costs of all EE technologies—except the one for LED Street Lights, which are not viable—is US$0.12 (BB$0.24). This is a weighted average based on the relative yearly savings of each technology, shown in Table 5-3. We use this average savings cost in Section 7 to calculate the overall cost of EE investments to achieve the Sustainable Energy Matrix.

**Electricity generation benchmarks**

We calculated the electricity generation benchmarks for economic viability using the following assumptions:

- *Oil price of US$100 per barrel*, based on the price of ten year oil futures[96]
- *Weighted average of fuel-only cost of generation for all plants of US$0.18 per kWh (US$0.20 per kWh when grossed up for 6.6 percent losses)*, based on fuel-only generation costs presented in Section 2.3.3, and on a typical relative time when the various plant types are on margin. We assumed 40 percent for low speed diesel plants (base load plants), 20 percent for gas turbine plants (peak plants), and 40 percent for steam plants (shoulder plants)
- *Low speed diesel all-in generation cost of US$0.19 per kWh (US$0.20 per kWh when grossed up for 6.6 percent losses)*, based on our analysis presented in Section 2.3.3.

**Tariff benchmarks**

We calculated the tariff benchmarks for commercial viability using the following assumptions:

- *Oil price of US$100 per barrel*
- *Fuel Clause Adjustment of US$0.18 per kWh*, consistent with our oil price assumption (see Section 2.5)
- *Residential tariff of US$0.30 per kWh*, based on the new Domestic Service tariff schedule—a base energy charge applied to an average consumption of 253kWh per month[97]
- *Non-residential tariff of US$0.32 per kWh*, based on the new Secondary Voltage Power tariff schedule—a base energy charge applied to an average consumption of 2,707kWh per month,[98] and a demand charge of US$0.05 per kWh[99]
- *Street Lighting tariff of US$0.27 per kWh*, based on BL&P's estimate of a US$0.05 per kWh tariff (not including the FCA) for street lights[100]
- *15 percent Value Added Tax* applied to base energy charges, demand charge, and FCA.

[96] Light Sweet Crude Oil (WTI), http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude.html.

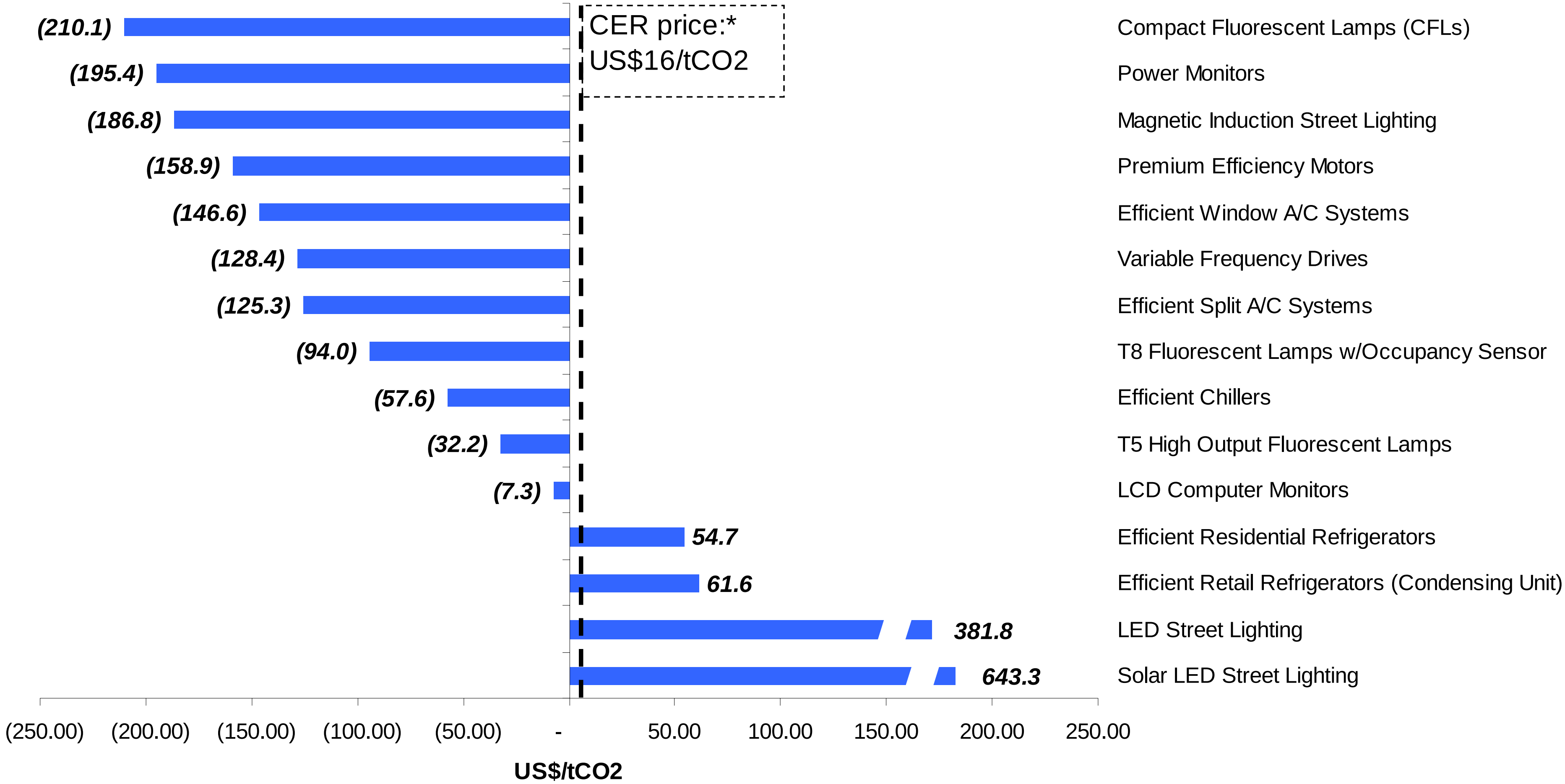
[97] 253kWh per month is the average residential consumption for 2008 according to BL&P 9 (see Section 2.4 for electricity tariffs). Domestic Service base energy charge of US$0.075 per kWh applied to the first 150kWh, and US$0.088 per kWh to the other (253-150) kWh.

[98] 2,707kWh per month is the average non-residential consumption for 2008 according to BL&P (see Section 2.4 for electricity tariffs).

[99] The demand charge is based on a consumer's monthly peak demand measured in kVA, and not on kWh as the base energy charge. To calculate the demand charge on a per-kWh basis, we assumed 1kVA=1kW, and applied the demand charge to the number of kWh consumed per month by a 1kW appliance running 30 days per month, and an average number of hours per day calculated as the weighted average of running hours per day of the EE technologies we analyzed. The formula used is: demand charge (US$/kWh) = demand charge (US$/kVA) / kWh consumed in a month by a 1kW device.

[100] Communication with BL&P management, 29 January 2010.

**Figure 5-2: $CO_2$ Abatement Cost Curve for EE Technologies**




Source: Castalia estimates

Note: * Price of a December 2010 CER (Certified Emission Reduction) as of 3 June 2010. Source: PointCarbon www.pointcarbon.com

### 5.2.4 Assessing the cost of additional $CO_2$ abatement

If the Government wishes to reduce $CO_2$ by supporting non-economically viable technologies, this will have a cost. Figure 5-2 shows that after the energy efficiency technologies that are economically viable—with a negative cost of abatement—are exhausted, the cost of reducing one ton of $CO_2$ begins at around US$55 for residential refrigerators, and reaches over US$643 for Solar LED Street Lights (off scale).

As for the abatement cost of renewable technologies in Section 4.2.4, the figure also shows the current price for Certified Emission Reductions (CERs). If the Government wants to reduce global $CO_2$ emissions, it should not do so by promoting any of the economically non-viable energy efficiency technologies—purchasing CERs from projects worldwide that can reduce emissions more cost-effectively would be a cheaper option.

We calculated the cost of $CO_2$ abatement in the same way described in Section 4.2.4 for renewable energy technologies—but we used an average emissions factor for all of BL&P's conventional plants.[101] We consider transmission and distribution losses to calculate the emissions avoided by all energy efficiency technologies.

## 5.3 Barriers to and Solutions for the Uptake of Energy Efficiency Technologies

Our analysis shows that use of energy efficiency technologies in Barbados falls far short of its economic potential. In this section, we analyze why this is the case (5.3.1), and propose solutions to overcome the barriers that block the uptake of viable EE technologies (5.3.2). We explain proposed solutions in detail in the following Section 6, together with all our recommendations for the SEF.

### 5.3.1 Barriers to EE technologies

Since all the economically viable energy efficiency technologies are also commercially viable, one would think that consumers would be rushing to adopt them. The technology would save money, so why don't people install it? Tariffs are not the reason—as discussed in section 2.5, if anything tariffs already create an excess of commercial incentive for energy efficiency, to which consumers are clearly not responding. Figure 4-1 shows that most savings costs are well below average tariffs—these technologies would already pay for themselves. Therefore, there must be other barriers stopping energy efficiency investments.

Table 5-5 summarizes the barriers to uptake. In short, the reasons are:

- **Limited access to capital**—many consumers would need to borrow to install the efficient technologies, and cannot find financiers willing to lend to them—or are charged prohibitive interest rates
- **Limited and uncompetitive equipment supply**—there is a chicken and egg problem; given limited uptake of many technologies in Barbados, they can be hard to purchase on the island, or are sold only at uncompetitive prices. Limited availability and high costs in turn retard uptake
- **Incomplete information**—where a technology is not widely used, people may be unaware of its benefits, again creating a chicken and egg problem

[101] Overall emission factor of 0.88 tons of $CO_2$ per MWh. Average weighted based on each plant type's share of generation in 2008.

- **Agency problems**—these take place when the person who should invest in the equipment is not the same person who uses it—this happens in the public sector, in the development of new construction, and in leased buildings

As Table 5-5 shows, barriers to energy efficiency investment apply equally to almost all types of viable EE technologies.

**Table 5-5: Barriers to Economically Viable Energy Efficiency Technologies**

| Economically viable EE technology | Lack of commercial viability | Tariff distortions | Limited access to capital | Limited and uncompetitive equipment supply | Incomplete information | Agency problems |
|---|---|---|---|---|---|---|
| Compact Fluorescent Lamps (CFLs) | – | – | B | B | B | B |
| Power Monitors | – | – | B | B | B | B |
| Premium Efficiency Motors | – | – | B | B | B | B |
| Efficient Window Air Conditioning Systems | – | – | B | B | B | B |
| Variable Frequency Drives | – | – | B | B | B | B |
| Efficient Split Air Conditioning Systems | – | – | B | B | B | B |
| T8 Fluorescent Lamps with Occupancy Sensor | – | – | B | B | B | B |
| Efficient Chillers | – | – | B | B | B | B |
| T5 High Output Fluorescent Lamps | – | – | B | B | B | B |

**Limited access to capital is a barrier when credit terms make EE technologies unattractive**

Based on our interviews of various types of financial entities in Barbados,[102] we find that many customers in Barbados—particularly low- and medium-income households, and small-medium businesses—can only access capital on terms that make EE measures unattractive to them. This fact may prevent a socially optimal outcome from being reached. However, it does not represent a market imperfection (such as incomplete information, or limited supply of equipment, discussed below)—in fact, it is evidence of the credit market working as expected to, and pricing in the higher default risk for these customers.

There is no shortage of capital in Barbados—all of our conversations with financial institutions in Barbados confirmed that liquidity is abundant, and that deposits have been growing at a rate of about 6 to 8 percent over the past few years. The problem is often not access to capital in itself either—most customers are likely to obtain lending, at least for small sums. The problem is that many borrowers do not have access to capital on terms that actually make EE technologies attractive.

Terms commonly vary depending on the type of client—larger companies and high-income households with an established credit history usually enjoy more favorable terms, while smaller businesses and low- or middle-income households normally face more unfavorable ones. Unfavorable terms include high interest rates, short lending tenors, and high collateral requirements—these are discussed in detail in Appendix L.

Limited access to capital can affect all EE technologies, large and small. It may seem less of a barrier for EE technologies that have a small unit cost, such as lighting technologies. However, even these technologies can be implemented by borrowing money when more units of the same technology (or various different technologies) are aggregated for comprehensive retrofit packages. And for a low income household living paycheck to paycheck, there may never be the surplus available to buy CFL bulbs instead of the cheaper incandescent bulbs.

**Limited and uncompetitive equipment supply is likely to be a temporary but important barrier**

In spite of being open and dynamic, Barbados remains a small and remote market. There are relatively few providers of energy efficient equipment—which is virtually all imported. Our visits to stores that sell electrical equipment[103] suggest that this situation creates two market barriers in Barbados: relatively high prices, and limited availability of EE equipment.

This is likely to be a temporary barrier as the market for EE equipment develops and becomes more competitive, but in the shorter term it affects all EE technologies. For example, CFLs in stores cost about 50 percent more than in the United States—in spite of often not being of the best quality. Power monitors are not available. Suppliers of electrical equipment we met have apparently not heard of 25 Watt T8 lamps—these are a better replacement for 40 Watt T12 lamps than the 32 Watt T8 lamps common in Barbados.

[102] The Caribbean Financial Services Corporation (CFSC); the Barbados National Bank (BNB); the Barbados Public Workers Credit Union Ltd (BPWCUL); Enterprise Growth Fund Limited (EGFL); City of Bridgetown Credit Union; First Caribbean International Bank.

[103] We visited the following stores between October 2009 and December 2009: Dacosta Mannings, Courts, and Simmons Electrical.

Mechanical measures (premium efficiency motors, variable frequency drives, and efficient chillers) are not readily available—this is sometimes the case in industrialized countries too, but in Barbados turnaround time is longer. A wide range of air conditioners is available in stores, but we saw very few efficient ones. This is the chicken and egg problem. Prices will fall and availability increase once demand is widespread, but in the meantime high prices and low availability retard demand.

**Incomplete information is likely a temporary barrier, but should not be underestimated**

Incomplete information is likely to be the least important of market imperfections, or at least a temporary one. We find that market agents—both sellers and buyers—are usually very responsive to commercially viable investments. The success of solar water heaters in Barbados is evidence that technologies that make financial sense take place: companies build, import, and sell them; consumers buy them; banks and credit unions finance them.

For new technologies though, there can be a chicken and egg problem with information too. People may not be aware of a technology until it is widespread, and lack of awareness can prevent a technology becoming widespread. The successful uptake of solar water heaters in Barbados required not just a good viable technology, but also an awareness campaign and tax breaks, as MFIE representatives pointed out during the Workshop in December 2009.[104]

For many of the technologies considered, consumers may also not be fully aware of the real costs and benefits of energy efficiency measures—for example, we sometimes came across a misperception that CFLs are not worth the money they cost because they burn out quickly, which may be due to low-quality lamps on the market creating a bad reputation for the technology. Providers of credit may be unaware of these projects' viability, and therefore be less inclined to finance them. Providers of specialized equipment and services may be not fully responsive to new opportunities—this is the case with the 25 Watt T8 lamps mentioned above. As we describe in Appendix J, Energy Services Companies (ESCOs) in the country and in the region are skilled, but are limited by scale and availability of financing.

Policy makers may also not be fully familiar with information about energy efficiency measures (our capability assessment will provide further insight on this matter). As a consequence, they may fail to provide information about them, or make rules enforcing them—the most critical example of this problem in Barbados is the lack of energy efficiency requirements in the building code, as we discuss below.

**Agency problems are mostly a barrier for the non-residential and public sectors**

Viable energy efficiency technologies may not happen when agents who should make the decision to invest in them are not the same people who would use them. 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 energy efficiency.

Agency problems working against energy efficiency are particularly important in the public sector, in the development of new construction, and in leased spaces:

- The Public Sector Energy Conservation Program (see Section 2.6.1) provides an example of agency problems in the public sector—responsibilities are unclear, staffing is insufficient, and there are no incentives or rules that ensure actual

[104] Workshop to present the results of Preliminary Report I, Bridgetown, 1 December 2009.

implementation of retrofits. A way out of this situation is to entrust implementation to specialized companies who will make money out of it

- 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—this may mean investing in cheaper but inefficient equipment and material. Building codes specifying energy efficiency requirements for material, equipment, and design can make it compulsory to comply—but Barbados' building code does not currently provide for any such rules, although an updated draft is being prepared by the Barbados National Standards Institute (see Box 5.1 below).
- In leased spaces, tenants have no interest in spending in new efficient equipment because the landlord will often not recognize their investment. Other times tenants will not buy efficient equipment because they will not lease the space long enough (or they do not know whether they will) for their investment to pay back for itself. Our meetings with the Barbados Small Business Association confirmed this is a major problem for their affiliates. Also, the Barbados Investment Development Corporation is the single largest owner of leased office space in Barbados, and its premises have significant potential for retrofit in lighting and air conditioning—hampered by agency problems, particularly because often tenants pay a flat electricity bill.[105]

**Box 5.1: Barbados' Building Code**

Barbados' building code does not address energy efficiency. Buildings in Barbados waste energy because simple measures like good insulation and proper control of air conditioning are often overlooked. Many buildings have natural ventilation through glass louvers in the wall that do not fully close. Often air conditioners fight incoming hot air to keep the space cool. Operating small fans for controlled ventilation can reduce the running time for air conditioners, but our field visits suggest this practice is not used.

The Barbados National Standards Institute (BNSI) has developed a draft building code that addresses some energy efficiency questions consistent with tropical countries—such as requiring an evaluation between natural and mechanical ventilation to identify the most efficient cooling option. The draft also requires that buildings be constructed more efficiently and with increased insulation. However, this draft building code does not provide a comprehensive energy performance standard for buildings—this would cover building envelope and wall construction requirements, as well as minimum equipment performance standards for lighting, heating, ventilation, and air conditioning.

Source: BNSI, *Building Code—Draft*, 2008

### 5.3.2 Proposed solutions to barriers

Table 5-6 shows our proposed solutions to remove the barriers to the uptake of viable EE technologies. We present these in detail in Section 6. Box 5.2 provides a brief overview of EE programs in other countries that have similar barriers to Barbados.

[105] Meetings at the Barbados Small Business Association and the Barbados Investment Development Corporation, December 2009 and January 2010.

**Table 5-6: Proposed Solutions to Barriers to EE**

| Barrier | Proposed solution |
|---|---|
| Lack of commercial viability | None—this is not a barrier. All economically viable EE technologies are also commercially viable, and pay for themselves. |
| Tariff distortions | None—this is not a barrier. If anything, the tariff structure provides excessive incentives for energy efficiency. A disaggregated tariff structure (mentioned in Section 4.3.2) will provide more correct price signals, but still make energy efficiency commercially viable. |
| Limited access to capital | Establish a consumer finance instrument (a subsidized hire purchase scheme) within the Smart Fund for viable energy efficiency technologies on terms that make them attractive. |
| Limited and uncompetitive supply of equipment | Establish financial instruments within the Smart Fund that will create a critical mass for key equipment on the supply side, and jump-start the market for them: (i) grants for promoting CFLs, (ii) a 'cash for clunkers' trade-in program for efficient air conditioners, and (iii) low-interest retrofit loans for residential and non-residential buildings, starting with those audited under the SEF. Establish technical standards for key technologies, and use them to establish eligibility for tax and customs incentives. |
| Incomplete information | Develop information campaigns for incentives described above (consumer financing, grants for CFLs, cash for clunkers for A/C, and low-interest retrofit loan), under an integrated approach that addresses both supply and demand within one program—as it was done for solar water heaters. Involve the private sector for marketing. Provide information that will orient purchase of equipment towards efficient technologies, also supported by the technical standards. Use standards to ban the import of substandard equipment, and consider phasing out incandescent lights. |
| Agency problems | Implement retrofits for the Public Sector Energy Conservation Program under a performance contracting scheme done by Energy Services Companies (ESCOs)—investments will be done by ESCOs who will profit from them. Mandate energy efficiency in the building code for new construction, also supported by the technical standards. |

**Box 5.2: EE Programs in Other Countries**

We present a brief overview of energy efficiency programs from three countries that have similar barriers to EE implementation as Barbados:

- Puerto Rico—incentives for energy efficiency audits
- Hawaii—removing information barriers
- New Zealand—improving upon previous policies

**Puerto Rico**

Puerto Rico's Building Energy Efficiency Retrofit Program gives rebates for the cost of energy efficiency audits and subsequent retrofits. If a commercial, non-profit, or governmental entity pays for an energy efficiency audit and then undertakes the audit's recommended upgrades, they may be eligible for a rebate of the price of the audit and material, equipment, and installation costs for the upgrade. Participating organizations must submit applications and documentation prior to making any expenditures, and must have their audit performed by a licensed professional engineer or registered architect.

**Hawaii**

The US state of Hawaii promotes energy efficiency through a complementary set of initiatives focusing on information and price barriers. The Hawaii BuiltGreen™ Program eases access to information by distributing EE guides, and addresses concerns about the quality of information by publishing voluntary EE building codes that have the implicit backing of the state. A variety of rebate programs are designed to increase uptake of favored energy efficiency products. Rebates available to residents include CFL bulb coupons, Energy Star appliance rebates, solar water heating rebates and high efficiency water heater rebates. For the commercial sector there are standard and custom rebates for qualified energy efficient technologies in existing and new buildings.

**New Zealand**

The New Zealand Energy Efficiency and Conservation Strategy (NZEECS) is a second-iteration policy focused on overcoming key barriers identified as weaknesses from the initial policy. The new strategy addresses lack of information, weak price signals, limited access to capital, and split incentives. These barriers are addressed in policy packages that are specifically tailored to five targets, three of which focus on energy efficiency:

- Homes—a mixture of interest-free loans for energy efficiency upgrades, grants for clean heating devices, energy efficiency grants for low-income families, and minimum energy performance standards for rental buildings
- Businesses—a mixture of capital grants to facilitate EE and RE investments, support for development of best-practice in key technologies, resources such as a one stop web access tool for EE information, and capacity building programs; and
- Public Sector—policies for the public sector include and surpass measures for businesses, including stricter targets for energy use reduction and extending EE planning to urban design (in coordination with local governments).

# 6 Proposed Policy and Regulatory Changes for the Sustainable Energy Framework

This section pulls together the recommendations for Renewable Energy and Energy Efficiency from the previous two sections, and expands them into a comprehensive program of policy and regulatory changes which together create a Sustainable Energy Framework (SEF) for Barbados. The main points recommended for the SEF are:

- Building the framework around five core policy principles, namely win-win approaches, cost-benefit analysis, use of international support, technology neutrality, and building on the existing strengths of Barbados' energy sector
- Changing the regulation of the power sector, in particular by requiring BL&P to demonstrate that its generation plan is least cost, and requiring BL&P to purchase power from renewable providers when doing so can reduce system costs without compromising power quality and reliability. BL&P should promulgate a Grid Code to ensure system stability, safety, and power quality under the new regime. Tariffs should also be made more cost-reflective, and a feed-in tariff could be established based on the experience of the BL&P Pilot Program. Statutory changes would be needed to enact parts of this recommendation (in particular, for licencing of new operators)
- Strengthen the capabilities of the Town and Country Development Planning Office with standardized environmental permitting and planning regulations for renewable energy
- Including energy efficiency requirements in a mandatory Building Code
- Establishing a Smart Fund that would include the following five financial instruments for promoting investments in economically-viable EE and RE technologies: (i) a pilot consumer finance facility for economically viable distributed renewable generation systems and energy efficiency technologies; (ii) a grant facility for CFL promotion; (iii) a trade-in program for efficient air conditioners; (iv) an energy efficiency retrofit and renewable energy finance facility; and (v) a discretionary facility
- Accelerating the implementation of the Public Sector Energy Conservation Program by moving rapidly to procure an energy services company ("ESCO")[106] to implement the improvements under a performance contracting scheme
- Leavings customs and tax provisions for renewable energy and energy efficiency largely unchanged, while better defining 'environmentally preferred products' for tax incentive purposes, banning the import of substandard CFLs, considering a phase-out of incandescent lights, and considering limiting the customs exemption on equipment for tourism to those that can be shown to be energy efficient
- Enacting an Energy Labeling program in a regional context

[106] An ESCO is a specialized business that (i) develops, finances, and implements energy efficiency projects on a turnkey basis; (ii) guarantees a contracted amount of savings to clients, assuming the risk for these savings' actual realization; and (iii) earns returns over time from the financial savings the projects create.

- Launching institutional strengthening for the Renewable Energy Unit of MFIE and the Government Electrical Engineering Department.

## 6.1 Core Policy Principles

The Government of Barbados may wish to base its sustainable policy framework on the following five core policy principles.

**Principle 1: Win-win approach—Top priority is to be given to measures that both increase sustainability and reduce the cost of energy to the economy**

The Sustainable Energy Scenario (see Section 7) based on the Sustainable Energy Matrix presented in Section 3 shows that by 2029 renewable energy could represent about 29 percent of energy generated, and consumption could be reduced by almost 20 percent through energy efficiency. Doing this would reduce $CO_2$ emissions by 4.6 million tons, and cut total electricity costs by US$283 million compared to a business as usual scenario. The government should focus its policies on promoting those measures that reduce costs while also reducing oil dependency and decreasing the potential impacts of global warming.

**Principle 2: Cost-benefit analysis—Where a measure could increase sustainability but would also increase costs to the economy, it will only be pursued if the sustainability benefits exceed the economic costs**

There are a number of additional technologies (not featured in the sustainable energy matrix) that could reduce oil imports and $CO_2$ emissions, but would, if deployed, *increase* the cost of energy to the country. These technologies range from efficient residential refrigerators (US$0.25 per kWh) and 10 kW wind systems (US$0.26 per kWh), to 1kW wind systems (US$0.41 per kWh) and LED street lighting (US$0.53 or US$0.76 per kWh, depending on whether grid-connected or stand-alone solar). Given the extensive range of sustainable energy options that reduce energy costs, and the fact that energy costs in Barbados are already very high by world standards, Government will not, as a general policy, pursue those sustainable energy options that increase the cost of energy to the country. Government will consider particular measures on a case-by-case basis, but will need to be convinced that the sustainability benefits to Barbados offset the additional costs imposed on the taxpayers and energy users of Barbados.

**Principle 3: International support—The Government will work to ensure that Barbados has full access to international support for sustainable energy measures, in the form of concessional finance, grants, and carbon credits**

Global mechanisms to address climate change include the Clean Development Mechanism, and carbon mitigation strategies supported by grants and concessional loans provided by entities such as the Global Environment Facility and the United Nations Environment Program. These measures can allow for further cost reductions for Barbados in pursuing sustainable energy measures. They may also increase the range of sustainable energy measures that make sense for Barbados, by reducing the cost of certain measures, and so ensuring that they can be implemented without increasing energy costs for citizens of Barbados. The Government believes that these global responses are appropriate for global problems, since they recognize that developing island nations such as Barbados are put at risk by a phenomenon that is largely caused by much bigger, richer, and less vulnerable countries. Therefore, the Government will work with international agencies to take full advantage of the global assistance available to Barbados.

**Principle 4: Technology neutrality—Policy will promote all measures that increase sustainability and reduce costs, rather than favoring particular technologies**

In developing policy measures, the Government will generally be neutral between technologies so far as possible. There is no need to 'pick winners'. Rather, the objective should be to create a framework in which market participants have the incentive and ability to develop renewable generation projects that benefit the country, regardless of technology. For example, rather than prohibiting specific technologies because they might be too expensive (for example, Ocean Thermal Energy Conversion—OTEC, or 1kW wind systems), Barbados should just put in place a framework that allows any economically viable technology to sell power to the grid below avoided cost—this framework could apply to any technology that, in time, becomes economically viable.

**Principle 5: Build on existing strengths—Elements of Barbados' country energy system that serve the country well will be supported and developed to promote sustainable energy, not undermined**

Barbados' energy sector is lower cost and more reliable than most of its Caribbean neighbors. Making the energy sector more sustainable should not put this achievement at risk. Rather, the policy changes should be designed to build on existing strengths. In particular, the Government will be mindful of the need to ensure that BL&P can continue to operate as a professional, financially viable electricity utility, and that regulatory decisions are made by the Fair Trading Commission (FTC), in accordance with its statutory mandates. Government policy initiatives will respect the independence and autonomy of both the utility and its regulator, the FTC.

## 6.2 Electricity Sector Regulation and Tariff Reforms

Based on the analysis above, this Section offers policy and regulatory recommendations to optimize renewable generation in Barbados. To allow these recommendations to be implemented, the Government should issue a policy direction to the Fair Trading Commission. It should also pass a law providing for licencing of third party generators, and giving the FTC the power to mandate BL&P to buy from such providers in certain, tightly-defined, circumstances.

After summarizing the proposed policy statement and legal reform, this Section recommends regulatory changes to promote utility-scale renewable generation, and then makes recommendations for optimizing distributed renewable generation. Technical regulations covering safety and interconnection of renewable generation systems through a Grid Code are also proposed.

### 6.2.1 Ministerial Policy Direction on regulation

Economic regulation of electricity providers is the preserve of the FTC. We recommend that the Government use its powers under the Fair Trading Commission Act to give the FTC a general policy directive encouraging it to implement the recommendations in this report, in accordance with the Government's sustainable energy policy.

The Fair Trading Commission Act provides at Section 17 that "the Minister may, after consultation with the Chairman, give the Commission directions of a general nature in respect of the policy to be followed by the Commission in exercising its functions in respect of utility regulation, consumer protection matters and fair competition matters, and the Commission shall comply with those directions."

Given the fact that sustainable energy policy is of national importance, and multi-faceted, requiring coordination between regulatory and other initiatives, we recommend that the Minister discuss the matter with the Chairman of the Commission (as required by the Act), and thereafter issue to the Commission a general direction as to policy with respect to renewable energy. Key elements of this policy statement should include that:

- It is the Government's policy that Barbados' electricity sector should develop in a way that promotes the use renewable energy and energy efficiency, while lowering the cost of power, to the greatest extent possible
- In line with this policy, the Government considers that it would be desirable if BL&P were required to demonstrate that it has considered a range of renewable energy and energy efficiency options in preparing its investment and operating plans, and to show that it has developed a plan likely to deliver electricity at the lowest cost
- Government also considers that, where parties other than BL&P are able to generate power from renewable or energy efficient sources at lower cost than BL&P is able to, and to do so reliably, BL&P should be encouraged to purchase power from these parties, and to pass on any resulting reduction in costs to its customers. This should include both utility scale renewable and cogeneration, as well as distributed generation
- Energy efficiency, and efficient distributed generation should be encouraged through a move toward a more disaggregated, cost-reflective tariff, together with appropriate social safety nets
- BL&P should remain responsible for the technical operation, safety, reliability and power quality of the grid, and to this end should be empowered to set reasonable technical and interconnection standards for third party generators and distributed generation, through promulgation of a grid code.

This policy statement would enable the FTC to make efficient renewable generation, utility scale and distributed, an explicit part of its regulatory approach, in a way that is consistent with other aspects of government policy.

### 6.2.2 Statutory regime for third party generation

The analysis in section 2.4 shows that the current statutory regime is deficient in two key respects:

- An Act of Parliament is required to allow any new commercial power suppliers[107]
- There is no clear mechanisms to require BL&P to buy power from third parties in cases where doing so could lower the total cost of electricity supply to customers, with no loss of power quality or reliability.

In light of these gaps in the current statutory arrangements in the sector, we recommend that the Government introduce a new law into Parliament that would provide the FTC with the following powers:

[107] It is important to note that we confirmed that this is also the interpretation of the Government, through direct discussions in Bridgetown and email communications with the Ministry of Energy and the drafters of the Electric Light and Power Act (ELPA). 11 March 2010, and 31 March 2010.

- The power to issue licences allowing firms to generate and sell power commercially, provided that they demonstrate the necessary technical and financial capacity, and comply with safety and technical requirements
- The power to require BL&P to buy power from other licenced generators, in cases where the FTC is satisfied that:
  - Such third party supply would lower the total cost of power to customers in Barbados, over the medium term
  - The quality or reliability of power supply on BL&P's systems is not reduced
  - No unreasonable financial risk is imposed on BL&P.

The law (or regulations issued under the law) should also make it clear that small scale distributed generation does not require a licence, but simply compliance with safety and technical standards. We understand this to be the current legal position, but it would be helpful if it could be explicitly stated by law or regulation.

### 6.2.3 Regulatory changes to promote utility scale renewable power generation

The analysis in this report has shown that greater use of renewable energy would increase sustainability and lower the cost of electricity service. The regulatory regime applying to BL&P is intended to ensure that customers pay no more than is reasonably necessary for electricity, while also allowing the utility to recover its reasonable costs (see section 2.4). To achieve this we recommend that the FTC develop a regulatory regime with three core elements:

- Requiring BL&P to show that its generation expansion plan is least cost
- Allowing BL&P to securely recover the costs of investments in renewable generation and fuel efficiency
- Requiring BL&P to purchase renewable and co-generated power from third party suppliers, where this is cheaper than providing power itself, and does not create risks to power quality or reliability.

**Require BL&P to show that its generation expansion plan is least cost**

The Fair Trading Commission (FTC) should require BL&P to demonstrate that its generation expansion plan is likely to result in the lowest cost of service, as a condition for allowing those costs to be passed on in tariffs. Specifically, BL&P should be required to:

- Use internationally recognized least-cost expansion planning optimization software[108] to generate its expansion plan

[108] The industry standard for many years for conducting utility power system studies has been either PSS/E (Siemens PTI product) or PSLF (GE Product). Other comparable packages (SKM Power Tools and ESA EasyPower) are unlikely to offer the same level of sophistication necessary for Barbados. Both software packages are very capable of handling the requirements of the Barbados system, considering its mix of potential generation types (PV, Wind, Diesel, Natural Gas), complexity, and the need to address fluctuating generation levels and overall system stability. These software are costly at about $50,000 each, but they includes power flow, fault, and dynamic simulation modules, and will model up to 150,000 buses. The PSS/E package also includes a function that takes into account fuel costs, incremental heat rates, and start-up priority rankings for all machines to be scheduled. PSLF: http://www.gepower.com/prod_serv/products/utility_software/en/ge_pslf/index.htm ; PSS/E: http://www.energy.siemens.com/hq/en/services/power-transmission-distribution/power-technologies-international/

- Include in the planning process plausible renewable options agreed with the FTC that can meet commercialization criteria
- Prepare the least cost expansion plan taking into account a range of future oil price scenarios.

BL&P should present its least cost expansion plan including renewable energy options to the FTC for approval *ex ante*, that is before BL&P makes investments. The FTC's approval should be given based on checking that BL&P's assumptions are reasonable (in particular regarding oil price assumptions), and its analysis is accurate and correct. The FTC should not be involved in approving specific investment decisions of BL&P—the role of the regulator should be one of control, and not one of management.

Approvals for least cost expansion planning should be *ex ante*, because is will be easier to prevent mistakes being made than to correct them later, and because BL&P will need assurance that it will be able to recover the costs of its investments before it makes those investments.

The least cost generation planning obligation would be created by the FTC establishing a Tariff Setting Principle confirming that, in any rate case, the tariff will be calculated using a rate base that includes all FTC-approved investments. The Tariff Setting Principle would establish the following process for BL&P to gain FTC approval of an investment:

- BL&P would produce a Least Cost Expansion Plan and submit it to the FTC for review and comment. This could be done as part of any rate case, or prior to committing to any major new investment or both
- The FTC would review the plan to:
  - examine the assumptions including the reliability criteria used, capital cost assumptions, fuel cost assumptions (including escalation rates), and forced outage and maintenance outage rates for the different plant types proposed
  - examine the proposed timing of plant retirements and the new plant installations
- The FTC would pose any questions of clarification or requests for further information to BL&P, which would be required to respond to the questions to the satisfaction of the FTC
- Assuming the FTC was satisfied with the proposals and clarifications, it would then indicate its approval of the least cost expansion plan
- Any investments made in accordance with the least cost expansion plan would be deemed to be approved by the FTC, and so automatically included in the rate base at the next rate case.

Box 6.1 describes the specifications for least cost planning, and two potential software packages that could work well for Barbados.

**Box 6.1: Specifications and Software for Least Cost Planning**

Effective capacity planning requires a good load forecast, combined with appropriate use of a capacity planning computer model that analyzes generating system expansion options to determine the least costly expansion path that will adequately meet the demand for electric power, subject to user-defined constraints. To measure the economic performance of alternate expansion plans, the model should use the present value of total system costs, including the capital cost of new generating units, fixed/variable operation and maintenance costs, fuel costs, and costs of unserved energy. The model should use probabilistic simulation to calculate the production costs and reliability parameters for numerous possible future system configurations, and use dynamic programming techniques to determine an economically optimal expansion path for the electric power system under consideration. System reliability should be evaluated on the basis of three indices: reserve margin, loss-of-load-probability, and unserved energy.

**Allow a 'Renewable and Fuel Efficiency Cost Recovery' alongside the fuel cost recovery mechanism**

When BL&P invests in a new renewable generation plant, it substitutes a capital cost for a fuel cost. Provided that the expected capital cost is lower than the expected fuel cost, this lowers total system costs and customers should benefit. However, BL&P may be concerned about its ability to recover the cost of its investment, particularly if fuel costs should fall in the future.

To overcome this risk, BL&P should have the option of getting FTC approval of a proposed renewable investment. The FTC should approve the investment if it is satisfied that the investment would be reasonably likely to lower the total cost of electricity generation. Once an investment was approved and operating, the fuel cost component of the tariff should be reduced by the amount of fuel saved, and in its place BL&P should be allowed to recover the cost of the renewable investment. This cost should be set at a fixed amount per year, sufficient to recover the capital cost of the plant (including a reasonable return on investment) as well as the operating and maintenance costs.

The same mechanism should be allowed for any capital investment that reduces the total cost of electricity by reducing the amount of fuel used. Such an incentive would make it more likely that BL&P would reduce total fuel consumption through available technical measures, such as converting GT05 and GT06 at Seawell to combined cycle operation. Technically it seems this could probably be achieved by adding a waste heat recovery boiler and a 20MW steam set that would operate free of additional fuel from the waste heat recovered from the two gas turbines. If this is indeed technically and economically viable, ensuring BL&P a return on such a fuel-efficient investment would seem to be the missing element to allow it to be implemented.

Separating the 'Renewable and Fuel Efficiency Cost Recovery' (RFECR) from the Fuel Clause Adjustment (FCA) is preferable to allowing BL&P to recover renewable energy costs through the FCA, because it is transparent—if oil prices decrease, BL&P would still have to recover its renewable energy investment costs, but it could not justify a higher FCA in front of customers.

We recommend that the FTC promulgate a Tariff Setting Principle that provides that, outside of any rate case, BL&P's tariff shall be adjusted by reducing the FCA and adding a

'Renewable and Fuel Efficiency Cost Recovery Adjustment', according to the following procedure:

- BL&P submits an application to the FTC showing:
  - A proposed renewable energy or energy efficiency investment
  - The likely annual charge required to recover the operating and capital costs of the investment over its life
  - The likely fuel savings, including a demonstration that cost savings from the investment are likely to exceed the cost of the investment, on an annual and lifetime basis
- The FTC shall check that the BL&P calculations are reasonable, and if they are shall approve the recovery of the annual costs of the investment through a 'Renewable and Fuel Efficiency Cost Recovery Adjustment', to be added to customers bills once the investment is operational, and provided it is saving the quantity of fuel that was predicted.

**Regime for Third Party Generation**

The above two measures should give BL&P the incentive and ability to identify and develop efficient renewable energy. On a small system like that in Barbados there are real advantages to having a single entity develop and operate the entire system. If BL&P can successfully identify and develop the main renewable generation opportunities on the island, it should be able to continue as the sole generator.

On the other hand, there is always the possibility that someone else may have a resource, technology, or insight that enables him or her to develop an opportunity that BL&P is not able or willing to develop. A good example would be the cogeneration facility the Barbados Cane Industry Restructuring Project is considering. Only the entity that requires process heat and power would know of, and be able to develop, a cogeneration opportunity. Another example would be the waste to energy generation facility the Sanitation Services Authority is considering. Typically the entity operating the landfill would be in the best position to develop such a project, since waste-to-energy generation is so closely intertwined with the operation of waste disposal.

For these reasons, we recommend that BL&P be required to purchase power from third parties who can supply at some margin below BL&P's avoided cost. The regime would have three main elements:

- Obligation to purchase power at a margin below avoided costs
- Licencing regime for third party generators
- Principles for Power Purchase Agreements with third party generators.

***Obligation to purchase power at a margin below avoided costs***. Where there is a credible offer to supply power to BL&P at a price below BL&P's own costs of generation, BL&P should have the obligation to purchase power from a third party provider. This would lower the total cost of service, and hence tariffs. Of course, BL&P should only do so if the third party supply provides adequate guarantees of reliability and complies with technical standards needed to preserve the power quality of the power supply.

A mechanism to promote third party supply when it lowers total costs can be introduced by the FTC under its existing powers to promulgate Tariff Setting Principles. The FTC has the power to stop BL&P from passing on to customers any costs that are above those the company necessarily and reasonably incurs in supplying power. It is consistent with the FTC's power and duties to require BL&P to show that it is supplying power at least cost. So under its tariff setting powers, the FTC can mandate a process to 'market test' BL&P's generation costs. If it turns out that BL&P's total cost of supply would be lower if it bought power from a third party, tariffs should be set at a level that would reflect the cost of supply using purchased power, rather than its own generation.

As an example, if an independent wind developer offered to supply power to BL&P at US$0.10 per kWh, and BL&P saved US$0.15 per kWh in fuel costs for every kilowatt hour of wind power supplied, then BL&P's avoided costs would be US$0.15 per kWh. In this case, BL&P should be willing to pay US$0.10 per kWh for the wind-power, since the result will be a total cost savings of US$0.05 per kWh. This cost saving should be passed on to customers.

We expect that BL&P would be willing to fairly evaluate offers from third party providers, and to contract with them in the event that the result is a reduction in the total costs of generation, while preserving reliability and power quality. The FTC should check that third party supply options are included in the least cost expansion plan recommended above. The FTC should also be willing to apply the proposed 'Renewable and Fuel Efficiency Cost Recovery Adjustment' when BL&P chooses to buy renewable or fuel-efficient power from a third party generator.

In addition to these voluntary mechanisms, the FTC should operate a 'market challenge' process, with an obligation on BL&P to purchase from third party providers where this lowers total costs without threatening the quality and reliability of supply.

Under this challenge process, third party generators who claim that BL&P is unwilling to purchase power from even though doing to would reduce total costs of supply, would have the ability to have this claim assessed independently by the FTC. Key elements of such a market challenge process would be the following:

- BL&P to establish 'avoided cost' benchmarks—BL&P should publish estimates of its avoided costs from various types of power purchase. In essence these would be:
  - Avoided fuel cost for non-firm supply—for example, for wind power, or solar power, the avoided costs will be fuel and other variable operating costs for the utility's marginal generators
  - Avoided capacity investment costs for firm power—this should be the actual savings in future costs of investment in capacity, derived from BL&P's least cost expansion plan. Calculating avoided capacity costs this way will remove the problem of BL&P having stranded generating assets as a result of third party supply. It means that a third party generator that simply duplicates existing BL&P capacity would not get paid for the cost of duplicated capacity—it would only get paid for capacity investments that actually save BL&P from having to make new capacity investments of its own

- FTC check—FTC should review BL&P's avoided cost estimates for reasonableness, and publish a threshold below avoided cost—for example, 10 percent—at which it would expect BL&P to purchase power from qualified independent generators
- Third party challenge procedure—any third party that wished to sell power to BL&P at below the avoided cost threshold, and that was unable to negotiate an agreement with BL&P, should file a 'market challenge' application with the FTC. This challenge should contain information stipulated by the FTC, including:
  - The offered price of power
  - Whether the capacity offered was firm or not
  - A demonstration that the offered price is below BL&P's avoided costs minus the threshold set by FTC
  - Willingness of the challenger to cover all the costs of its project, including the costs of connection to the grid
  - Demonstration that the offered price is reasonable, taking into account the costs of the project and the need for the challenger to earn a return on capital employed commensurate with the risk of the venture
  - Demonstration that the challenger would comply with the licencing requirements recommended below
  - Affirmation of the challenger's willingness to a sign a PPA with BL&P consistent with the PPA principles set recommended below
  - Affirmation of the challenger's willingness to comply with a system operations and grid code developed by BL&P and approved by the FTC, (discussed below)
- Review of the application—FTC would review the challenge application. In doing so, it would seek comments from BL&P, and may also seek comments from the public. If FTC determined that:
  - The price offered was below the avoided cost threshold
  - The price offered was reasonably cost-based
  - The challenger had the ability to comply with the various licencing, PPA and other requirements

  then the FTC would indicate to the utility that it would be in the public interest for the utility to purchase power from the third party generator. If the utility did not agree to purchase power from the challenger, the FTC would nevertheless set tariffs in the future in line with the cost of service that would be expected if the utility were purchasing from the third party.
- Following approval of the recommended law on third party power supply, the FTC would be able to mandate directly that BL&P purchase power from third party generators, where the criteria in the law were met.

***Licencing regime for third party generators***. As described in section 2.4, third party commercial power supply to the public is currently not possible without an Act of Parliament. We recommend that a new law be passed giving the FTC the power to issue licences to qualified third party generators.

An applicant for a licence under the new law should be required to satisfy the FTC as to:

- The location and type of facility that it intends to use for power generation
- Its technical capacity to operate such a facility reliably and safely
- Its financial capacity to build and maintain the facility.

***Principles for Power Purchase Agreements with third party generators***. We recommend that the FTC establish principles for Power Purchase Agreements (PPAs) between BL&P and third party generators. Any third party generator should be required to sign a PPA with BL&P. The PPA should govern the conditions and terms under which the third party generator will build, own, and operate the project, and will sell the capacity and energy from the project to BL&P.

Generally, this PPA will need to be signed before the third party generator closes financing for its project—meaning the PPA should be signed before the generation unit is built (if this is not done, the third party generator will probably not be able to raise the finance to build the project).

The terms and conditions of the PPA should comply with the following principles:

- The term of the PPA should be for the estimated useful life of the equipment being used to generate the power, starting from the completion of the project, but the PPA may also provide that it may be extended for an additional period
- Payments should be structured as follows:
  - A specified payment per kWh supplied to BL&P
  - If the project is to supply firm capacity as well as energy, the PPA should provide for BL&P to pay the third party generator a monthly fixed charge for the available capacity. The PPA should provide for availability of the capacity to be tested at regular intervals.
  - Other charges—such as a charge per unit start—may be included if they match the cost structure of the project
- Payments should be subject to indexation and adjustment in line with specified provisions. These provisions should be project specific, but may include the following:
  - Capital costs could be adjusted for inflation beginning on the date on which the PPA is signed, based on the U.S. Consumer Price Index and from an agreed date based on the indices in the Engineering Procurement and Construction Contract (EPC Contract)
  - The portions of the capacity and energy payments that correspond to debt service on foreign currency loans, return on the investment of US Dollar

investors, and foreign currency expenses may be adjusted for foreign exchange fluctuations

  - Pass through of increased taxes, increased compliance costs due to changes in regulation, and other factors outside the generator's control, may be allowed

- The generator should be required to comply with BL&P's grid code and other technical standards
- The PPA should provide for the generator to only schedule maintenance outages with the approval of BL&P, and not to schedule maintenance outages during peak months or for more than an agreed percentage of the available hours without suffering liquidated damages
- The PPA should provide for "step-in rights" that would ensure that, if the third party generator ceases to operate the project for an agreed period of time without the consent of BL&P for any reason (other than *force majeure*, a forced outage, approved maintenance, or BL&P's actions), BL&P would have the right to take over the operation of the project until the third party generator demonstrates that it can resume normal operations of the project
- The PPA should provide for liquidated damages to be assessed against the generator for the following reasons:
  - Delays in financial closing
  - Delays in completion of the project
  - Shortfalls in capacity at completion of the project
  - Subsequent shortfalls in capacity of the project
  - Failure to comply with the grid code
  - Failure to deliver energy in accordance with BL&P's dispatch instructions
- The third party generator should be required to post security deposits to ensure the payment of these liquidated damages and other damages
- The third party generator or its EPC contractor should be required to obtain specified insurances throughout the term of the PPA and to apply the proceeds of such insurance to the repair of the project
- BL&P should have the right to review key project documents, and to approve them or submit disagreements to the FTC or another dispute resolution mechanism. Key project documents would include the following:
  - All project agreements and financing documents for the project
  - The third party generator's plans for construction, operation and maintenance
  - The appointment of the third party generator's principal contractors, including its EPC and O&M contractors
- BL&P should have the right of first refusal over transfers of interest in the project (other than for financing purposes) and over transfers by upstream owners of interests in the third party generator

- The PPA should provide that it can be terminated for default events which should include at least the following:
  - A *force majeure* event that persists for more than a specified period of time
  - Expiration or termination of any concession or other implementation agreement with Government

  BL&P should also have an option to purchase the project at a price equal to the depreciated book value of the project minus any damages owed to BL&P if BL&P terminates the PPA because of the generator's default
- Disputes arising under the PPA should be resolved by way of a three-level procedure comprising (i) mutual discussion of the parties, (ii) referral to an expert, and (iii) arbitration pursuant to the laws applicable to arbitration in Barbados.

### 6.2.4 Policies for distributed renewable power generation

Recent reductions in the cost of small scale solar and wind generation technologies mean that customers in Barbados will start to find it attractive to install these technologies on their premises. The savings on their power bills will, under current tariffs, provide a reasonable return on their investment. Other small scale distributed generation opportunities may become financially viable in time.

When customers invest in distributed generation, their consumption of the power BL&P generates with fossil fuels will decrease. At the same time, because the distributed renewable power is intermittent, and often will not fully meet customer's demands, those customers will continue to demand that BL&P maintain their connection to the power grid, and will expect BL&P to supply them with power when generation from the customer's own unit is not enough. Customers will also at times generate power in excess of their own needs. This power can be made available to the grid, and customers will expect to be paid for it.

It will be in Barbados' interest to develop a regulatory and tariff structure that facilities efficient investment in distributed renewable generation. At the same time, it should not give incentives for inefficient investments that will end up increasing the total cost of electricity supply in the country. To achieve these twin objectives, we recommend that BL&P develop, and FTC review and approve:

- A disaggregated cost reflective tariff
- Feed-in tariffs and metering rules for distributed generation.

It would be helpful if the Ministerial Policy Statement recommended in section 6.2.1 also covered these points.

**Create a disaggregated, cost-reflective tariff**

The current tariff may discourage some economically beneficial distributed generation, as it does not allow for sale of power back to the grid. At the same time, it may encourage some economically inefficient generation, since, in many cases, customers installing distributed generation can reduce their bill by more than the reduction in BL&P's costs.

We recommend a tariff structure that will allow for the disaggregation of the tariff into several components. The best way forward would be to revise the tariff structure by:

- Disaggregating the current tariff into separate, cost reflective charges for:

  - Supply of energy
  - Connection to the distribution system
  - Provision of generating capacity in order to give customers the ability to rely on BL&P for back-up and stand-by power by paying only the capacity and connection charges
- Reduce cross-subsidies between customer classes
- Have tariffs that vary by time of day in line with cost variations over the day, so far as this is practical given the additional metering and billing costs involved.

The first step in doing this will be to calculate separately the full costs of generation, distribution, and the provision of back-up and stand-by services. These cost calculation should include capital as well as operating costs, and be disaggregated by customer class and time of day. After these costs are known, a tariff structure needs to be developed that ensures that customers' financial incentives are aligned with underlying economic costs. Since such a tariff structure is likely to lead to higher bills for residential users and low-volume users, some social safety net may need to be developed.

BL&P advises that it already makes calculations that will be useful in determining a disaggregated tariff structure. However, our review of the information provided shows that while it shows expenses for generation, and those associated with the various aspects of service delivery at the transmission, distribution, metering and customer service etc., for the various categories of consumers, it does not provide the capital costs associated with these aspects of their operations. Thus, further work will have to be done to identify the separate costs associated with service delivery at the transmission, distribution and service connection levels for the various categories.

**Create a feed-in tariff for small distributed generation, and establish metering rules**

The FTC should also require BL&P to purchase power from small distributed generation units. The price BL&P is required to pay should be no more than its avoided cost. Generally this will be the avoided fuel cost.

To implement this policy it would be necessary to meter separately the power that the customer buys from BL&P, and the power BL&P buys from the customer (since they are charged at different prices). This would require an investment in metering, and new rules for the types of meters to be used, who is to pay for them, and how they are to be read. The FTC should ask BL&P to develop a suggested approach, and the FTC should review this approach to ensure it is reasonable and in line with the principles in this report.

Some countries use a 'net-metering' approach to avoid the need for investment in additional meters. Under this approach, the electricity supplied back into the grid by the customer simply runs the meter backward, effectively subtracting kilowatt hours from the customer's recorded consumption. This approach is economically questionable, as it is equivalent to setting a feed-in tariff at the retail rate. The result is that the utility pays considerably more than avoided cost for power, and so the total cost of the electricity supply goes up. If the utility is to remain financially viable, this cost sooner or later needs to be passed on to customers. The ultimate effect of net metering, then, is that those customers who do not have distributed generation end up subsidizing those who do. We would not recommend net-metering as a long-term approach because this tends to increase the total cost of electricity supply by promoting inefficient distributed generation. Therefore, BL&P and the FTC will also need to establish metering rules that reduce cost of electricity—BL&P's Pilot Program proposes bi-directional metering, which is a good step in this direction.

In its application to the FTC for a review of electricity rates, BL&P proposed a 'Rider for Renewable Energy' actually calculated at avoided cost—1.8 times the FCA or BB$31.5 cents, whichever greater. The 'Rider for Renewable Energy' would apply to a Pilot Program including a maximum of 200 systems (or 1.6MW) under an interconnection agreement of up to three years (see Section 4.2.3).

In making these estimates, BL&P have assumed that the PV solar output will peak between 11:00am and 1:00pm each day, and that there will be no output from this source at night. In the case of wind sources, they have assumed them to be constant. They have then superimposed this pattern on the daily load curve, averaged over a month, to see what conventional generation this renewable generation production would displace, starting from the most expensive (least efficient) production.

Using the above assumptions and methodology, BL&P have calculated that the average cost of the generation that could be displaced by the specified amount of renewables amounts to about BB$0.347. At the time of carrying out the analysis, the average fuel only cost of generation was BB$0.191, which is the amount that would be passed through to the tariff as the fuel clause adjustment (FCA). The ratio between average cost of conventional generation displaced by renewables, and average cost per kWh, both on a fuel-only basis, is therefore about 1.8.

The proposals made by BL&P in the Rider for Renewable Energy therefore appear to be reasonable, and following careful monitoring and validation of the Pilot Program under the supervision of the FTC, and the development of the technical rules for interconnection, the Pilot Program should be capable of replication on a wider scale.

Some of the aspects that the FTC and BL&P are likely to consider for a replication of the Pilot Program, or a permanent Program for distributed generation, include the following:

- *The decommissioning of steam plants*—steam turbines are the most expensive type of generation in Barbados (both in terms of fuel and capital costs), and should be replaced by other generation technologies (low speed diesel generators, gas turbines, or cheaper renewable technologies). The calculation of the 'Rider' should be based on the least-cost mix of conventional generators
- *A different and more diverse mix of renewable technologies*—the 'Rider' is tailored to the mix of PV and wind technologies expected for the Pilot Program. BL&P's methodology is such that it can be adapted to a different mix of these technologies, and to the introduction of other or newer technologies
- *The adequacy of the interconnection agreement and grid interconnection requirements for an increased capacity, a longer term, and a more streamlined procedure*—the interconnection agreement[109] and grid interconnection requirements[110] proposed by BL&P for the Pilot Program seem appropriate (see section below). Technical and procedural

[109] BL&P, *Renewable Energy Interconnection Agreement*, 28 May 2009

[110] BL&P, *Requirements for Grid Interconnection of Renewable Generation Systems*, 18 August 2009.

requirements may need to be modified for systems beyond the initial ones—Section 2.11 of the grid interconnection requirements indicate that the capacity of all renewable generation systems permitted to be interconnected to the BL&P grid is limited to 1 percent of total system demand (this is equal to the 1.6MW for the Pilot Program). In addition, interconnection is available on a first-come, first-served basis up to a maximum of 200 eligible systems—upon reaching this limit, BL&P will not allow systems to be connected, even if capacity is below 1.6MW. This limit is appropriate for a pilot program, but a plan for the maximum intermittent renewable fraction should be developed for the longer term (see section below for our recommendations).

### 6.2.5 BL&P to establish a Grid Code

As other generators connect to the system, BL&P will need to retain control of the grid to ensure safety, reliability, and power quality. To this end, BL&P should develop a Grid Code—that is, a set of technical and operating standard to apply to all generators, both utility scale and distributed, who connect to the grid. This Grid Code should be subject to approval by the FTC to ensure that it does not impose restrictions on third party generators beyond those that are necessary to ensure safety, reliability, and power quality across the grid.

The Grid Code may be largely developed from existing policies and procedures of BL&P, and from the technical rules proposed in BL&P's proposed Pilot Program for distributed renewable generation. Below we set out:

- General matters the Grid Code should cover
- Provisions for safe and reliable connection of small scale distributed generators to the grid
- Provisions for maintaining grid stability as the share of non-firm renewable generation on the grid increases
- Provisions for amendments to the Grid Code overtime
- Reserve Powers to be retained by BL&P as System Operator.

***General matters the Grid Code should cover***. Specifically, the Grid Code should contain provisions mandating:

- Engineering standards relating to voltage regulation and Volt-Amp-Reactive (VAR) control[111] to avoid voltage fluctuations and reduce loss of generation
- Engineering standards relating to grounding regulations
- Engineering standards relating to transformers
- System operation policy and procedures relating to operational standards of security of supply
- Instructions, procedures and standards relating to revenue metering
- Protective relaying philosophy and practices.

[111] See for example http://www.gepower.com/businesses/ge_wind_energy/en/technology/var.htm

***Safe and reliable connection of small scale distributed generators to the grid***. As outlined in section 4.2.3, BL&P's Pilot Program for distributed generation includes a set of technical specifications. Based on the review of relevant BL&P documents (Requirements for Grid Interconnection of Renewable Generation Systems, Renewable Energy Interconnection Agreement, and the Application for a Review of Electricity Rates), we think BL&P's technical approach to interconnection of distributed renewable generation to the grid are sound, and would provide a good basis for inclusion in a future Grid Code.

In particular, the following provisions of the Requirements for Grid Interconnection of Renewable Generation Systems are appropriate:

- The metering and disconnect configurations (indicated in Section 2.6) are two common arrangements that are readily achievable, and present no cost or installation concerns
- Frequency and voltage variations of the BL&P distribution system (as indicated in Sections 3.1 and 3.2) are 0.4 percent and 6 percent, respectively. These variations do not pose a problem for commercially available inverters
- Harmonic distortion limitations, set at below 5 percent according to the Institute of Electrical and Electronics Engineers (IEEE) Standard 519 (as indicated in Section 3.4) are achievable from commercially available inverters
- Fault and line clearing requirements (as outlined in Section 3.6) are achievable from commercially available inverters. Commercially available inverters are typically UL 1741 compliant, and hence meet the requirements
- Overcurrent, undervoltage, and overvoltage protection (as outlined in Sections 4.5 and 4.6) are integral with commercially available inverters.

In summary, the technical requirements outlined in the relevant BL&P documents are appropriate. The requirements do not impose any undue technical, schedule, or cost implications.

It is the capacity limitations and procedural requirements of the documents which pose more of a concern. These following requirements should be carefully reviewed and, if justified, amended, as the pilot program is scaled up into a program of general applicability:

- *Insurance requirements*—Section 2.8 of the Requirements for Grid Interconnection mandates insurance coverage of BB$100,000 for systems with capacities less than 5 kW, and of BB$500,000 for systems with capacities up to 50kW. These levels of insurance may be unattainable for most customers. These limits reduce the ability for customers to install systems on facilities that would not normally require these levels of insurance. For example, although a warehouse structure might require only a BB$25,000 insurance policy, it might be ideal for a 50kW PV installation. However, the incremental insurance cost may make the project not commercially viable
- *Capacity limited to 50 percent of main service breaker*—Section 2.1 of the Requirements for Grid Interconnection limits the capacity of each Renewable Generation System to 50% of the main service breaker. This may complicate the interconnection approval. It will be worth assessing whether this restriction could be relaxed in future

- *Period for approval*—As indicated in Section 2.3 of the Renewable Energy Interconnection Agreement, the approval process for an interconnection with BL&P can take as long as 11 weeks. It will be worth assessing whether the process could be streamlined, and the period for obtaining approval reduced.

***Provide for grid stability***. As intermittent renewables are added to the grid, it becomes harder for the grid operator (BL&P) to maintain system stability. When the wind drops, for example, all the wind generators stop generating. If another generator is not ramped up immediately, frequency and voltage on the system will fall. If this fall is prolonged, load will need to be shed by dropping feeders, or else the grid will start to collapse as generating units are forced to disconnect from the grid one after another. For this reason, the Grid Code will need to contain mechanisms to provide for grid stability.

The proportion of intermittent generation that a grid can safely handle is proportional to the response time of the stand-by and load-following generating units. Diesel units have very rapid response times. Since the current and projected generation mix for Barbados incorporates a substantial portion of diesel generators, the expected response time is rapid. The rapid response time of the Barbadian grid mix suggests a lower susceptibility to grid instability related to large fractions of intermittent RE sources.

The FTC should work with BL&P to develop a framework to allow BL&P, as the system operator, to be able to keep the grid stable. This would involve use of technological measures if they are cost-benefit justified. The costs and characteristics of various technical measures are described in Appendix G. Use of these measures should be considered during the Least Cost Expansion Planning process recommended in section 6.2.

The Grid Code should also include Technical Measures, such as limits on the percent of capacity on the grid which can be intermittent, requirements that owners of additional intermittent capacity bear the additional investments necessary to ensure system stability, and technical standards for intermittent generators connected to the grid.

Box 6.2 contains an example of technical regulations for wind.

**Box 6.2: Technical Regulations for Wind**

Well defined standards for utility scale wind implementations have been developed in other countries. These standards may need to be modified for the unique nature of the Barbados grid. The following specific interconnection regulations (included in Federal Energy Regulatory Commission (FERC) documents) are necessary for grid stability and reliability within the North America grid:

- Low Voltage Ride-Through (LVRT) Capability—The need for the generation to ride through a zero volt, 9 hertz disturbance and still not drop off line
- Power Factor Design Criteria (Reactive Power)—A wind generating plant shall maintain a power factor within the range of 0.95 leading to 0.95 lagging, measured at the Point of Interconnection
- Supervisory Control and Data Acquisition (SCADA) Capability—The wind plant shall provide SCADA capability to transmit data and receive instructions from the Transmission Provider to protect system reliability.

***Procedures for amendment of the Grid Code***. BL&P should also include in the Grid Code a mechanism by which it can be amended. We recommend establishing a Review Panel, which should be a standing body charged with keeping the Technical Rules and their working under review. We propose that the Review Panel should be composed of at least the following five persons:

- One person representing BL&P's System Control department
- One person representing BL&P's Distribution System department
- One person representing BL&P's Generation department
- One person representing IPPs and co-generators
- One person representing consumers.

This panel could be empowered to amend the Grid Code, subject to review by the FTC.

***BL&P System Operator Reserve Powers***. While the Grid Code should contain the procedures for the safe and efficient capture of supplies of renewable energy generated in all parts of Barbados, taking into account a wide range of operational circumstances, the Code will not be able to address every possible situation. Where such unforeseen situations occur, BL&P—as the System Operator—should be required and empowered to act as a reasonable and prudent operator in the pursuance of any or a combination of the following:

- Protection of the safety of the public and its employees
- The need to preserve the integrity of the system
- The need to prevent damage to the system
- Compliance with conditions of the company's Licence
- Compliance with the ESA and FTC rulings.

## 6.3 Strengthen the Capabilities of the Town and Country Development Planning Office with Standardized Environmental Permitting and Planning Regulations for Renewable Energy

The Government should direct the Town and Country Development Planning Office (TCDPO) to move to a standardized, technology specific approach for the environmental permitting and planning regulation of renewable energy projects, streamlining the development of viable technologies. Standard environmental and planning regulations for renewables would make things easier for developers by identifying the form and content of Environmental Impact Assessments (EIAs), and the full criteria to be met for obtaining planning approval.

The Physical Development Plan (amended in 2003, and approved in 2007) provides that any development that affects the environment requires an EIA. The TCDPO has issued guidelines to developers for preparing EIAs of renewable energy projects, but these guidelines are specific for each project, not for each technology type.[112] This means that each project is treated in isolation, with a case by case approach that creates delays and

[112] However, guidelines for the development of small wind systems have been submitted to the TCDPO under the SEF Pilot Program.

uncertainties (and ultimately, higher costs) for both developers and public authorities. An EIA must go to public consultation, and then modified until it addresses all concerns raised during the public consultation—the EIA for the Lamberts Wind Farm has been subject to many and very substantial modifications, and is finally on its way to being approved. The biomass cogeneration project is preparing Terms of Reference for developing an EIA; and the TCDPO has received an EIA for an unsolicited waste to energy project proposal—these developments are likely to meet delays and complications similar to (or even greater than) those encountered by the Lamberts wind farm.

Resources to respond to the number and diversity of renewable energy development applications are limited—not only in the TCDPO, but also in the various agencies with jurisdiction. Currently, the TCDPO relies on the cooperation of several agencies—the Environmental Protection Department, the Ministry of the Environment, the Coastal Zone Management Unit, the Ministry of Public Works—all of which form an EIA Committee that provides advice to the Chief Town Planner's decision.

New regulations would allow the TCDPO to use a standardized approach for permitting each technology, rather than treat each new application on a case by case basis. Precedent and procedure must be established and then followed for future developments. This will specifically streamline and reasonably limit public consultation and queries by developing the database of responses and rulings to the technology specific concerns raised. For example, once an appropriate assessment on the impact of low frequency noise from wind turbines has been done, a standard response may be formulated, and future queries need not proceed through the full evaluation process. (A standard description of sound from wind turbines is provided in Box 6.3 below).

The TCDPO informed us that Terms of Reference for the review of the Orders emitted under the Town and Country Planning Act, and for the strengthening of the management capabilities of the TCDPO, have been prepared. The IDB is also considering supporting the institutional strengthening of the TCDPO.[113] We recommend that these activities be integrated and complemented by the development of new environmental permitting and planning regulations for renewable energy. This would require additional resources for specialized support, which the Government should make its best effort to secure.

The environmental permitting and planning regulations should:

- ***Establish the power for the TCDPO to prescribe criteria for a register of qualified and approved persons for preparing Environmental Impact Assessments for renewable energy***—the criteria may regard professional and academic qualifications; years of experience; knowledge of renewable energy technologies; skills in preparing EIAs for renewable energy developments; and previous experience in Barbados, the Caribbean Region, or tropical small island countries
- ***Establish the content of EIAs for renewable energy projects***—EIAs should be made to include five standard parts for all developments:

[113] Conversation with the TCDPO, 10 March 2010.

- a description of the method, extent, and duration of activities involved in the construction, operation, maintenance, and decommissioning of the renewable energy development
- an assessment of the likelihood, severity, and extent of the relevant impacts, whether adverse or beneficial, that the activities mentioned are expected to have
- a description of actions that the developer commits to undertake or have undertaken to mitigate, avoid, or remedy adverse environmental impacts, and an estimate of the likelihood and extent to which such plans may be effective
- a monitoring plan to be implemented through a specialized independent third party
- a demonstration of the financial ability to undertake required actions.

- ***Establish the specific activities and potential impacts that Environmental Impact Assessments for key renewable energy technologies should cover***—regulations should prescribe that EIAs for key RE technologies for Barbados address the specific activities and impacts involved in these developments, and list what such activities and impacts are. For example:
  - *activities* for wind project development would include the building or operation of wind turbines, and building of infrastructure to access the wind resource
  - *impacts* for wind project development would include the production of noise, impacts of visual amenity, and avian or bat mortality
- ***Establish the framework to set technology-specific Standards developers must comply with***—regulations should also create the framework for the TCDPO to issue Standards that specify the detailed levels of acceptability of environmental impacts for key renewable energy technologies. A Standard for any particular renewable energy technology should consist of a matrix which, for each impact that needs to be addressed, specifies:
  - a level below which the impact is allowed—activities that cause an environmental impact not exceeding this level should not be a cause for rejecting a development permission
  - a level above which the impact is prohibited—activities that cause an environmental impact exceeding such level should be a cause for rejecting a development permission
  - a band between these two levels—activities that cause an environmental impact within such band should be assessed on a case by case basis
- ***Establish the power for the TCDPO to set specific fees for monitoring and enforcement of compliance***—developers must include in EIAs a monitoring plan to be implemented by a specialized independent third party, and must pay a fee that covers the reasonable cost of doing this.

This framework (inspired by the one used in New Zealand) would mean that developers of renewable energy projects would have the following duties:

- To address activities and impacts prescribed for environmental impact assessments for specific RE developments
- To undertake (or have undertaken) actions to mitigate, avoid, or remedy adverse environmental impacts as assessed in the environmental impact assessment, or resulting from the development
- To comply with a standard prescribed for all impacts of the specific renewable energy development undertaken, once the standard is prescribed—but until it is not, developers still need to address all activities and impacts required for the technology they intend to use.

The situation described above is not unique to Barbados—it is common to many other Caribbean countries, such as Dominica, which Castalia has recently supported in creating new regulations for the environmental permitting and planning for renewable energy developments. Pursuing these regulations in a regional context, like for other measures recommended for the SEF, would be the most effective and efficient way to proceed for Barbados.

**Box 6.3: Wind Turbine Sound**

Wind farm developments in Barbados have been particularly plagued by public concerns regarding wind turbine sound and potential health impacts. While it is clearly important to provide due diligence in the treatment of these concerns, it should also be noted that public resistance to any new technology is not always founded on firm scientific evidence.

The following excerpt from the American Wind Energy Association (AWEA) provides a useful discussion on wind turbine sound:

> *The sounds emitted from wind turbines can be mechanical, from internal equipment such as the gearbox or yaw drive, or aerodynamic, from air moving past the rotor blades. Modern, state-of-the-art turbine designs effectively reduce mechanical sound through advanced sound proofing. Of course, when one is standing at the door of a wind turbine tower, some vibrations from the equipment inside could be audible.*
>
> *Aerodynamic sound, often described as a "whooshing" sound, is what can normally be heard near the base of a wind turbine—and is, in fact, what Gibson amplified with his boom microphone. It's worth noticing that the microphone also amplified the sound of the wind whipping across the soy bean field in which he was standing. Wind plants are always located where the wind speed is higher than average, and the "background" sound of the wind tends to "mask" any sounds that might be produced by operating wind turbines—especially because the turbines only run when the wind is blowing.*
>
> *In general, wind farms are fairly quiet. "Virtually everything with moving parts will make some sound and wind turbines are no exception," finds a report by the Scottish Environmental Department. "However, well-designed utility scale wind turbines are generally quiet in operation and the sound from such turbines is very low compared to that of road traffic, trains, aircraft and construction activities."*
>
> *To fully respond to concerns regarding wind turbine sound, a detailed study was performed for the American Wind Energy Association and the Canadian Wind Energy Association. The following conclusions summarize the results:*
>
> - *Sound from wind turbines does not pose a risk of hearing loss or any other adverse health effect in humans*
> - *Sub-audible, low frequency sound and infrasound from wind turbines do not present a risk to human health*
> - *Some people may be annoyed at the presence of sound from wind turbines. Annoyance is not a pathological entity*
> - *A major cause of concern about wind turbine sound is its fluctuating nature. Some may find this sound annoying, a reaction that depends primarily on personal characteristics as opposed to the intensity of the sound level.*

Source: http://www.awea.org/newsroom/pdf/Turbine_Sound_Real_Story_27Oct08.pdf

## 6.4 Mandate Energy Efficient Design in the Building Code

We recommend that the Government encourage the Barbados National Standards Institute to mandate energy efficiency measures in the building code. As explained in Box 5.1, Barbados' building code does not address energy efficiency—limited information, and well as agency problems, lead to overlooking many measures that would avoid wasting energy. Tenants and purchasers of buildings often cannot reliably determine how much energy the building may consume, but they do know how much it costs to rent or buy a building. This leads builders and landlords to avoid energy efficiency investments that would increase the capital cost of the buildings, even when those investments would be more than paid-back by the reductions in energy costs.

Building energy standards provide a degree of control over building design and encourage energy conscious design in building. These inefficiencies could be reduced over time if the building code required energy efficient designs and materials in new buildings and major renovations. Many industrialized countries have included such requirements in their buildings codes.

The Barbados National Standards Institute (BNSI) has developed a draft building code that addresses problems specific to tropical countries, such as moisture control, and covers the following areas:

- Preparation of a site
- Fire precautions
- Structural Requirements
- Ventilation
- Resistance of transmittance of sound
- Building access
- Drainage and sanitary facilities
- Combustion appliances
- Storage of waste
- Fitness of materials and workmanship.

However, this draft building code does not provide a comprehensive standard for the energy performance standard of buildings. Only the ventilation section of the draft code mentions energy efficiency—it requires a comparison between natural ventilation and mechanical ventilation to determine the best option for the building. This speaks to the fact that buildings be constructed with increased insulation and a "tighter" construction—but it does not specifically state minimum standards for insulation.

Additional energy efficiency rules are needed, and in particular include the following:

- Lighting, by defining a maximum lighting density (Watts per square meter) based on the space type
- Insulation, by stating minimum levels for wall R-values, window properties, and "tightness" of the envelope
- Equipment efficiency, by setting minimum standard for mechanical equipment such as air conditioners.

A standard for Barbados could quickly be developed from an existing one. We recommend that a standard such as the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 90.1 2007 be reviewed for its application in Barbados. Bermuda, The Bahamas, the Dominican Republic and Jamaica are the only Caribbean climate zones described in the standard—however, we think that the standard could also be applied to Barbados with little or no modification. This standard covers sets out minimum requirements for:

- Building Envelope
- Heating, Ventilating, and Air Conditioning
- Service Water Heating
- Power
- Lighting
- Other Equipment (such as electric motors).

Each section refers to requirements based on the climate zone for which a building is designed. They are structured to include a general description of the section, definition of compliance path, mandatory provisions, submittals and product information requirements. This standard would complement the draft building code previously discussed, as most areas are not duplicated (ventilation being the only area covered by both).

A standard such as this should be adopted to form minimum requirements for new facilities. Throughout North America this standard is used in most green building construction programs—actually, most of these programs require the buildings to exceed this standard in energy efficiency performance. Many jurisdictions have mandated that any public facilities be designed to this energy performance standard. Consideration should be given to the potential for an incentive or recognition for facilities that exceed these standards.

The ASHRAE Standard 189.1 Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings was published in February 2010.[114] Energy efficiency performance requirements of this new standard are higher than the ones of ASHRAE 90.1, and could be considered once it is finalized.

These standards mentioned may provide a good basis for the BNSI for constructing the building code. We recommend that both local and international experts be involved in the process. Both the Jamaican EE building code and ASHRAE 90.1 follow a similar structure and this should be maintained for application in Barbados. A further step would be to work towards performance incentives for exceeding the minimum requirements. This would require an energy analysis of the facilities to demonstrate the building exceeds the requirements.

## 6.5 Establish a Smart Fund for Increasing Investments in RE and EE

The Government intends to establish a Smart Fund (the 'Fund') to promote EE technologies and RE projects. This Smart Fund will provide grants and subsidized loans to promote increased use of EE and RE. The Government is negotiating a US$10 million Investment Loan with the IDB; the proceeds of this loan will be used to capitalize the Fund.

This Fund can become an excellent instrument for overcoming some of the key barriers to the uptake of viable energy efficiency and distributed renewable generation technologies. The analysis in sections 4 and 5 showed that technologies such as CFLs, efficient air-conditioners, power monitors and more efficient motor technologies are economically and

[114] See http://www.ashrae.org/.

commercially viable, but hardly used in Barbados. In commercial and industrial premises there is also considerable scope for efficiency gains from energy audits and retrofits that could install more efficient lighting and insulation, as well as better motors, efficient air-conditioning, and make process improvements.

The main barriers to uptake of these energy and money-saving ideas were found to be:

- Difficulties in accessing credit, meaning that many people cannot afford the up-front cost of the new technologies, even though the technologies would quickly pay for themselves
- A chicken-and-egg problem—because many of the technologies are not in great demand, there is only limited supply of them, with the result that the products are not widely available, competition between suppliers is limited, and the supply chain lacks economies of scale, thus pushing up prices and reducing availability
- Lack of information about the benefits of many of these technologies—because the technologies are new, are not widely used in Barbados, the marketing and peer networks through which people often get information on what to buy do not work to inform people about these technologies.

We recommend that the Smart Fund be dedicated to overcoming these problems through:

- Providing finance to overcome the access to capital problem
- Funding campaigns to develop a critical mass of users of some of the most promising technologies, in order to break through the chicken-and-egg problem, and develop a new market equilibrium in which these technologies become the new normal, and so benefit from stronger competition and economies of scale in the supply chain
- Providing information on the experience with the technologies the fund is supporting, ensuring that the experience of satisfied users is disseminated to their peers, and made available to suppliers to use in marketing their products.

To this end, we recommend that the Smart Fund offer the following five distinct components:

- **A Pilot Consumer Finance Facility (Hire Purchase)**—A US$0.5 million revolving fund that provides loans at below-market rates to supporting low-interest hire purchase schemes. This facility would offer capital at low interest rates—around five percent—to approved retailers and finance firms that provide hire purchase for consumer durables (such as Courts, or Dacosta Mannings, or solar water heater/solar PV companies). Given the small size of this component, we recommend competitively selecting only one company for the pilot phase. The approved retailer or finance firm would be able to draw on a credit line offered by the Facility to offer hire-purchase finance on approved consumer-scale energy efficiency and renewable generation technologies such as solar water heaters, solar photovoltaic generators, and efficient air conditioning units. The participating retailer or financier would be required to pass on savings from their lower cost of finance to customers in lower interest rates. This Finance Facility would revolve—that is, as the line of credit was repaid by the retailer, the funds would be lent out again to support additional hire purchase finance. A five percent interest rate should be enough to cover administration costs of the Finance Facility, making it self-sufficient. The MFIE indicated that it intends to testing how this innovative mechanism would work and that, if successful, it would consider replicating it under a possible second phase of the Investment Loan that is being considered with the IDB. Replication would entail selecting more than one retailer or provider of finance, and establishing several lines of credit

- **Compact Fluorescent Lamps Promotion**—A US$0.5 million grant facility to kick-start the market for Compact Fluorescent Lamps (CFLs). The goal is to customers familiar with the technology, change their buying habits, and ensure that CFLs are available wherever people normally shop for light bulbs. The Smart Fund would work with participating retailers on a limited time give-away program. Under this program, the Smart Fund would pay the wholesale cost of CFLs, and the retailers would source the CFLs and give them away to customers. Retailers would agree certain conditions with the Smart Fund, such as a limit to the number of CFLS each customer can take, and only giving the CFLs away with purchases of other products over a certain value, to stop the system being abused. This promotion should get the CFLs into shops, retailers marketing them, and people using them. This measure would complement the phase-out of incandescent light bulbs that the Government intends to enact
- **Air-conditioner rebate trade-in program**—A US$1.5 million grant facility that would give people credits worth about half the value of a new efficient air-conditioning unit, in exchange for an old unit. Under this scheme, participating retailers would accept inefficient AC Units, and give customers a rebate of a fixed amount—set to about half the value of an efficient unit of broadly the same type—on the purchase of a new efficient air conditioner. The retailer would be responsible for destroying and safely disposing of the old unit. The Fund would reimburse the retailer for the rebate given. The exact percentage of the rebate can be modeled once the Fund is operational, but should not be below 33 percent to avoid undermining the very rationale of this component—the barrier that is being targeted with the grant is the limited supply of equipment rather than the lack of financing (which is addressed by the hire purchase and retrofit finance components)
- **Energy Efficiency Retrofit and Renewable Energy Finance Facility for SMEs**—A US$6.5 million below-market loan facility to pay a portion of the cost of energy efficiency retrofits and installation of small renewable energy systems. This facility would lend commercial and industrial enterprises (including hotels, according to the Government's indication) funds to cover up to half the costs of efficiency retrofits, provided these follow the recommendations of an approved energy audit. This facility will help overcome the access to finance barrier, and also prompt the uptake of efficient commercial and industrial technologies such as efficient motors, efficient chillers, Variable Frequency Drives, and lighting technologies. Providing finance for these technologies around an energy audit program will help to ensure that recommendations of the audits can be implemented, and that the technologies being financed are appropriate. It will also make it easier to achieve economies of scale in equipment supply, since auditors will be able to coordinate the types of units recommended and group orders

together. This Finance Facility can operate on a revolving basis, with the funds repaid from early loans being lent out again, thus increasing the number of retrofits that can be supported. The interest rate on the facility will be set at a level to make it self-supporting

- **Discretionary Facility**—A US$1.0 million grant facility for the Government's discretionary use on activities that would not generate any revenues, but that would be important for increasing the use of EE and RE by households and businesses in Barbados. The Government could use such facility for funding awareness activities, or replicating activities of the SEF Pilot Program (purchase and installation of small RE systems, and distribution of CFLs). This component would also cover administrative costs of MFIE for supervising the Fund management.

The Smart Fund should be supervised within the Ministry of Finance, Investment and Energy, but the actual management of the Funds can be outsourced to the Enterprise Growth Fund Limited (EGFL) against payment of a spread for the loan components (EE Retrofit and RE Finance Facility, and Pilot Consumer Finance Facility), and of a disbursement fee for grant components (Air conditioner rebate trade-in program, and CFL promotion).

The Government should seek additional grant and concessional loan funds to further capitalize and expand the Fund, allowing for the programs that prove successful to be continued and expanded—in particular, the Pilot Consumer Finance Facility, which was originally conceived to use most of the funds available from the Investment Loan. The IDB has already indicated a willingness to provide a kind of line of credit, allowing further funds to disbursed for the same purposes after the first US$10m has been deployed. A detailed description of the Smart Fund design is contained in Appendix L.

## 6.6 Procure an ESCO for Implementing the Public Sector Energy Conservation Program

Implementation of this valuable program is lagging behind the Government's expectations. Audits for 15 public buildings were completed, but retrofits expected to begin before the end of 2009 still wait for complete terms of reference to be launched.(see Section 2.6.1).

The Energy Unit has prepared draft terms of reference for outsourcing the retrofit of those buildings that have already been audited to an Energy Services Company (ESCO) under a performance-based contracting scheme. Under this arrangement, an ESCO would be procured to finance the capital works needed. The ESCO would guarantee a pre-established amount of savings, and would receive its return through a share of the savings achieved.[115]

We agree that the ESCO approach is a good one. It will help to overcome the twin problems of implementing such programs entirely within the public sector—namely a lack of finance and a lack of incentives. Our recommendations are simply that:

- The Energy Unit move forward rapidly with implementation of the ESCO approach to the Public Sector Energy Conservation Program

[115] It is likely that the selected ESCO will audit each facility again—based on information from existing audits—prior to implementing any energy efficiency measure. The reason is that an ESCO would guarantee savings and finance the project only based on its own assessment.

- Those parts of the Ministry of Finance in charge of government budgeting and expenditure actively support the Energy Unit in this effort, given the potential this program has to reduce government expenditure.

## 6.7 Customs Provisions and Tax Incentives—Steady as she Goes

Barbados has introduced a number of tax and customs incentives for renewable energy and energy efficiency equipment, as described in section 2.6.2. The BNSI is also developing standards (known as 'certificates') for air conditioners and refrigerators. It is expected that these certificates will establish minimum performance standards for these appliances, and provide the basis for customs staff to decide whether they are eligible for reduced duties. We understand that BNSI's criterion for starting with air conditioners and refrigerators is that these are among the most common types of equipment sold. Our analysis shows that other types of equipment—such as premium efficiency motors, or efficient lighting technologies—are much more cost-effective than refrigerators, but lack a certificate. In the case of CFLs, the ability to get a duty exemption without a certificate may be a reason why there are low-quality lamps on the market.

The only changes we recommend to the current arrangements are that:

- The Barbados National Standards Institute complete the standards that can be used to define with certainty what constitutes 'Environmentally Preferred Equipment' for the purposes of income tax deductions, and the Inland Revenue formally adopt these. Careful attention will need to be paid to refrigerators, since our analysis has shown that refrigerators that are considered energy efficient in North America do not necessarily perform well in Barbados
- The Customs Department (perhaps in conjunction with the Barbados National Standards Institute) set minimum standard that CFLs must reach to qualify for the reduced rate of duty, and ban importation of sub-standard CFLs from any source
- The Government consider adjusting the duty free regime for imports for the tourism industry, to ensure there is a differential between conventional equipment and energy efficient equipment in this sector also. Currently, since all equipment for the tourism industry can be imported duty free, the duty waiver that incentivizes purchase of more efficient equipment in other sectors has no practical effect on tourist investments. A practical approach would be to limit the duty exemption on equipment for tourism purposes to equipment that is certified as energy efficient, under the scheme being developed by the Barbados National Standards Institute.

While it is true that greater customs and tax incentives would create greater incentives to purchase energy efficient products, we do not recommend extensions of these incentives programs, for the following reasons:

- For some products, such as air conditioners, reducing the cost of energy efficient products might lead people who otherwise would not have bought the appliance to buy one, thus increasing total energy consumption

- For some customer categories, distorted electricity tariffs already create incentives to invest in energy efficiency and distributed renewable generation beyond the economically optimal level
- The analysis in this report shows that cost is not the binding constraint preventing uptake of efficient energy technologies and distributed generation. Rather, it is a lack of capital, information, and widespread competitive supply. Government will get greater results for each dollar spent through initiatives such as those proposed for the Smart Fund, which directly address these barriers, than it will through further tax deductions and customs waivers.

## 6.8 Consider a Phase-Out Plan for Incandescent Light Bulbs

Governments worldwide have turned to two key policy options for improving the efficiency in lighting end-uses for residential and non-residential customers—fiscal support, or direct regulation. We recommended instruments for fiscal support of efficient lighting under the SEF Pilot Program, and the Smart Fund; and we recommended instruments for direct regulation as minimum standards for CFLs, for banning the importation of sub-standard CFLs and decide eligibility for any other fiscal or customs incentive.

The Government of Barbados has indicated that, in addition to these instruments, it wishes to take a further step in direct regulation for supporting efficient lighting by phasing out traditional incandescent light bulbs, or General Lighting Service (GLS). This would entail a restriction in (i) import, and (ii) sales of incandescent light bulbs.

Policy can be directed towards the phasing out of GLS. GLS can be promptly banned and directly substituted by CFL alternatives, as was the case in Cuba, or can be gradually phased out by the introduction of Minimum Energy Performance Standards (MEPS) as was the case in Australia.[116]

If the Government were to regulate the use of GLS, with the aim of removing GLS from the market, we recommend that the most effective way to do this would be through a gradual phase out, much like what is currently operating in Australia. The proposed policy should follow these stages:

1. **Setting a deadline for phase out of all inefficient light-bulbs** (for example, 2015)—in consultation with key stakeholders, including industry, consumers, various government agencies and technology developers, policy makers should set a final deadline by which it is feasible to phase out all inefficient residential GLS
2. **Issuing a policy that establishes phased levels of acceptable efficiency of light-bulbs by the established deadline**—light sources that produce less than 25 lumens (a measurement of light intensity) per watt of energy consumed are inefficient, given currently available technology. Such a level of efficiency should represent the Minimum Energy Performance Standard used
3. **Implementing a phased and progressive restriction on the import and sale of inefficient light-bulbs**—initially the most inefficient light sources should be removed from the market (less than 15 lumens per watt), progressing to the more efficient (less than 25 lumens per watt). The most effective policy instrument by

[116] Global Efforts to Phase-Out Incandescent Lamps. An update from Paul Waide, International Energy Agency (IEA).

which inefficient light sources can be effectively removed from the market is the implementation of a MEPS—Table 6-1 shows the efficiency of different light bulb types.

**Table 6-1: Efficiency of Different Light Bulb Types**

| Light Type | Lumens per Watt |
|---|---|
| General Lighting Service/Halogen | 12-24 |
| Compact Fluorescent Lamp (CFL) | 50-70 |
| Sodium Lamp | 90-140 |
| Light Emitting Diode (LED) | 200+ |

Source: Eco-Green Power Solutions, http://www.eco-gps.com/led_info.html

Since Barbados (like many countries today, also given the large predominance of China in producing light bulbs) imports most or all of its GLS bulbs, it can enforce a phase-out of GLS by restricting the import of certain light bulbs. The restriction would be based on the bulbs' failure to meet requirements set by a MEPS. The MEPS can be increased over time until only light bulbs with the required level of efficiency are imported.

Import restrictions are commonly supplemented with a staggered restriction on the sale of inefficient light-bulbs. For example, if GLS that produced less than 15 lumen per Watt had complete import restrictions enforced form January 2011, then by December 2011 the market will have sold much of the standing stock, and had time to import CFL alternatives for when a restriction on selling less than 15 lumen per Watt GLS comes into force. The MEPS can then be increased to restrict the importation of the next tier of inefficient lighting, providing that an efficient and acceptable substitute is available or developed. Table 6-2 illustrates an example timeframe from Australia of import and sales restrictions on increasingly inefficient light sources based on increasing MEPS.

It is important to note that a MEPS does not necessarily promote one particular type of light bulb technology over another, but rather promotes a light bulb technology that complies with required efficiency levels—this is consistent with the recommended technology-neutral principle of the SEF. At a MEPS of 25 lumens per Watt, CFLs are likely to be the technology best placed commercial expansion, but both Sodium Lamps and LEDs comply with MEPS and are more efficient than CFLs. The cheapest technology that complies with required efficiency levels is likely to prevail.

Finally, we note that phasing out GSL must consider the appropriate disposal of CFLs, due to the mercury content of the most likely alternative to GSL. Though CFLs do contain mercury, it is many times less than a household thermometer or a watch battery—however, the volume of CFLs on the market can make this a real problem. (Generally, CFL use is likely to reduce mercury within the atmosphere—the most potent vector for which Mercury enters the human body—as reductions in energy demand are likely to be coupled with reduction in fossil fuel burning and therefore mercury emissions). The required instruments to deal with it include appropriate disposal facilities or mechanisms, and public awareness and education campaigns for the public on how to dispose of used or broken CFLs. The Environmental Assessment for CFL disposal program we produced for the SEF Pilot Program deals in greater detail with these matters.

**Table 6-2: GLS Import and Sales Restrictions in Australia**

| Light Type | Import Restriction | Sales Restriction |
|---|---|---|
| GLS light bulbs (Tungsten Filament)<br>Extra low voltage (ELV) halogen non-reflectors<br>Self-ballasted CFLs | Jan 2011 | Dec 2011 |
| >40W candle, fancy round and decorative lamps<br>Mains voltage halogen non-reflectors<br>ELV halogen reflectors | Jan 2012 | Dec 2012 |
| Mains voltage reflector lamps, including halogen (PAR, ER, R, etc)<br>>25W candle fancy round and decorative lamps | Jan 2014 | Dec 2014 |
| Pilot lamps 25W and below | To be determined dependent on the availability of efficient replacement products | To be determined dependent on the availability of efficient replacement products |

Source: Department of Climate Change and Energy Efficiency of Australia, http://www.climatechange.gov.au/

## 6.9 Enact an Energy Labeling Program in a Regional Context

Energy labeling is an important factor in identifying energy efficient equipment and influencing consumer decisions to purchase the appliance. In North America the most prevalent is the 'Energy Star' labeling program (a joint program of the US Environmental Protection Agency and the US Department of Energy),[117] while Europe has the European Union (EU) Energy Label.[118]

At least the most common equipment should be validated with a clear 'certificate' by the Barbados National Standards Institute. Certificates need to ensure that devices imported achieve promised results. As noted, the Barbados National Standards Institute is already working on certificates for air conditioners and refrigerators.

The BNSI stated[119] that:

- Because of its market size, Barbados may be forced to import some external certificates for equipment. In spite of some geographical peculiarities of Barbados (year-round summer), and differences in the US rating of air conditioning units (which takes into consideration the winter period), US or European standards could be adopted in Barbados without major problems

[117] See a description of the Energy Star Program at http://www.energystar.gov/index.cfm?c=about.ab_index.

[118] See a description of the EU Energy Label at http://www.energy.eu/focus/energy-label.php.

[119] Communication with the BNSI, 10 January 2010.

- The BNSI has not estimated the cost of creating a labeling system specific for Barbados. It could require manufacturers to commission tests on equipment to make sure it meets a particular standard for Barbados, and that it actually performs as the manufacturer says. These tests could also be performed in the country where the equipment is manufactured—however, they would need to be performed by a reputable, accredited, and independent third party acceptable to Barbados
- There have been initial discussions to rationalize testing services among various Caribbean national standards bureaus—for example, tests on refrigerators, freezers, and residential air conditioners could be done in Jamaica, where a larger amount of such equipment exists
- The BNSI can randomly select and test products from those imported, whether accompanied by a certificate or not. However, those accompanied by a certificate from an accredited body would be allowed into the country with significantly less scrutiny.

Our field work shows the importance of making sure that these standards are set with Barbados-specific conditions in mind—the case of refrigerators is a good example—and not simply adopted from overseas. It would not be economically efficient for Barbados to develop its own testing facilities strictly for testing products, especially given that there is an existing testing facility in Jamaica.

We recommend that Barbados be at the forefront of a Caribbean energy labeling program for major energy using equipment, such as refrigerators and air conditioners. This program could build upon the certificates BNSI is working on, and achieve economies of scale by ensuring that they represent a standard common to other Caribbean countries. The Government should explore the possibility of testing equipment in Jamaica's facilities, and involve in the process the BNSI, the Bureau of Standards Jamaica (BSJ), and the Trinidad and Tobago Bureau of Standards (TTBS) as a start—each of these organizations already issues Standard Marks in the Caribbean community. A Standard Mark means a registered certificate trade mark granted to commodities, processes and practices which consistently perform to national specifications.

## 6.10 Launch Institutional Strengthening for the Renewable Energy Unit and the Government Electrical Engineering Department

Castalia performed an Institutional Capabilities Assessment (Appendix N), from which it emerged that institutional strengthening is required for two key entities:

- The Renewable Energy Unit of the Energy Division of MFIE
- The Government Electrical Engineering Department.

### Strengthening the RE Unit of the Energy Division of MFIE

Interviews with MFIE's Energy Division indicated that there has not been a sustained effort to build capacity for the Divisions' RE Unit, and that the turnover rate has been high due to difficulties in retaining staff (unlike what has happened for staff focusing on fossil fuel activities of the Division). The Division also plans to expand its data collection and elaboration activities, particularly in a regional context—something that requires adequate number of staff qualified in RE that the Division currently lacks. Given the importance that RE is expected to have in Barbados' energy policy, more qualified staff is required.

The Energy Division is well aware of this situation, and has already completed the administrative task of creating seven new positions for the RE Unit. These positions would bring the Unit to a size appropriate to its duties in the medium term. These positions remain not filled and temporarily frozen due to the Government's strained fiscal position. However, the Energy Division has indicated that some funds are available for filling at least 'some' of these positions in the short term—unfreezing the positions would pertain to the Ministry of Civil Service. The positions created are:

- 6 technical positions, of which 3 for graduate candidates ('officers'), and 3 for non-graduate candidates ('technicians')
- 1 clerical position.

We strongly support filling, as possible based on available funds, 3 or 4 of the technical positions in the short term, and considering more than one junior candidate in addition to at least one senior candidate. A The person in charge of RE development should be elevated at least to the level of Director of Natural Resources in the Energy Division's organization chart. s we indicate in the Institutional Capabilities Assessment, this is necessary to raise the relative importance of RE in the overall sector administration, and to ensure effective implementation of the SEF.

Regarding the implementation of the Smart Fund, outsourcing its management to the Enterprise Growth Fund Limited (EGFL) seems a reasonable option based on our conversations with them and our analysis of their experience and skills:[120]

- The EGFL has significant experience in providing credit to small and medium enterprises in Barbados—this is consistent with the Smart Fund's main focus on SMEs—and in channeling Government funds
- The EGFL is open to different arrangements regarding the spread it would apply on Government funds for its clients—this could be a fixed spread negotiated with Government, as well as a flexible spread within an agreed range (1-2 percent, according to the EGFL's experience)
- The EGFL has solid and established contacts with private companies through Barbados' key SME associations—in particular the Barbados Manufacturers' Association, the Small Business Association of Barbados—and has used such associations for effectively marketing its credit products with companies
- The EGFL can also administer grants from the Government, with payment of a disbursement fee (up to 1 percent on funds disbursed).

**Strengthening the Government Electrical Engineering Department (GEED)**

The GEED focuses primarily on the safety and compliance with standards of electrical installations in Barbados. While the Chief Electrical Officer of the GEED has had formal training and experience in RE technologies, and has personally supervised the installation of the few RE systems implemented so far in Barbados, other staff do not have the training and

[120] Conversations with the EGFL, 17 September 2009, and 3 June 2010. www.egfl.bb

experience required to inspect installation as the numbers of these increases—particularly after the approval of the pilot Rider for Renewable Energy.

The Chief Electrical Officer stressed that the strengthening needed is in terms of training—not numbers. The number of GEED employees required for inspection of RE installations is adequate, but they need appropriate training. We concur with this assessment, and recommend that allocating funds for specific training of existing GEED staff in installation of the most common RE systems, particularly solar and wind. As we have recommended for other activities, a regional approach with other Caribbean countries would be the most efficient way to contain costs and allow exchange of experience and information among experts of different countries with similar needs.

**Other Government entities and public awareness**

Regarding other Government entities, institutional strengthening of the TCDPO is being addressed separately with IDB support, and can be effectively completed with the development of standard environmental permitting and planning regulations, as we recommended. The Fair Trading Commission can perform all of its daily activities with current capabilities, and for others activities that take place at a lower rate—such as licence applications, or future rate applications—outsourcing is the most efficient, effective option (as well as one that is already used and proven by the FTC).

Finally, the SEF Pilot Program we designed (see Appendix P) includes an awareness campaign to be outsourced to a specialized entity, and focusing on EE and energy conservation through the distribution of CFLs and power monitors. A budget of US$50,000 was provided for this pilot awareness campaign. Based on this experience, the Government may replicate the campaign for a broader audience, with funding through the Discretionary Facility of the Smart Fund.

# 7 Projected Benefits of the Sustainable Energy Framework

In this section we present projections of demand and supply for electricity in Barbados given the existing conditions in the electricity sector (described in section 2.2 and section 2.3), the potential for renewable energy investments (in Section 4), and the potential for energy efficiency investments (evaluated in section 5). These projections are made for the following four scenarios, each with different assumptions regarding investments in renewable energy and energy efficiency:

- A business-as-usual scenario
- A high renewable energy (RE)scenario
- A high energy efficiency (EE) scenario, and
- A Sustainable Energy Scenario that combines high levels of investment in energy efficiency and renewable energy—this is consistent with the 'Sustainable Energy Matrix' presented in Section 3.1.

The results of this scenario analysis are summarized in Table 7-1. These results indicate that the Government's support for renewable energy and energy efficiency could have significant benefits in terms of reducing fuel costs, lowering $CO_2$ emissions, and achieving targets for the proportion of energy generated from renewable plants. Renewable energy will have higher associated capital costs, but our modeling suggests that these will be offset by lower fuel bills and will also generate environmental benefits.

**Table 7-1: Summary of Projected Costs, $CO_2$ Emissions and Renewable Capacity**

| Scenario | Present Value of Fuel Cost (2010-2029) (US$ Million) | Present Value of Capital Cost (2010-2029) (US$ Million) | Total $CO_2$ Emissions (2010-2029) (Million $tCO_2$) | Proportion of Renewable Energy (% in 2012) | Proportion of Renewable Energy (% in 2029) |
|---|---|---|---|---|---|
| Business as Usual | 2,648 | 166 | 19.3 | 2.1% | 1.5% |
| High RE | 2,451 | 337 | 17.4 | 18.4% | 22.6% |
| High EE | 2,487 | 348 | 18.7 | 2.4% | 2.1% |
| Sustainable Energy | 1,979 | 552 | 14.7 | 19.3% | 28.9% |

Notes: In each of the scenarios the oil price is assumed to follow current forward contract prices for light sweet crude oil, which were trading at US$ 80.73 per barrel for December 2010 delivery and US$ 95.75 per barrel for 2017 delivery. See www.nymex.com

We calculated the present value of the fuel and capital costs using a discount rate of 6 percent.

The analysis shows that, compared to a business as usual scenario, a sustainable energy scenario that promotes both renewable energy and energy efficiency could:

- Cut total electricity costs by US$283 million—net effect of higher capital costs (by US$386 million) but lower fuel costs (by US$669 million)—by 2029

- Cut $CO_2$ emissions by 4.6 million tons by 2029
- Reduce reliance on fossil fuels to about 71 percent by 2029.

The rest of this section is structured as follows:

In Section 7.1, we describe each of the scenarios and list the main assumptions used to project electricity supply and demand over the next 20 years in Barbados.

In Section 7.2, we compare the different outcomes of the four scenarios in terms of overall economic cost with a breakdown into capacity cost and energy cost; $CO_2$ emissions; and percentage of energy generated by renewable sources.

In Appendix M, we describe all the assumptions we used and present detailed projections of supply and demand for each of the four scenarios.

## 7.1 Description of Energy Future Scenarios

In this section, we describe the four scenarios used to project future electricity supply and demand in Barbados. We have created a spreadsheet model of the electricity sector in Barbados for projecting demand and supply over the next 20 years. In the model we have specified the following four scenarios to analyze different investment patterns and inform policy-making decisions:

- **Business as usual scenario**—In this scenario, BL&P invests in new thermal generation capacity to replace decommissioned plants and meet demand growth. The only investment in renewable energy capacity is the planned Lamberts wind farm, and no investment for energy efficiency is made. This scenario is based on BL&P's capital expansion plan. The only difference is that we moved medium speed diesel D17 forward from 2013 to 2012 to keep the reserve capacity margin above 20 percent.
- **High RE scenario**—In this scenario, new generation investment is focused on renewable energy until available renewable resources have been utilized. All economically viable renewable technologies that are discussed in Section 4 are utilized in this scenario. New thermal capacity is commissioned to ensure the reserve capacity margin calculated based on firm capacity is above 20 percent and to meet annual demand. No investment for energy efficiency is made.
- **High EE scenario**—In this scenario, commercial, residential, and industrial consumers invest in economically viable energy efficiency technologies identified in Section 5. We calculate the investment requirement for energy efficiency based on kWh of electricity saved, and a US$0.12 weighted average cost to save 1 kWh of electricity, as mentioned in Section 5.2.3.
- **Sustainable Energy scenario**—In this scenario, all the renewable energy projects identified in the high RE scenario are implemented and consumers invest in all economically-feasible energy efficiency appliances identified in the high EE scenario. New thermal capacity is commissioned to ensure the reserve capacity margin calculated based on firm capacity is above 20 percent and to meet the expected annual demand. This scenario is the Sustainable Energy Matrix presented in Section 3.1

Table 7-2 summarizes the main assumptions made in each of the four scenarios. Details of the resulting demand forecasts and generation expansion plan in each scenario are provided in Appendix M.

**Table 7-2: Summary of Main Assumption in Scenarios**

| | Business as Usual | High RE | High EE | Sustainable Energy |
|---|---|---|---|---|
| Customer number growth rate – Residential | 1.37% | | | |
| Customer number growth rate - Commercial | 5% (2010-2014), 3% (2015-2019), 2% (2020-2029) | | | |
| Customer number growth rate - Industrial | 1.5% | | | |
| Average consumption growth rate – Residential | 2.11% | 2.11% | 0.79% | 0.79% |
| Average consumption growth rate – Commercial | -0.92% | -0.92% | -2.11% | -2.11% |
| Average consumption growth rate – Industrial | -1.95% | -1.95% | -2.61% | -2.61% |
| Average annual demand growth (%) | 2.14% | 2.14% | 0.97% | 0.97% |

## 7.2 Scenario Results

The four scenarios described above have been used to evaluate how investments in energy efficiency and renewable energy are projected to impact on:

- Sector operating and investment costs
- $CO_2$ emissions
- The proportion of energy generated from renewable sources.

These results illustrate how the demand and supply of electricity in Barbados could change over the next 20 years with different investment patterns. The sustainable energy scenario (corresponding to the Sustainable Energy Matrix presented in Section 3.1) is the most interesting, as it shows the benefits of maximizing the uptake of all economically viable energy efficiency and renewable options, whereas the high RE and high EE scenarios show the impact of either renewable energy or energy efficiency options.

### 7.2.1 Sector operating and investment costs

We estimate the costs of each scenario by analyzing the fuel costs and capital expenditure required to meet demand in each scenario. These costs will change depending on the assumptions made regarding energy efficiency and renewable energy—with investments in energy efficiency and renewable energy leading to lower consumption of fuel, but generally having higher capital expenditure needs. This approach assumes that other sector operating costs, such as distribution costs, will be the same across the different scenarios.

To compare the overall sector costs under the four scenarios we discounted the fuel and capital expenditure costs into present value terms, using a discount rate of 6 percent. The results are shown in Table 7-3. The higher capital expenditures under the high RE scenario are projected to be almost offset by the expected savings in fuel costs. The high EE scenario is also expected to result in lower overall costs than the business as usual scenario. The sustainable energy scenario produces the greatest cost savings on fuel and highest capital expenditure, combining the cost savings and capital expenditures projected in both the high EE and high RE scenarios.

**Table 7-3: Present Value of Capital and Fuel Costs in Different Scenarios**

| Present value (DCR = 6%) | Business as Usual | High RE | High EE | Sustainable Energy |
|---|---|---|---|---|
| Fuel costs | 2,648.3 | 2,450.6 | 2,484.7 | 1,979.3 |
| Capital costs – Investments in thermal power plants | 150.7 | 104.1 | 99.2 | 84.9 |
| Capital costs – Investments in renewable energy | 15.6 | 233.3 | 14.7 | 233.3 |
| Capital costs – Investments in energy efficiency | 0.0 | 0.0 | 234.1 | 234.1 |
| **Total** | **2,814.6** | **2,788.0** | **2,834.7** | **2,531.6** |

Note: All amounts are in US$ millions

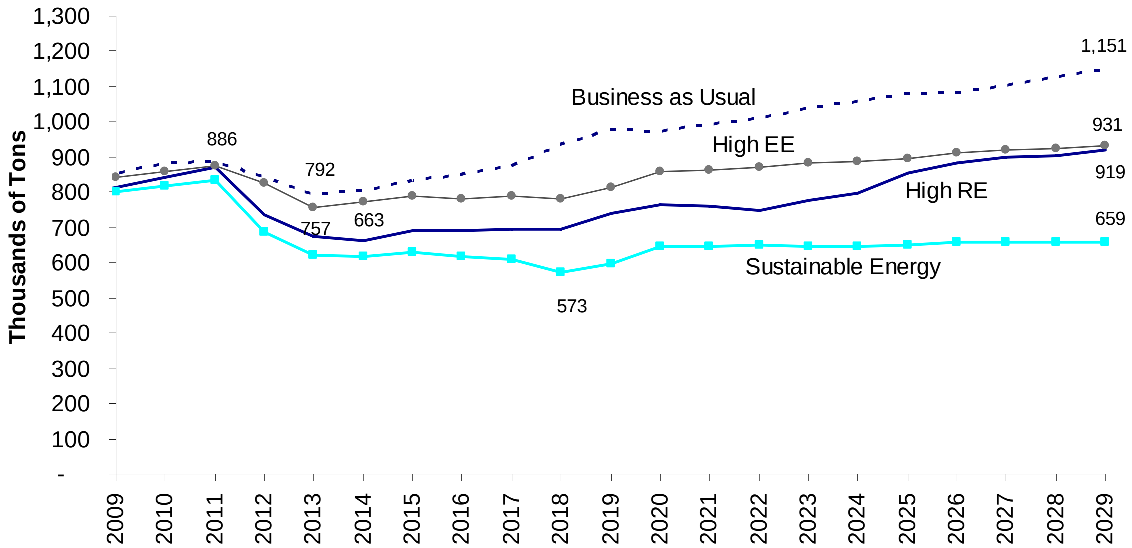
### 7.2.2 $CO_2$ emissions

In 2009, BL&P produced 832,000 tons of carbon dioxide ($tCO_2$) from electricity generation. This implies an average emissions factor of 0.876 $tCO_2$ per MWh of electricity generated.

Under the business as usual scenario, the annual $CO_2$ emissions will decrease briefly between 2011 and 2013 to around 792,000 $tCO_2$, as the relatively $CO_2$ intensive steam generating plants are decommissioned and the Lamberts wind farm is added to the system. $CO_2$ emissions will increase thereafter as BL&P adds more thermal generation plants to meet growing demand. In 2029, we expect BL&P to produce more than 1.15 million $tCO_2$ under the business as usual scenario.

$CO_2$ emissions would be lower than business as usual in the three other scenarios. $CO_2$ emissions are projected to stabilize under high energy efficiency scenario at around 931,000 $tCO_2$ per annum, with less thermal generation required to meet demand. Under the high renewable energy scenario, emissions are projected to fall sharply from 2011, reaching a low of around 663,000 $tCO_2$ per annum in 2014. The reduction in $CO_2$ emissions during this period is the result of the investment in available renewable resources and the decommissioning of existing thermal plants. Emissions remain flat until 2018 and are projected to resume a growth trend after 2018 because new thermal generation plants are needed to meet demand as available renewable energy resources are fully utilized. The sustainable energy scenario maintains a flat $CO_2$ emission level after 2018 due to the reduced need for new thermal capacity arising from investments in energy efficiency.

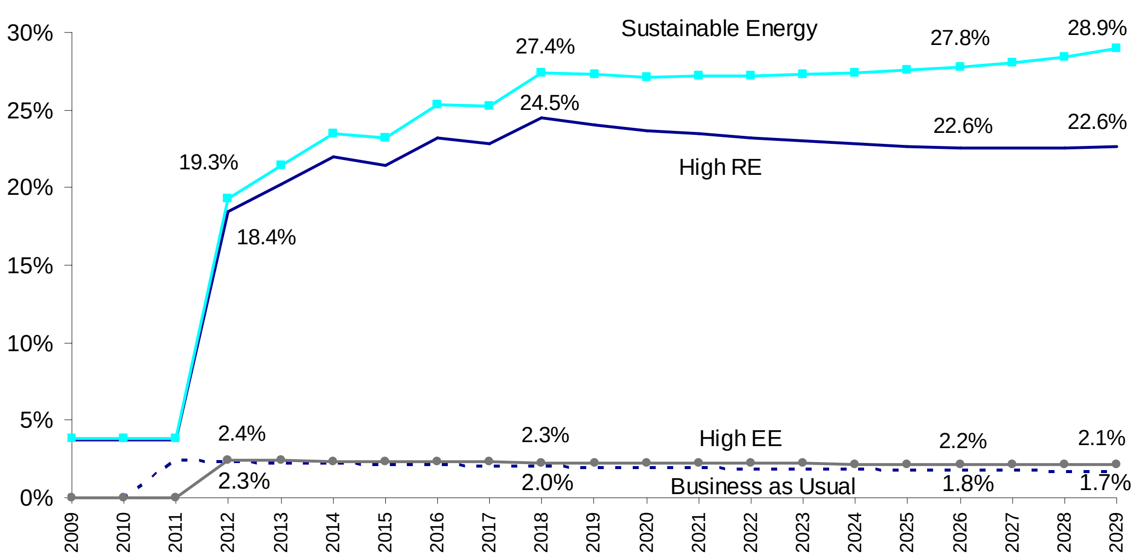
**Figure 7-1: Projected $CO_2$ Emissions in Different Scenarios**




### 7.2.3 Proportion of energy generated from renewable sources

In the 2006 draft national energy policy, the Government set indicative targets for generating 10 percent of electricity from renewable sources by 2012, and 20 percent by 2026. Figure 7-2 shows the percentage of energy that will be generated from renewable sources in each of the four scenarios. Neither of the targets in the draft energy policy would be achieved in business-as-usual scenario or high EE scenario. However, both targets would be met in the high RE scenario and the sustainable energy scenario.

**Figure 7-2: Proportion of Renewable Energy Generated in Different Scenarios**



It is important to note that the increased levels of renewable energy and energy efficiency shown in the Sustainable Energy Matrix should be indicative targets, with the purpose of guiding policy and project implementation based on the economic viability of the underlying technologies. They should not be fixed targets to be achieved at any cost—this would be counter to the objectives of the Sustainable Energy Framework.

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