Inter-American Development Bank

Achieving Sustainable Energy in Barbados

Energy Dossier

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Abstract

This Energy Dossier is part of a series of publications produced by the Energy Division of the Infrastructure and Environment Department of the Inter-American Development Bank. It is designed to increase the knowledge base about the composition and organization of the energy sector of Latin American and Caribbean countries. Each dossier describes the energy matrix of the country under analysis and then dives deeply into the institutional organization and regulatory framework of the energy sector in that country.

Keywords: Energy; electricity; energy matrix; Caribbean

JEL Codes: Q40, Q43, Q48

Index

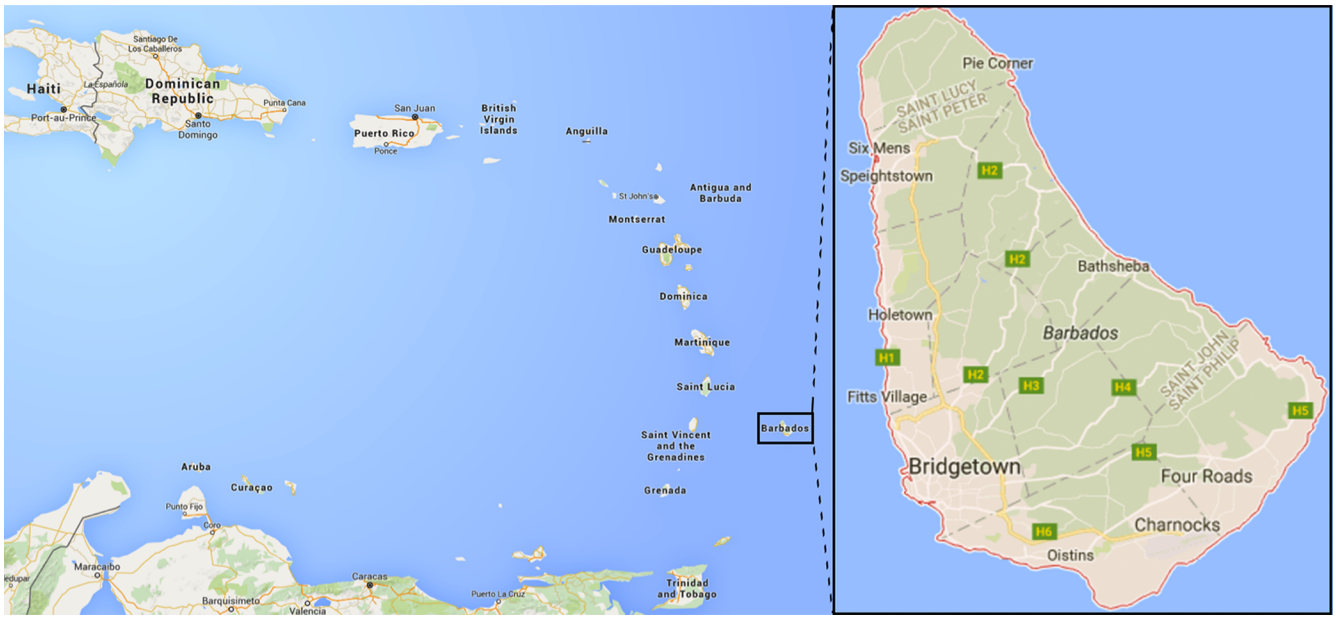
Acronyms

BL&P	Barbados Light & Power Limited
BNOCL	Barbados National Oil Company Limited
BNTCL	Barbados National Terminal Company Limited
boe	Barrels of oil equivalent
CR&W	Combustible Renewables & Waste
EE	Energy efficiency
ELPA	Electric Light and Power Act
FCA	Fuel Clause Adjustment
FTC	Free Trading Commission
GDP	Gross Domestic Product
GWh	Gigawatt hour
HFO	Heavy fuel oil
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
IRP	Integrated resource plan
Kboe/day	Thousand barrels of petroleum equivalent per day
KW	Kilowatt
LNG	Liquefied natural gas
MW	Megawatt
NAMA	Nationally Appropriate Mitigation Action
NEP	National Energy Policy
NPC	National Petroleum Corporation
NSEP	National Sustainable Energy Policy
OLADE	Latin American Energy Organization
PES	Primary Energy Supply
PV	Photovoltaic
RER	Renewable Energy Rider
SEF	Sustainable Energy Framework
TES	Total Energy Supply

Country Overview: Barbados

Barbados is an island state of the Lesser Antilles located about 180 km east of St. Vincent and the Grenadines. Due to its location eastward of the other islands of the Lesser Antilles it is technically classified as an Atlantic island, not a Caribbean island. Barbados has a population of 284,644 people living across 431 square kilometers, making it one of the most densely populated islands in the world. Around 25 percent of Barbados' population lives in the capital Bridgetown with a total urbanization rate of 44 percent.[1]

Map 1 Barbados



Source: Author's own work

Barbados has performed remarkably well since independence in 1966. Quality of life improved steadily to give Barbados one of the highest standards of living in the western hemisphere. Nominal per capita income increased fourfold between 1980 and 2013 (US$3,458 to US$15,374).[2] Barbados has a high level of development with a score of 0.776 ranking 59th out of 187 countries on the 2013 Human Development Index (HDI).[3] In 2013 it recorded a national GDP of US$4.28bn.[4]

Historically, Barbados' economy relied heavily on agricultural products, especially sugar cane production, and the sector accounted for as much as 60 percent of GDP. The economy, however, has since then become more diversified and the four main sectors contributing to the GDP are retail trade, business and other services, government services and tourism. The largest foreign exchange earning sectors are the tourism and hospitality industry, international business services, manufacturing and agriculture.[5] Exports of goods and services (including tourism and financial services) accounted for 42 percent of GDP in 2012.[6] Over 70 percent of tourists originate from the United Kingdom, United States of America, and Canada, making the tourism subject to the economic conditions in those markets.

[1] World Bank, 2014b.
[2] IMF, 2015.
[3] UNDP, 2014.
[4] IMF, 2015.
[5] Invest Barbados, 2010.
[6] World Bank World Development Indicators data, 2012.

Current Energy Sector

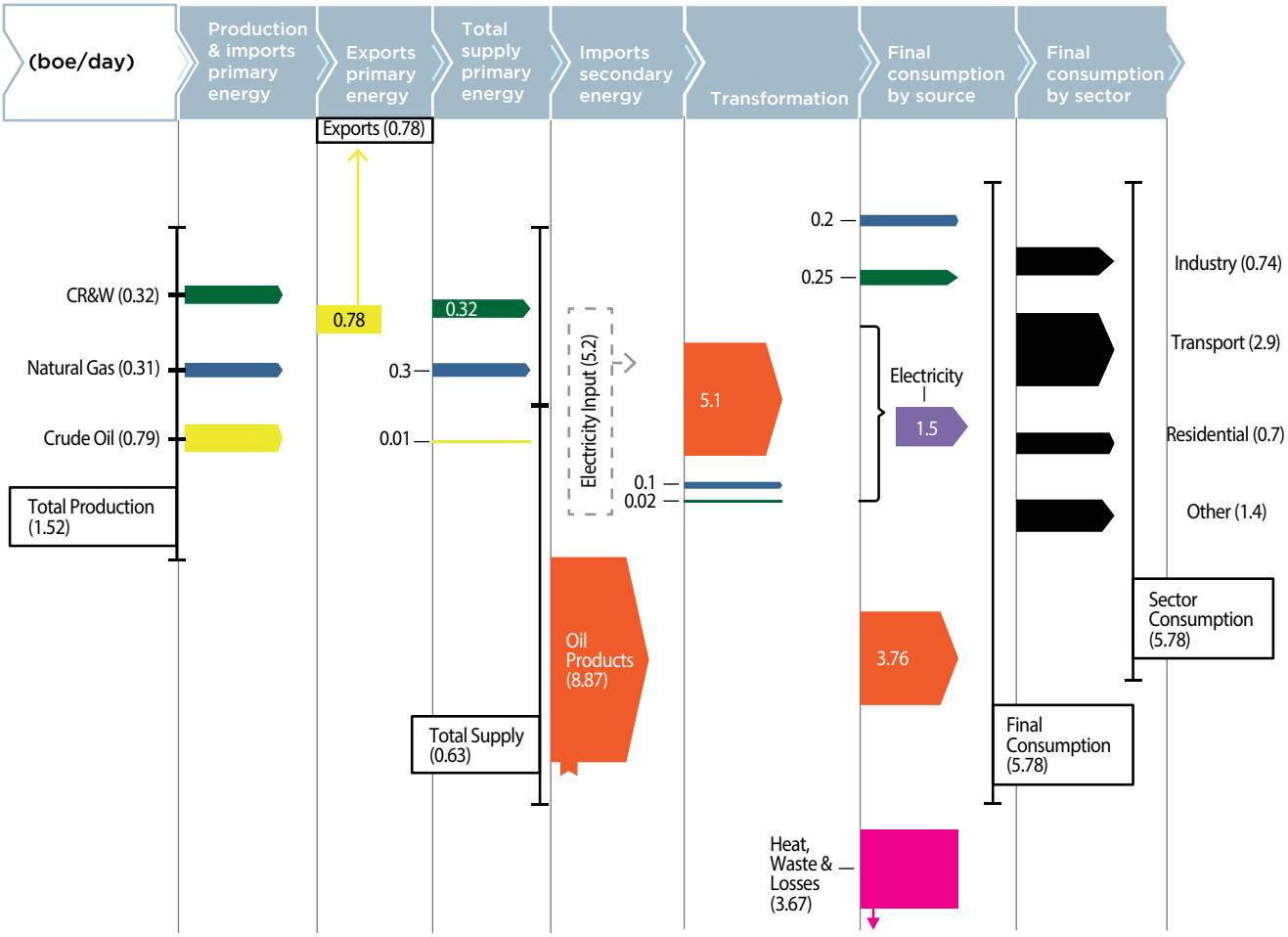
Description of Energy Matrix

Barbados produced 1,520 barrels of oil equivalent of primary energy per day (boe/day), coming from 320 boe/day of combustible renewables and waste (CR&W), 310 boe/day of natural gas and 790 boe/day of crude oil of which 780 boe/day are subsequently exported. Total supply of primary energy stood at 630 boe/day. It imports 8,870 boe/day of oil products, 5,100 boe/day of which are used for the generation of 1,760 boe/day of electricity. Losses during the generation process account for 3,670 boe/day.

In total, final consumption of Barbados is 5,780 boe/day, of which 180 boe/day are natural gas, 250 boe/day are CR&W, 1,580 boe/day are electricity and 3,760 boe/day are in the form of oil products.

Consumption by sector is as follows: The transportation sector consumes about 2,920 boe/day equal to 50 percent of energy, followed by the industrial sector with 740 boe/day, and the residential sector with 710 boe/day. Other, which includes agriculture, combines for 1411 boe/day.

Figure 1 Barbados, 2011



Inter-American Development Bank, 2015
Infraestructure & Enviroment / Energy

Editor: Ramón Espinasa (INE/ENE).
Authors: Malte Humpert
Source: Own calculations based EIA World energy Balances

Total Energy Supply

The Total Energy Supply (TES) in Barbados totaled 9,500 boe/day in 2011. This supply is made up mainly of oil products, all of which are entirely imported. Other important sources are CR&W fuels (basically firewood for rural consumption) and natural gas. Crude oil production is exported except for 10 barrels a day.[7]

Out of the 9,500 boe/day supplied in 2011, 8,870 came from the import of oil products – around 93 percent of the total supply. The second largest source of energy, like in the majority of countries of the Caribbean, were combustible renewables and waste. This resource totaled 320 boe/day and represented 3.5 percent of the TES. Natural gas is third level of importance and contributed 310 boe/day to the TES, equal to 3.5 percent.[8]

Domestic Production

In 2011, Barbados produced about 790 boe/day of crude oil from around 250 onshore wells in the Woodbourne area located in the southeast of the island. As the country does not possess any refining capacity, crude oil is shipped to Trinidad and Tobago for processing and the refined product is subsequently returned to the island. As domestic production supplies only about 15 percent of the total energy need, the majority of the energy supply is imported.[9]

Figure 2 Share of Total Energy Supply,2011

Source: United Nations Statistics Division, 2013

In addition to its crude oil production Barbados also produced about 310 boe/day of natural gas, used for domestic consumption by its approximate 20,000 residential and commercial customers. The natural gas network is owned and operated by the National Petroleum Corporation (NPC), which receives the natural gas from Barbados National Oil Company Limited (BNOCL).

Commercial Balance of Primary Energy

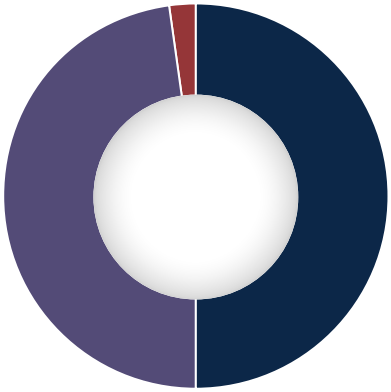
Barbados did not import any primary energy in 2011.

[7] United Nations Statistics Division, 2013.
[8] United Nations Statistics Division, 2013.
[9] Castalia, 2010; Williams, 2010.

Domestic Primary Energy Supply

The Primary Energy Supply (PES) in Barbados stood at 640 boe/day during 2011, representing around 7 percent of TES. Of this, 320 boe/day came from CR&W, 310 boe/day came from natural gas, and 10 boe/day came from crude oil. CR&W represents 50 percent of PES, followed by natural gas with 48 percent and crude oil with 2 percent.[10]

Figure 3 Share of Primary Energy Supply, 2011

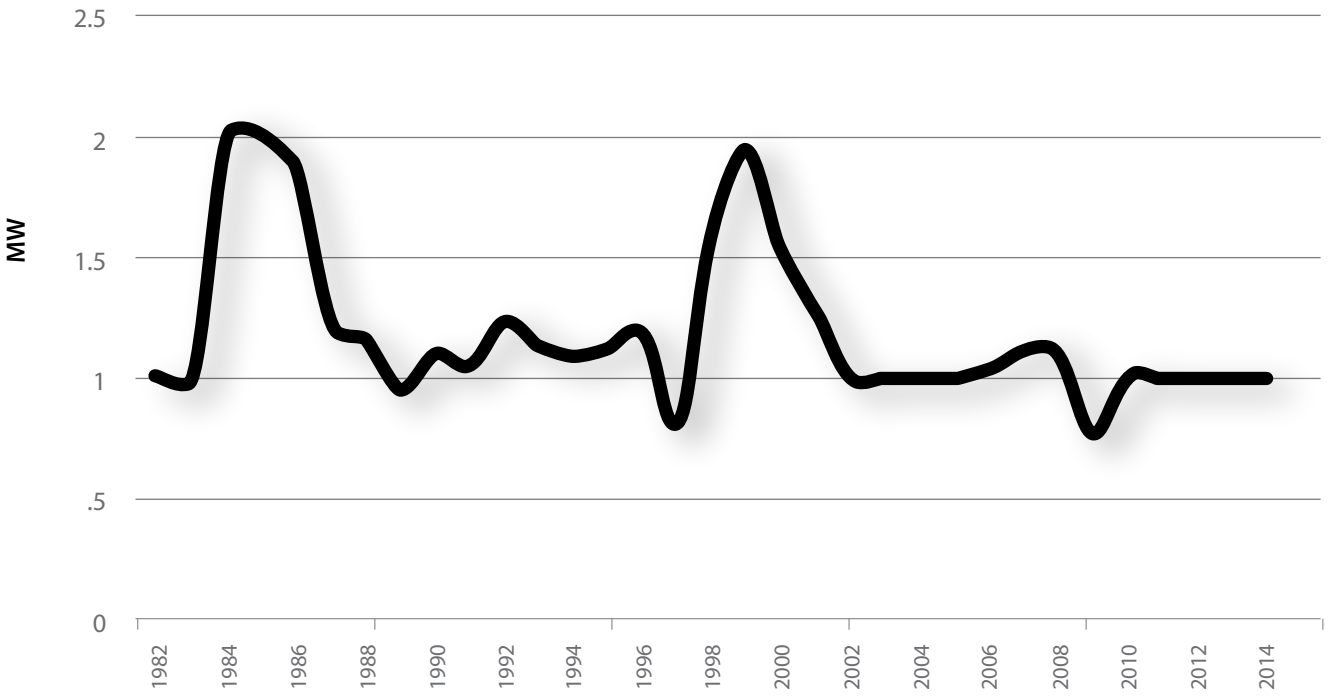


50% CR&W
48% Natural Gas
2% Crude Oil

Source: United Nations Statistics Division, 2013

Between 1982 and 2014, Barbados' crude oil production has fluctuated between 750 boe/day and 2000 boe/day. Since the year 2001, production has been mostly stable around 1000 boe/day.

Figure 4 Crude Oil Production, 1982-2015



Source: EIA, 2015

Electricity

Installed Capacity

Barbados Light & Power Company (BL&P), the country's sole utility company, has an installed capacity of 256.6MW and supplies electricity to around 125,991 customers. In addition to BL&P's utility-scale generation capacity, a number of hotels and commercial buildings operate back-up diesel generation in case of outages and for self-consumption. According to 2010 estimates, these installations accounted for 8 percent of total installed generation capacity on Barbados.[11] Furthermore, with the introduction of the Renewable Energy Rider (RER) in 2010, a growing number of grid-connected distributed solar photovoltaic (PV) systems have been and continue to be added to the grid. Their total capacity stood at around 10.4MW at the end of 2015 and is currently capped at 20MW.[12]

BL&P operates three power stations. The Spring Garden Power Station opened in 1967 and is the main generation station, with an installed capacity of 153.1MW. It also houses BL&P's generation control room. The site consists of three main stations. The Steam Station houses two steam turbine generators with a capacity of 20MW. The units are slated for decommissioning at the beginning of 2017. The Low-Speed Diesel Station "A" houses four low-speed diesel generators with a capacity of 12.5MW each, which are connected to a co-generating unit with a capacity of 1.5MW. The units have an expected retirement date of January 2019. The new Low-Speed Diesel Station "B" opened in 2005 and houses the two newest units, two 29.7MW low-speed diesel generators connected to co-generating units with a capacity of 2.2MW. These new units are tentatively scheduled for decommissioning in 20 years at the beginning of 2036. A legacy gas turbine unit remains onsite although it has been officially retired. All of Spring Garden's units are fueled by heavy fuel oil (HFO).[13]

The Seawell Power Station is located near the Grantley Adams International Airport, about 12 kilometers southeast of the capital, Bridgetown. The station has an installed capacity of 73MW and operates four gas turbine generators, one with a capacity of 13MW and three with capacities of 20MW each. The units were installed in 1996, 1999, 2001, and 2002 and are slated for retirement at the beginning of 2022, 2025, 2027, and 2028 respectively. The 13MW unit and two of the 20MW units have been refueled to run on diesel fuel while one unit continues to run on Jet A1. The station is fully developed and is operated and run remotely via a fiber-optic link from the Spring Garden station.

The Garrison Hill Power Station operates a single diesel-fired gas turbine generator with a capacity of 13MW; it was installed in 1990. The unit is scheduled for decommissioning at the beginning of 2017.

[11] Castalia, 2010; Williams, 2010; World Bank, 2010.
[12] FTC, 2015b, BL&P, 2016a.
[13] BL&P, 2014c.

Table 1 Inventory of BL&P Power Stations, 2015

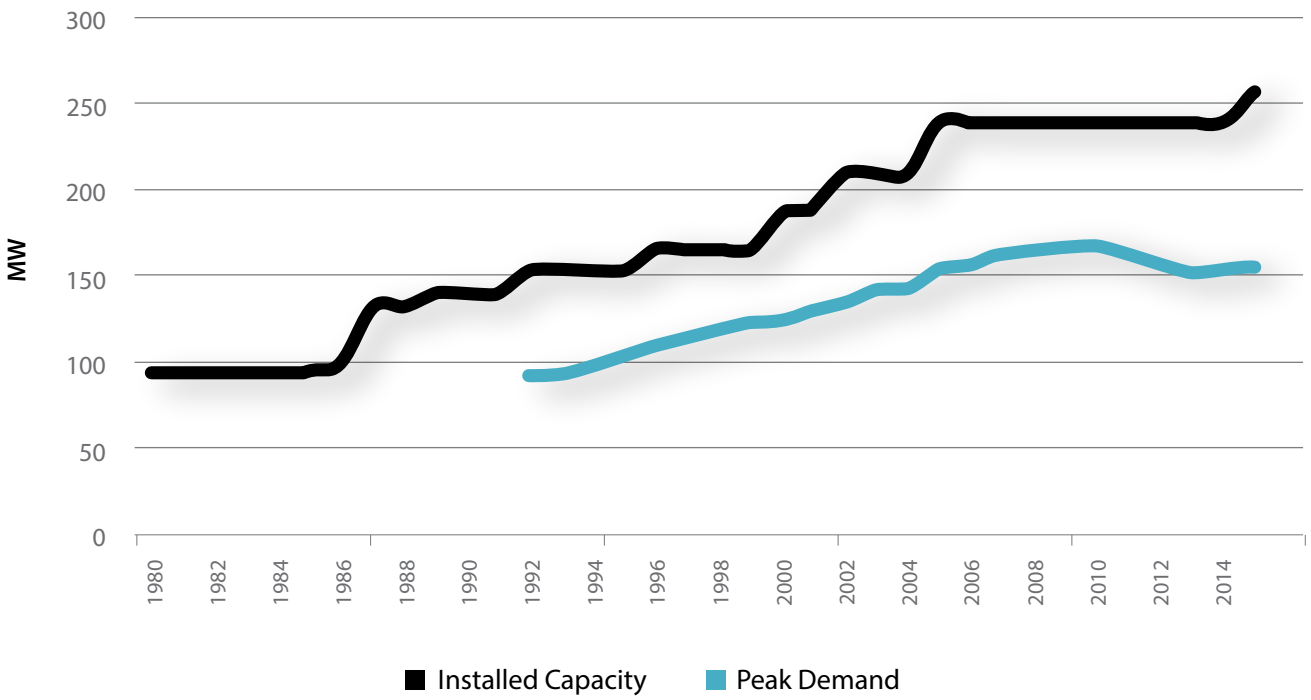
Power Stations	Fuel	Capacity	Details	Heat Rate kJ/kWh	Year of PPA
BL&P		256.6MW			
Spring Garden		153.1MW	Opened 1967		
S1	HFO	20MW	Steam Turbine Generator	14,377	2017/01
S2	HFO	20MW	Steam Turbine Generator	14,377	2017/01
S10	HFO	12.5MW	Low Speed Diesel Generator	8,063	2019/01
S11	HFO	12.5MW	Low Speed Diesel Generator	8,063	2019/01
S12	HFO	12.5MW	Low Speed Diesel Generator	8,063	2019/01
S13	HFO	12.5MW	Low Speed Diesel Generator	8,063	2019/01
CG01		1.5MW	Co-generating unit connected to D10-13		2019/01
CG02		2.2MW	Co-generating unit connected to D10-13		2036/01
DA14	HFO	29.7MW	2005, Low Speed Diesel Generator	7,456	2036/01
DA15	HFO	29.7MW	2005, Low Speed Diesel Generator	7,456	2036/01
GT01			Retired		
Seawell		73MW			
GT03	Diesel	13MW	1996, Gas Turbine Generator	13,276	2022/01
GT04	Diesel	20MW	1999, Gas Turbine Generator	11,134	2025/01
GT05	Av-Jet	20MW	2001, Gas Turbine Generator	11,134	2027/01
GT06	Diesel	20MW	2002, Gas Turbine Generator	11,134	2028/01
Garrison Hill		13MW			
GT02	Diesel	13MW	1990, Gas Turbine Generator	13,276	2017/01

Source: BL&P, 2014c

Over the past 35 years, BL&P's capacity has grown by 250 percent, from 94MW in 1980 to 239.1MW in 2005 when the last additions were made in the form of two low-speed diesel units. Significant increases in capacity were recorded between 1985 and 1989, when capacity increased from 94MW to 140MW, and again between 1999 and 2002 from 165.5MW to 209.5MW.

Barbados' peak demand similarly increased significantly over the past twenty years. Between 1993 and 2013, peak demand grew by 65 percent from 92MW to 152MW. Peak demand reached 167.5MW in 2010 and has since declined slightly to 155.2MW in 2015. As shown below, peak demand in Barbados was on a continuous upward trend, growing 3–4 percent per year between 1999 and 2005. Growth then slowed to about 1–2 percent between 2006 and 2010 and has since slowly declined by about 10 percent, in part due to limited economic growth and due to the introduction and significant expansion of distributed solar PV self-generation.

Figure 5 BL&P Installed Capacity and Peak Demand, 1980-2015



Source: BL&P, 2004; BL&P, 2005; BL&P, 2006; BL&P, 2007; BL&P, 2008; BL&P, 2009; BL&P, 2010; BL&P, 2011; BL&P, 2012; BL&P, 2013; BL&P, 2014a

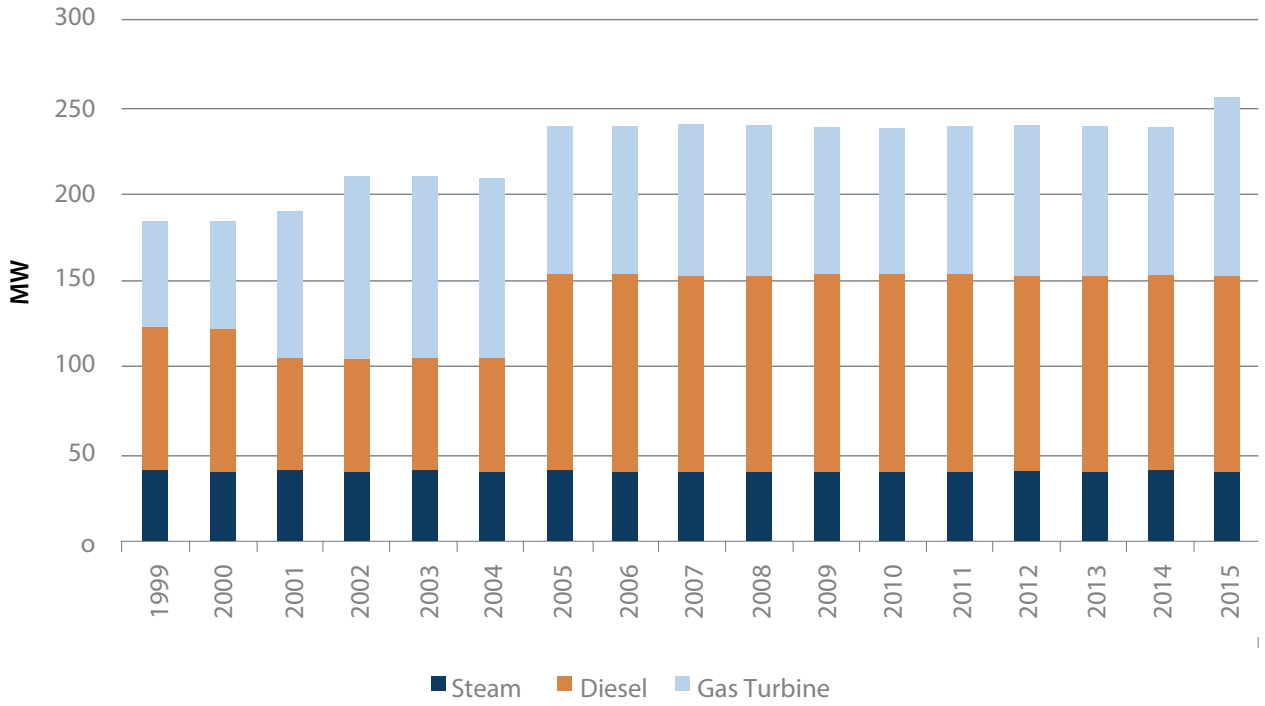
BL&P operates 113.1MW of low-speed diesel generators accounting for 44 percent of installed capacity, 103.5MW of gas turbine generators representing 40 percent of capacity, and 40MW of steam turbine generators accounting for 16 percent.

Figure 6 BL&P Share of Installed Capacity by Type, 2015

Source: BL&P, 2016 a

Between 2001 and 2005, gas turbines accounted for 50 percent of installed capacity. Following the addition of two 29.7MW low-speed diesel generators in 2005 and the subsequent retirement of a 20MW a gas turbine generator, low-speed diesel generators have accounted for nearly half of capacity for the past ten years.

Figure 7 BL&P Installed Capacity by type, 1999-2015



Source: BL&P, 2014c; BL&P,2016a

Distributed Capacity under the Renewable Energy Rider Program

Barbados began a distributed renewable energy program in 2009 on a pilot basis; it was made permanent in 2010. By 2014, 6.8MW of capacity had been installed under the program, which allows participating private citizens of businesses to sell excess electricity to BL&P. Installed capacity in 2015 stood at 10.4MW. Total system capacity is currently limited to 20MW by the Fair Trading Commission (FTC).[14]

Table 2 Renewable Energy Rider Capacity, August 2015

System Size	Installed Capacity, MW	Committed Applications, MW
Residential < 5kW	1.7	0.3
Residential > 5kW	2.1	0.4
Commercial < 25kW	0.8	0.8
Commercial > 25 kW	4.3	6.5
Total	8.9	8.1

Source: IRENA, 2016

[14] BL&P, 2016a.

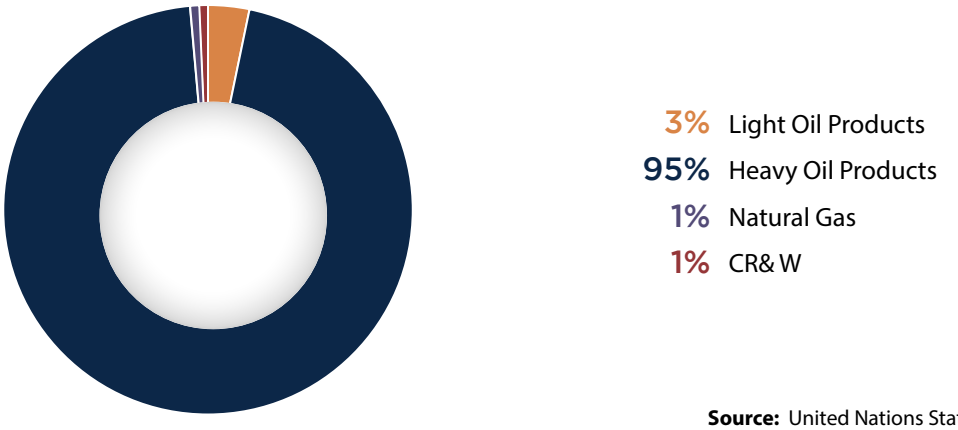
Current Expansion of Capacity

In August 2015, BL&P signed a contract with South American firm Grupotec for the construction of a 10MW (DC)/8MW (AC) solar PV plant at Trents, St. Lucy. Construction for the BB$43 million project began in November 2015 and the plant is being construction on 42 acres of land. BL&P expects the facility to provide BB$10 million in fuel cost savings, reducing oil imports by 73,000 barrels while generating 20GWh of electricity powering 7,700 households, equivalent to 2.2 percent of the island's electricity. The 44,000-panel installation was connected to the grid in early June 2016.[15] According to BL&P the utility is considering a similar-sized installation in another part of the island.[16] The 10MW capacity of the solar plant will not count towards the 20MW limit set by the FTC.[17]

Input to electricity generation

According to the United Nations Energy Balances, of the 5,200 boe/day intended for electricity generation in 2011, 5,100 boe/day came from liquid fuels, 100 boe/day came from natural gas, and 20 boe/day came from CR&W. As BL&P does not operate units that run on natural gas or CR&W, these inputs must be used for off-grid self-generation units.[18] HFO and diesel fuels accounted for more than 99 percent of inputs into electricity generation in 2011.

Figure 8 Share of Inputs into Electricity Generation by Fuel Type, 2011



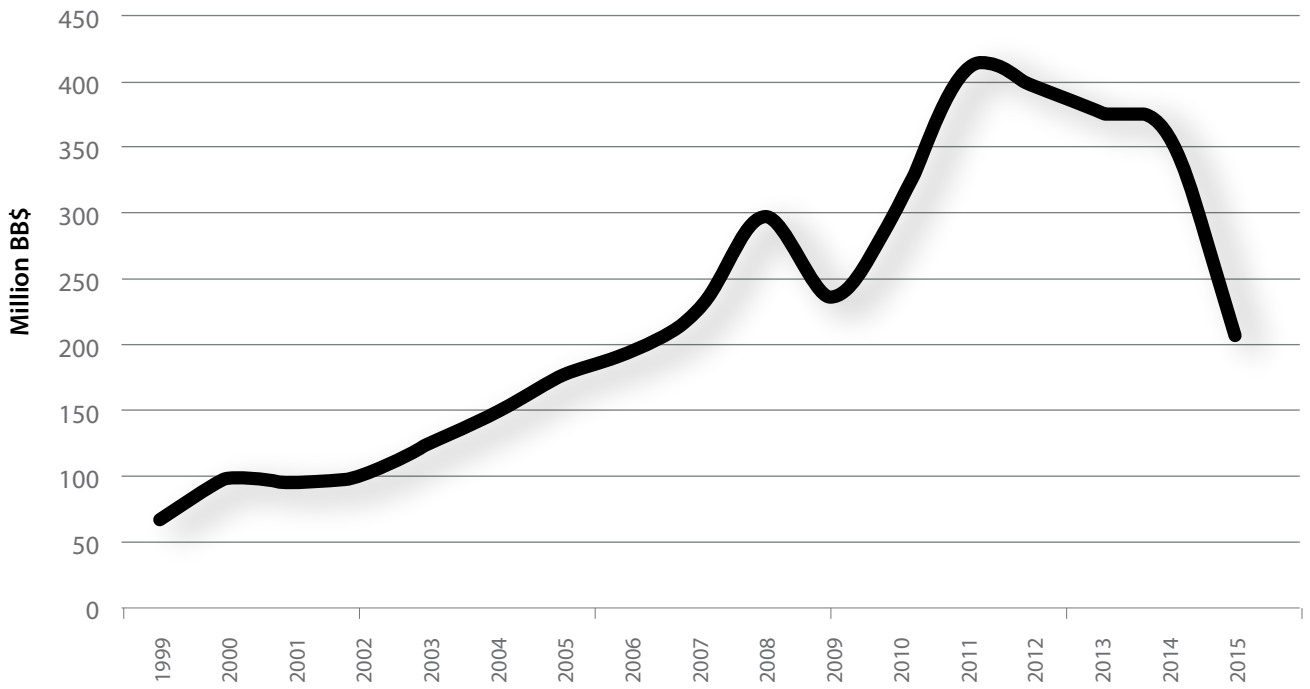
Source: United Nations Statistics Division, 2013

There does not yet exist utility-scale renewable energy generation capacity in Barbados. Following the introduction of the RER in 2010, however, the prevalence of small, grid-connected distributed solar PV installation has increased significantly and these units represent around 10MW of capacity. In addition, the prevalence of solar water heaters in middle- and high-income households represents a significant contribution to reducing electricity demand. About 40 percent of properties in Barbados, totaling about 50,000 homes, employ solar hot water heaters, saving an estimated 100,000MWh of electricity annually.[19] The popularity of solar water heaters can in part be explained by the effects of the Fiscal Incentive Act of 1974, which grants import benefits and tax exemptions to solar water heater producers, and by the 1984 Income Tax Amendment, which allowed taxpayers to directly and fully deduct solar water systems from their taxes.[20] The renewable energy potential in Barbados is high due to high levels of solar radiation and a steady wind supply due to its location in the trade winds.

[15] http://www.nationnews.com/nationnews/news/84008/hoyos-file-solar-investments-hanging-balance.
[16] Barbados Today, 2016.
[17] Grant, 2015.
[18] United Nations Statistics Division, 2013.
[19] Bugler, 2012.
[20] FTC, 2014f.

The high reliance on imported oil products for fossil fuel generation has meant a significant increase in BL&P's fuel costs over the past fifteen years. The utility recovers fuel costs through the Fuel Clause Adjustment, which is set on a monthly basis. Fuel costs increased from BB$67 million in 1999 to more than BB$400 million in 2011. In 2013 and 2014 BL&P recorded fuel expenses of BB$376.7 million and BB$361.4 million respectively. With the declining world oil prices since late 2014, BL&P's fuel costs came down significantly, to BB$208.7 million in 2015.[21]

Figure 9 BL&P Fuel Costs, 1999-2013



Source: BL&P, 2004; BL&P, 2005; BL&P, 2006; BL&P, 2007; BL&P, 2008; BL&P, 2009; BL&P, 2010; BL&P, 2011; BL&P, 2012; BL&P, 2013; BL&P, 2014a; BL&P, 2016a

Electricity Matrix

In 2015, net electricity generation by BL&P stood at 967.8GWh, with sales of 915.2GWh. This represents a 1 percent increase in net generation and a 1.4 percent increase in sales over 2014, when the company recorded a net generation of 958.4GWh and sales of 900GWh.

Table 3 BL&P Electricity Generation and Sales in GWh, 2010-2015

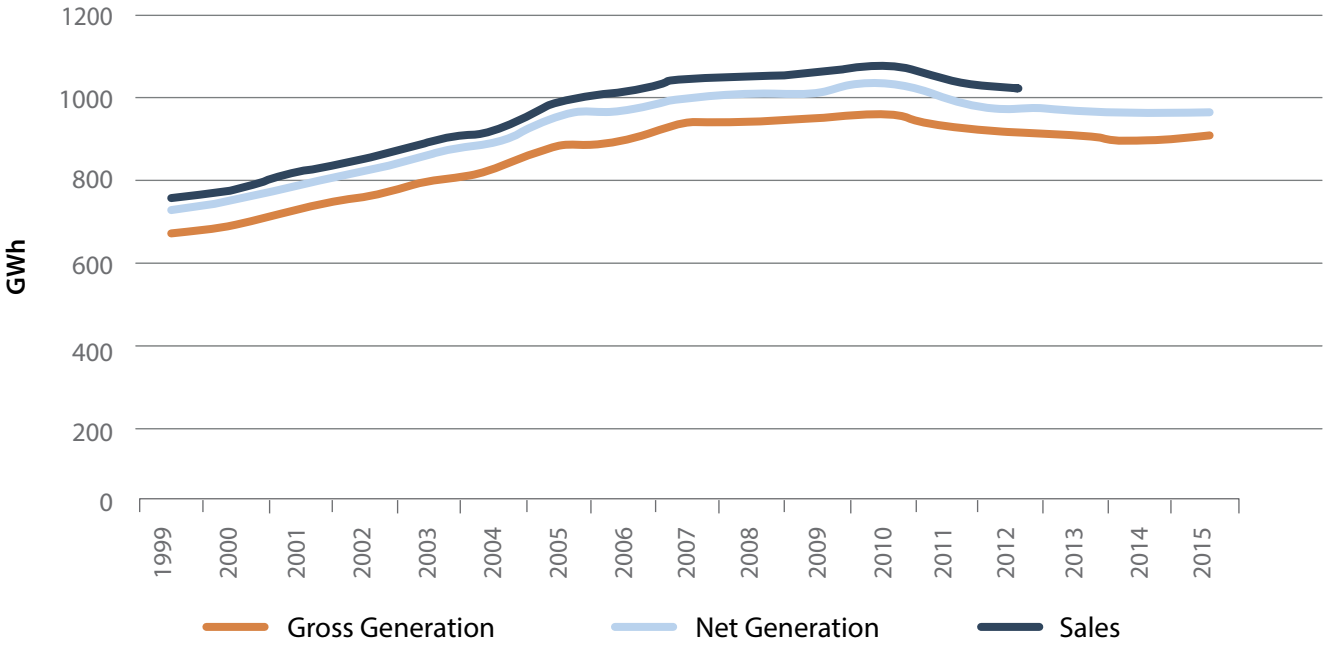
Electricity in GWh	2015	2014	2013	2012	2011	2010
Net Generation	969.4	958.4	969.4	980.9	1001.5	1036.7
Sales	915.2	900	912	918.1	933.3	960.9

Source: BL&P, 2011; BL&P, 2012; BL&P, 2013; BL&P, 2014a; Emera, 2015

[21] BL&P, 2016a.

Over the past 17 years, BL&P's net generation grew by 33 percent from 733GWh in 1999 to 969GWh in 2015. Between 1999 and 2005, generation increased at an annualized rate of 4.5 percent before growth rates declined to 1.7 percent between 2005 and 2010. Since then net generation has decreased at an annualized rate of 2.2 percent. In 2014, sales reached a nine-year low with 900GWh, down around 6.5 percent from the peak of 961GWh in 2010, before growing slightly to 915.2GWh in 2015.

Figure 10 BL&P Electricity Generation and Sales in GWh, 2010-2015



Source: BL&P, 2004; BL&P, 2005; BL&P,2006;BL&P,2007;BL&P,2008;BL&P,2009;BL&P,2010;BLI&P;2011;BL&P,2012;BL&P,2013;BL&P,2014a

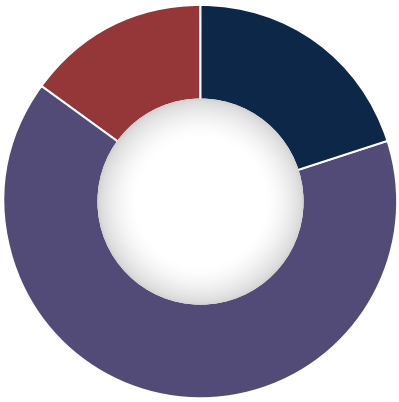
In 2015, low-speed diesel generation accounted for 65 percent of produced electricity with 629.3GWh. BL&P's steam turbines contributed 190GWh representing 20 percent and the company's gas turbines produced 148.5GWh equaling 15 percent.

Table 4 Gross Electricity Generation by Type between 2008-2015, GWh

Electricity in GWh	2015	2014	2013	2012	2011	2010
Steam	190	165.9	198	214.3	189.1	155.3
Diesel	629.3	616.7	626.1	654.3	638.6	708.1
Gas Turbine	148.5	175.8	145.3	155.7	216.3	214.9
Total	967.8	958.4	969.4	1,024.3	1,044.0	1,078.3

Source: BL&P, 2009; BL&P, 2010; BL&P, 2011; BL&P, 2012; BL&P, 2013; BL&P, 2014a; BL&P, 2016a

Figure 11 Share of Electricity Generation by Type, 2012

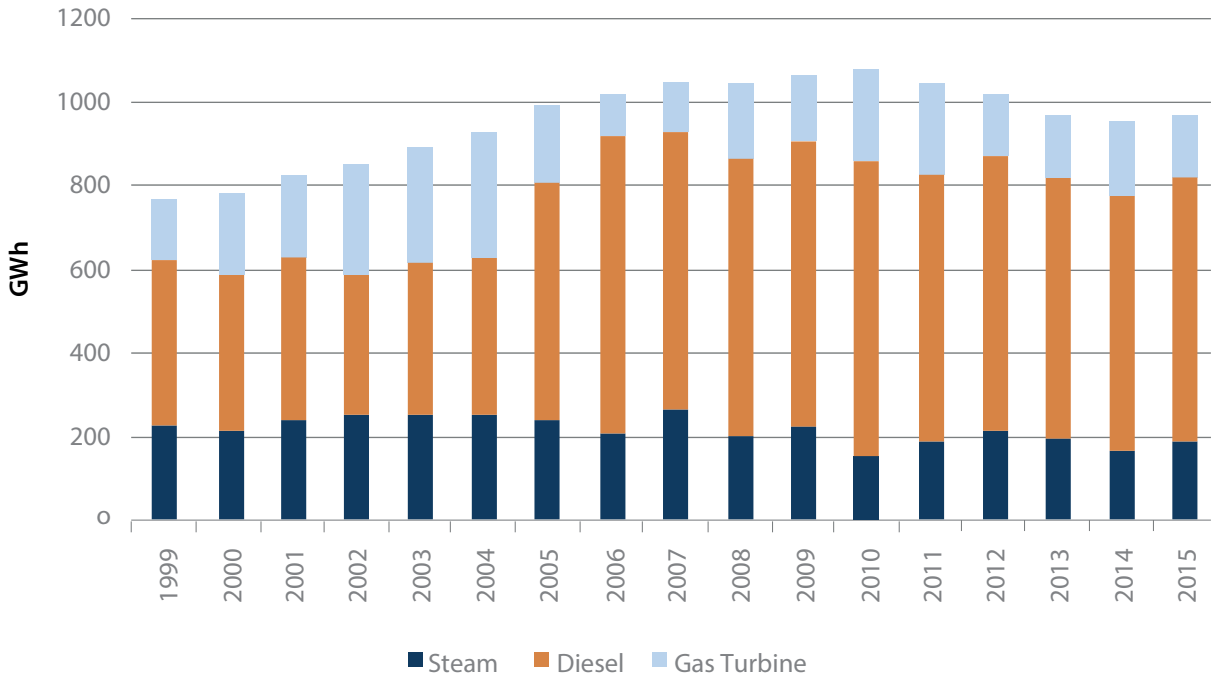


Source: BL&P, 2016a

BL&P's three types of generation capacity each have differing variable and fixed operating and maintenance costs. The company's low-speed diesel generators have the lowest short-run costs (such as fuel and other operating costs), followed by the steam turbines and the gas turbines. In order to produce electricity in the most cost-effective way, BL&P aims to dispatch the units in order of increasing marginal costs. Ideally, units with the lowest short-run costs are run continuously and provide the bulk of electricity. They are known as "base load plants." Units with higher short-run costs that provide capacity throughout the day as demand fluctuates are known as "load following plants." Lastly, units with the highest short-run costs should be reserved to only provide electricity during peak times when the grid records the maximum level of demand. These plants are called peaking power plants.

Prior to the installation of the two new low-speed diesel generators in 2005, the company's gas turbines, with the highest short-run cost, accounted for a significant share of generation and were not just limited to provide peak load electricity. After the two new units were commissioned, electricity generated by BL&P's diesel units rose sharply and the amount of electricity produced by the higher-cost gas turbines decreased.

Figure 12 Electricity Generation by Type, 1999-2015



Source: BL&P, 2004; BL&P, 2005; BL&P, 2006; BL&P, 2007; BL&P, 2008; BL&P, 2009; BL&P, 2010; BL&P, 2011; BL&P, 2012; BL&P, 2013; BL&P, 2014a,2016a

BL&P gives priority to steam turbines and low-speed diesel engines, both running on HFO. Ideally, it would fully prioritize its low-speed diesel engines over the steam turbines, especially for base load operation, as modern low-speed diesel engines are significantly more efficient. But BL&P argues that the steam plants' age (more than thirty years) has made them too unreliable to frequently be turned on and off. They are thus run continuously, even if low-speed diesel engines would produce electricity at a lower marginal cost. A 2013 review by the FTC nonetheless suggests that BL&P prioritize the low-speed diesel engines and keep the steam units on "hot standby." The FTC also recommended in April 2013 to replace the steam turbines with more efficient generating plants.[22]

BL&P's generation costs are relatively low due to a combination of low fuel prices, efficient generation, and limited system losses. The utility company has managed to reduce costs by using HFO for the majority of its generation rather than more expensive diesel fuels. Its generating units, especially the low-speed diesel generators, have a low heat rate and thus generate electricity efficiently. Lastly, BL&P's system losses are among the lowest in the Caribbean at around 6 percent. In combination, these factors mean that BL&P's generation costs fall in line with or are below those of neighboring Caribbean despite relying 100 percent on thermal generation and not being able to take advantage of lower-cost hydropower, as is the case in St. Vincent and the Grenadines, for example.[23]

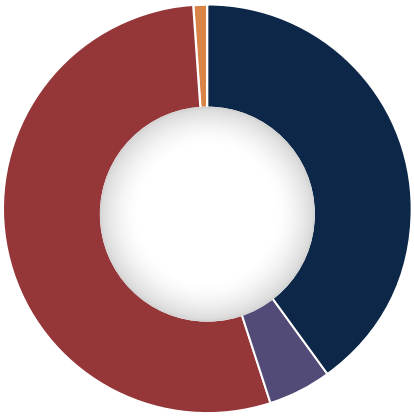
Electricity Generation under the RER Program

By 2015, electricity production under the RER had reached significant levels, representing around 2 percent of annual electricity sales. In 2014, generation reached 5.3GWh and then grew more than threefold to 18.7GWh in 2015.

Consumption by Sector

Electricity access in Barbados is high; over 91 percent of residents have electricity in their homes.[24] The electric utility served 125,991 customers in 2014. Of these, 105,755 were domestic customers and 18,339 were commercial customers. Large commercial and industrial consumers account for almost 54 percent of consumption, followed by residential consumers with 40 percent and smaller commercial consumers at 5 percent. Street lighting accounts for 1 percent. The 84 hotels and guest houses account for almost 10 percent of total electricity sales; between 1999 and 2008 consumption of electricity by the tourism sector grew at an annual rate of 8.5 percent.[25]

Figure 13 BL&P Electricity Sales by Sector, 2015



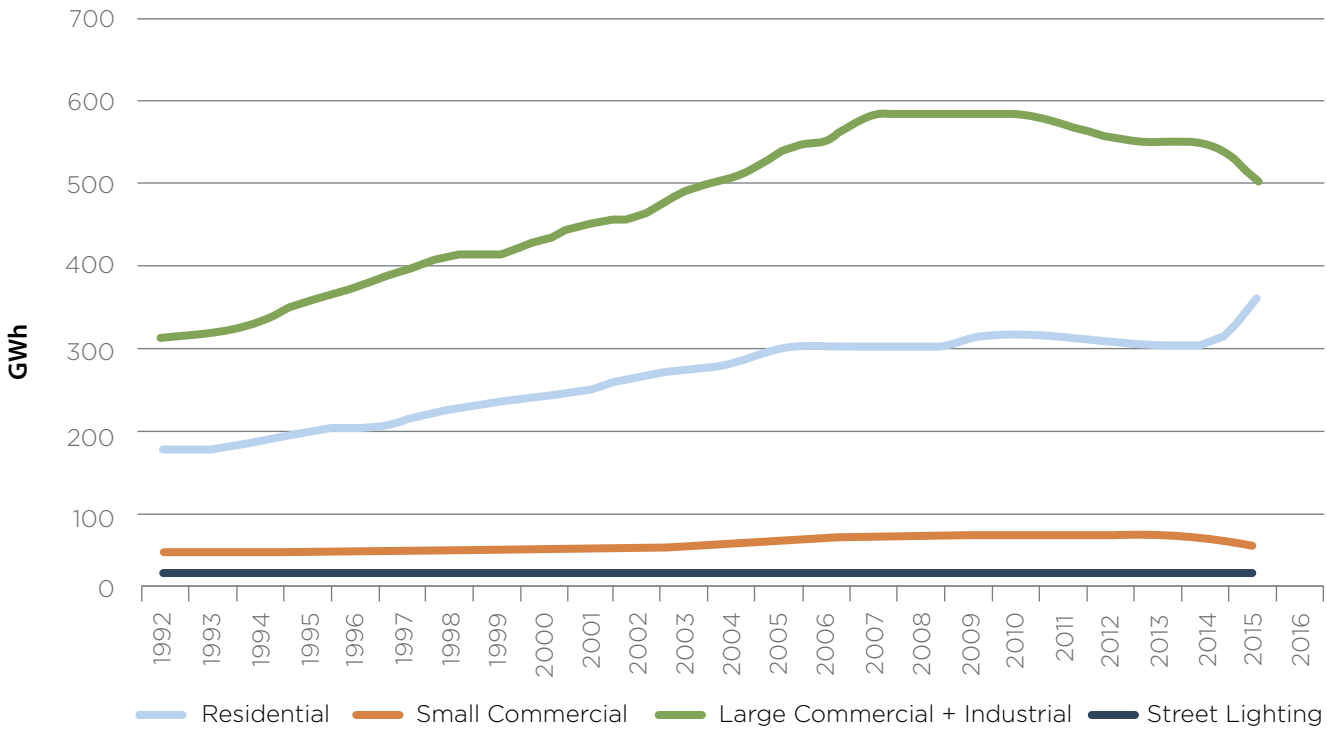
40% Residential
5% Small Commercial
54% Large Commercial Industrial
1% Street Lighting

Source: BL&P, 2016a

[22] FTC, 2013c; FTC, 2014e.
[23] Castalia, 2010.
[24] World Bank, 2016.
[25] Castalia, 2010; Duffy-Mayers, 2010.

Large commercial and industrial consumption grew at an annualized rate of 4.3 percent between 1992 and 2007, increasing from 310GWh to 581 GWh. From its peak of 581GWh in 2007, consumption declined by 1 percent annually and stood at 546GWh in 2013. The residential sector experienced growth of 4.4 percent between 1992 and 2005 when consumption grew from 161GWh to 294GWh. Consumption peaked in 2010 at 310GWh and has since declined by 1 percent per year and stood at 301GWh in 2013. Between 2014 and 2015, residential consumption experienced a sharp growth of nearly 20 percent from 301GWh to 361.6GWh. It is unclear what accounts for this increase. Small commercial consumption recorded the largest annualized growth with 5.6 percent between 1992 and 2009, increasing from 23GWh to 58GWh. Consumption has been flat since then and stood at 57GWh in 2013 and 2014 before declining to 45GWh. Street lighting increased from 8GWh to 10GWh at an annualized rate of 1 percent.

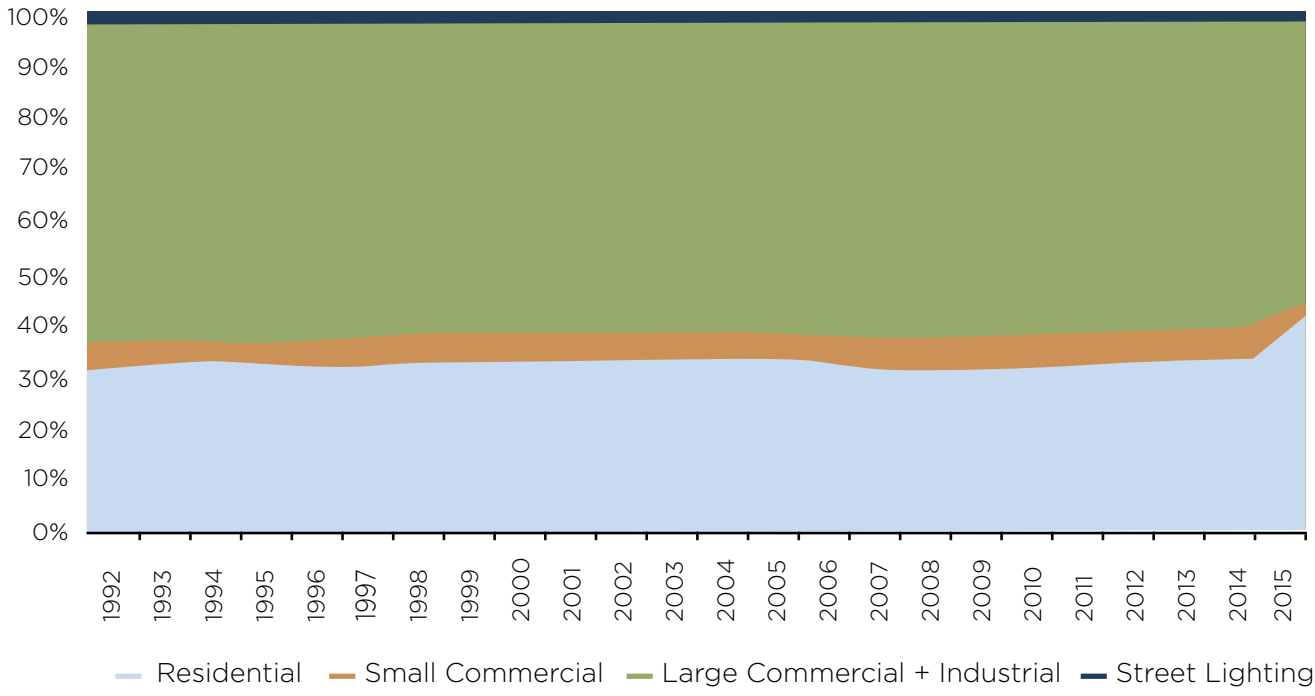
Figure 14 BL&P Electricity Sales by Sector in GWh, 1992-2015



Source: Source: BL&P, 2004; BL&P, 2005; BL&P, 2006; BL&P, 2007; BL&P, 2008; BL&P, 2009; BL&P, 2010; BL&P, 2011; BL&P, 2012; BL&P, 2013; BL&P, 2014a; BL&P, 2014c; BL&P, 2014d; BL&P, 2016a

Setting aside the rapid and unexplained growth in residential consumption in 2015, there has been limited change in the share of electricity sales by sector between 1999 and 2014. In 1992, large commercial and industrial consumption accounted for 61.8 percent of sales, followed by residential consumption at 31.1 percent, small commercial consumption at 4.6 percent, and street lighting at 1.6 percent. More than two decades later in 2014, large commercial and industrial consumption accounted for 59.6 percent, residential for 33 percent, small commercial for 6.3 percent, and street lighting for 1.1 percent due to the rapid increase of residential consumption in 2015.

Figure 15 BL&P Share of Electricity Sales by Sector, 1992-2015



Source: BL&P, 2004; BL&P, 2005; BL&P, 2006; BL&P, 2007; BL&P, 2008; BL&P, 2009; BL&P, 2010; BL&P, 2011; BL&P, 2012; BL&P, 2013; BL&P, 2014a; BL&P, 2014c; BL&P, 2014d; BL&P, 2016a

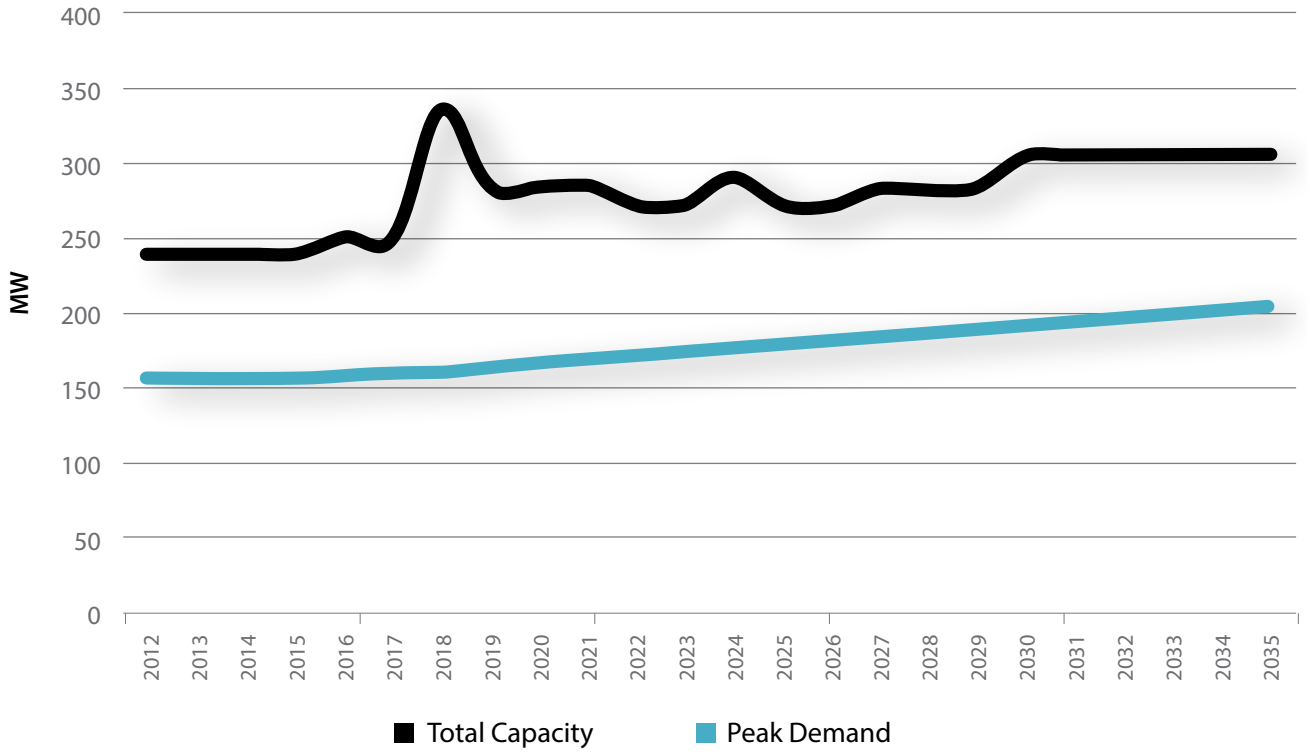
Future Expansion of Capacity

Substantial initial investment will be needed to pursue many of the renewable energy resources identified as commercially and economically viable, as well as the use of natural gas for power generation. According to the 2014 version of BL&P's integrated resource plan (IRP), the utility plans to increase capacity from 239.1MW in 2014 to 305.6 in 2035, representing an annualized growth in capacity of 1.2 percent. Over the same period the company forecasts an increase in peak demand from 157MW to 208MW, an annual growth of 1.4 percent.

Regarding natural gas for power generation, in 2014, the Inter-American Development Bank (IDB) carried out a regional liquefied natural gas (LNG) study to assess LNG options in the Caribbean and showed promising results for Barbados. The study indicates that replacing HFO with LNG for power generation may generate cost savings between 15 and 30 percent even at currently low oil prices. A potential of 110MW (almost half of the total installed capacity of the country) could be upgraded to LNG, resulting in an increased demand of this fuel of approximately 18 million cubic feet per day (mmcfpd) and reduced power generation costs.[26]

[26] BL&P, 2015.

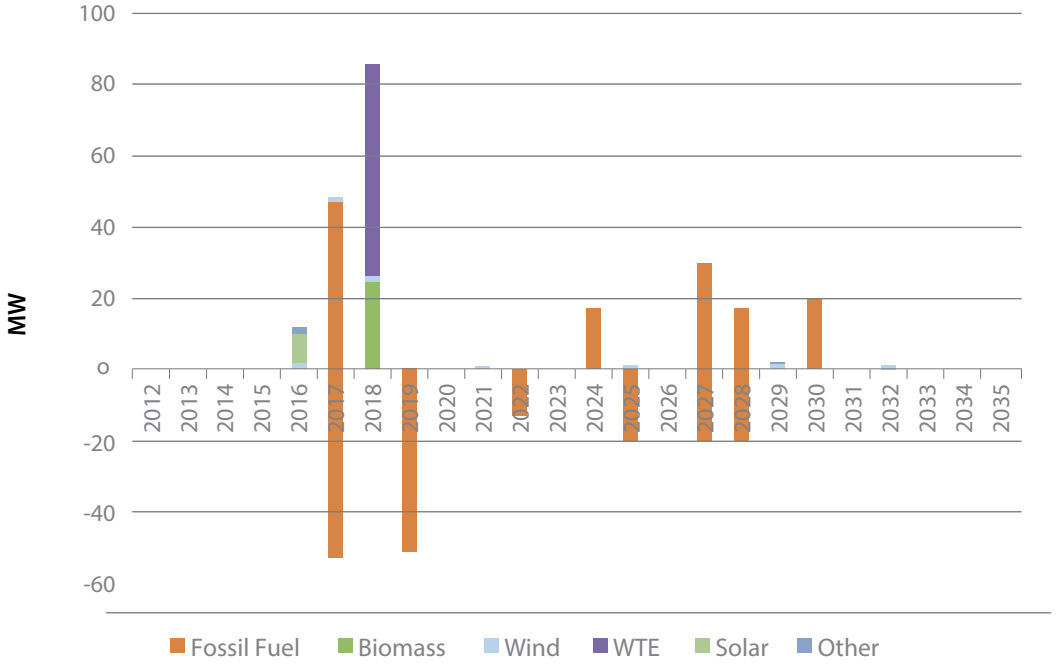
Figure 16 Projected Installed Capacity and Peak Demand, 2013-2035



Source: BL&P, 2014c; BL&P, 2014d

Based on the IRP, the utility will retire a significant number of units over the coming five years. At the end of 2016 the company will retire the two steam turbines at Spring Gardens as well as the single gas turbine at Garrison Hill for a combined capacity of 53MW. Two years later, at the end of 2018, it will retire 60MW of low-speed diesel units. To replace retired capacity, BL&P suggests adding a mix of fossil fuel–based and renewable generation capacity.

Figure 17 Projected Addition and Deduction to BLP´s Generation Capacity, 2013-2035



Source: BL&P, 2014c; BL&P, 2014d

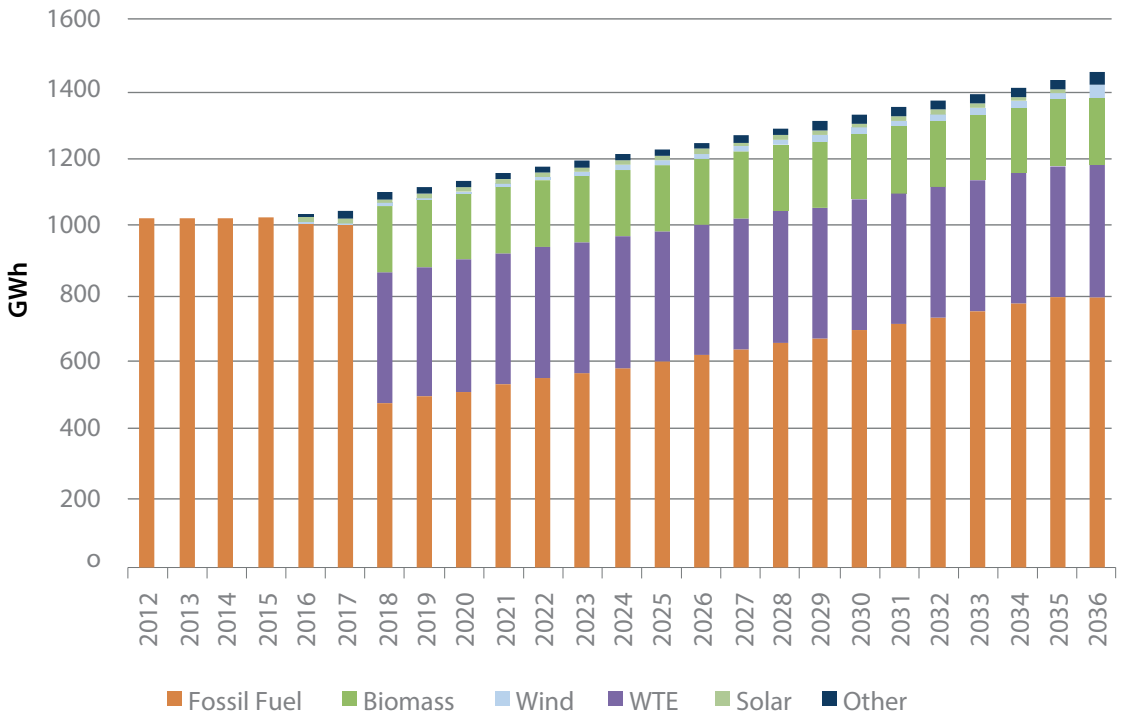
Based on BL&P's plan, the share of its electricity generated from fossil fuels will decrease from 100 percent in 2014 to 54 percent in 2035. Waste-to-energy-based (WTE) generation will account for 27 percent, followed by biomass with 13 percent, wind at 3 percent, solar at 1 percent, and other at 2 percent.

Figure 18 Share of Electricity Net Generation by Type, 2036

Source: BL&P, 2014c; BL&P,2014d

The IRP indicates, however, that fossil fuel–based generation will remain a key provider of electricity over the next two decades. Starting in 2018, the share of electricity generated from fossil fuels will decrease by more than 50 percent, with the introduction of waste-to-energy and biomass-based generation. From 2018 to 2035, BL&P foresees the share of fossil fuel–based generation will increase again.

Figure 19 Net Generation by Type, 2012-2036

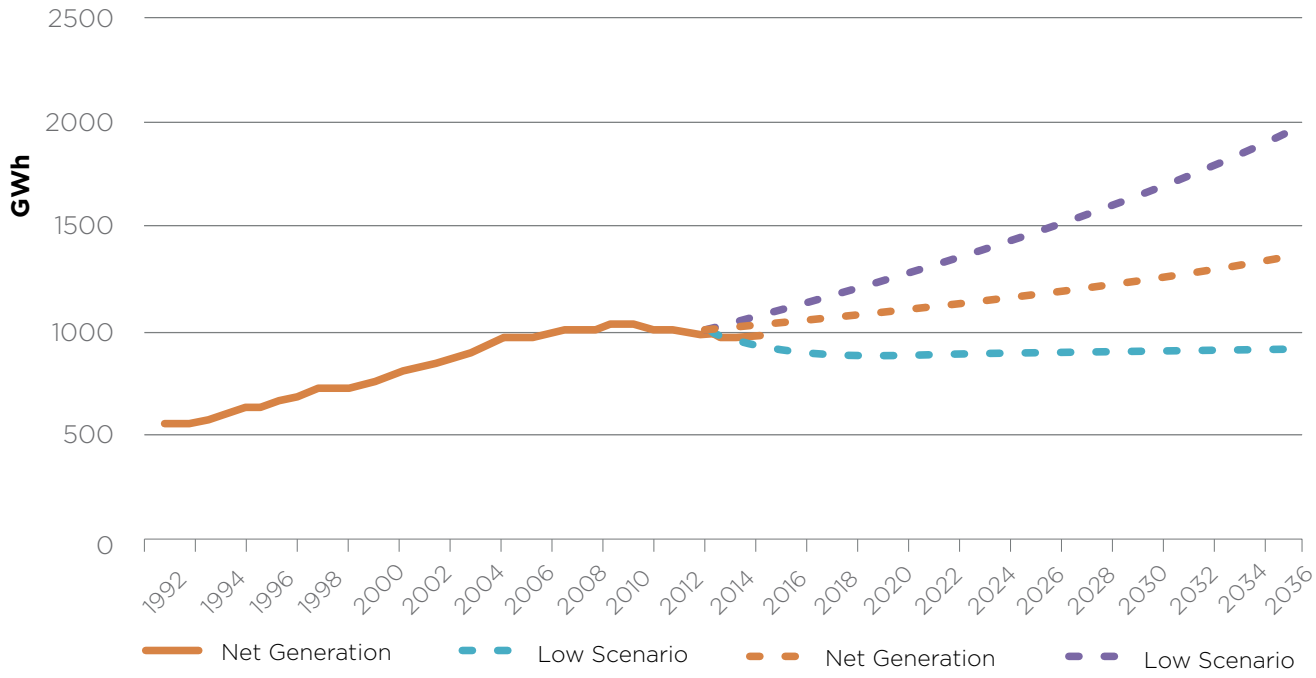


Source: BL&P, 2014c; BL&P, 2014d

Future Demand

BL&P examined three demand scenarios for the period of 2013–2036. Under the low scenario, demand would decline at an annualized rate of -0.25 percent from 955GWh to 903GWh. Under the base scenario, assuming a continuation of the consumption pattern seen over the past two decades, consumption would increase at 1.4 percent per year from 989GWh to 1358GWh. The high-demand scenario would see annual demand increases of 3 percent and consumption would almost double from 1003GWh to 1986GWh.

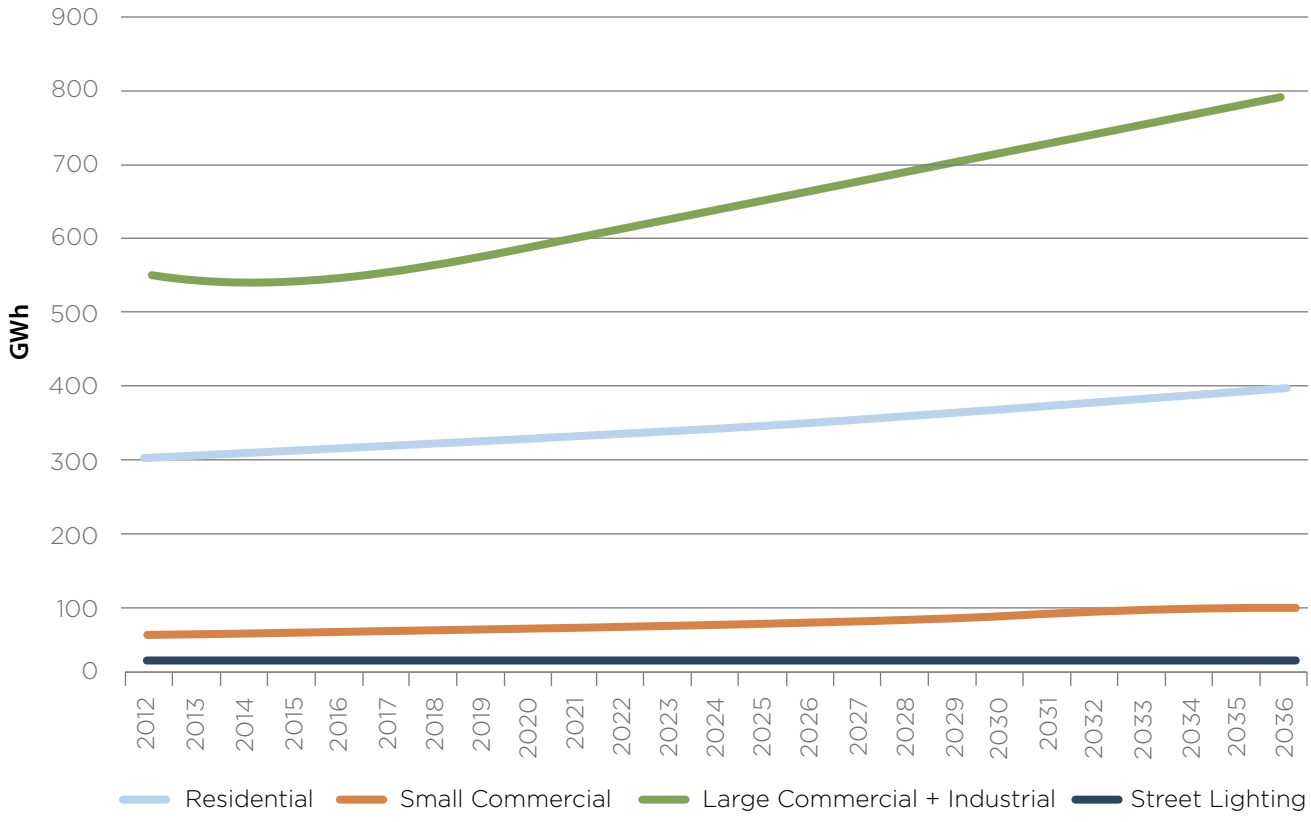
Figure 20 Projected Electricity Demand, 2013-2036



Source: BL&P, 2014C; BL&P, 2014D; BL&P, 2016a.

Under the base scenario, large commercial and industrial consumption would increase from 546GWh to 778GWh, residential consumption would grow from 301GWh to 386GWh, small commercial consumption would increase from 57GWh to 91GWh, and street lighting would remain stable at 10GWh.

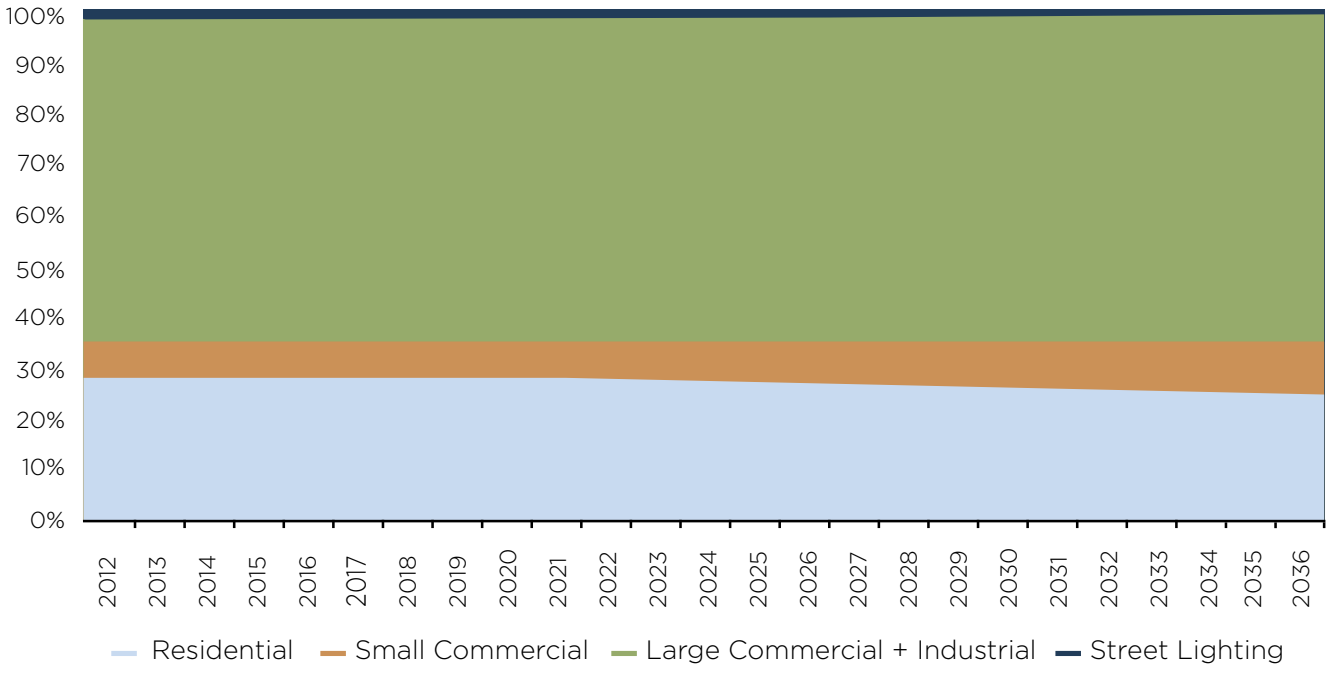
Figure 21 Projected Electricity Demand by Sector, 2012, 2036



Source: BL&P, 2014c; BL&P,2014d

The share of large commercial and industrial consumption as part of total consumption would expand slightly from 59.5 percent to 61.5 percent. Residential consumption would decline from 33 percent to 30.5 percent and small commercial consumption would grow slightly from 6.4 percent to 7.2 percent.

Figure 22 Projected Share of Electricity Demand by Sector, 2012-2036



Source: BL&P,2014c; BL&P,2014d

Barbados Wind and Solar Integration Study

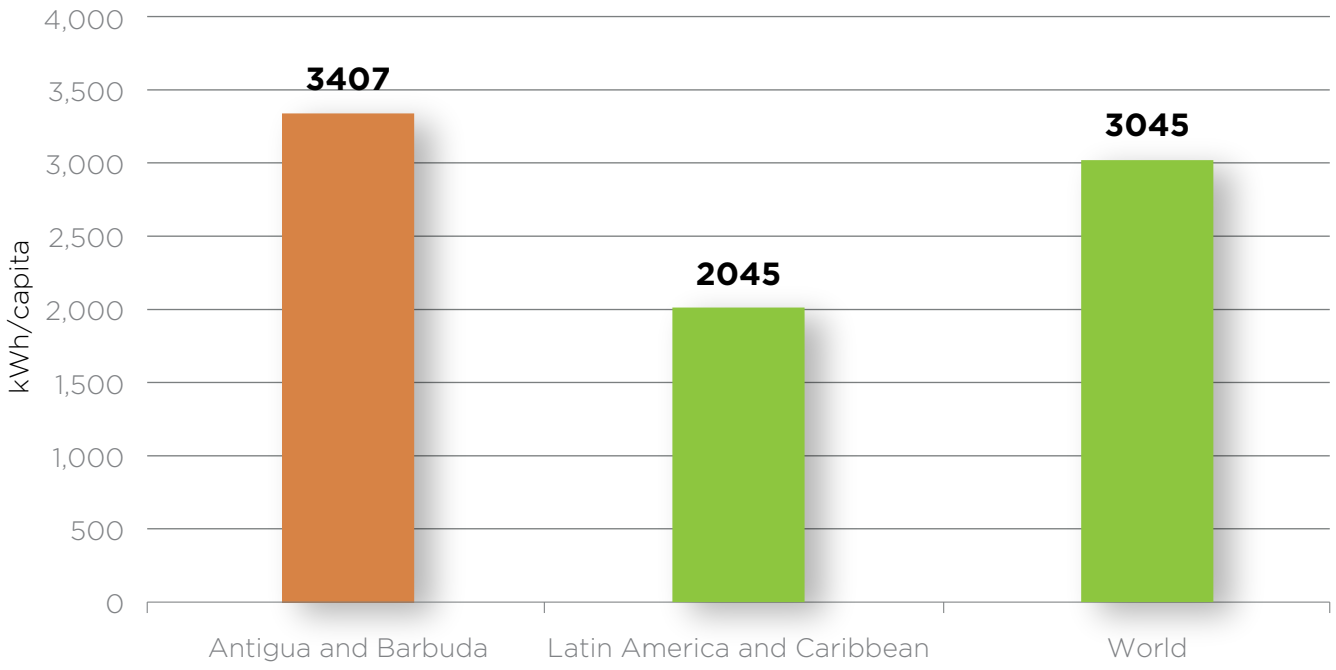
Following the IRP, BL&P released the Barbados Wind and Solar Integration Study in February 2015. This study produced a model with General Electric Energy Management Consulting indicating that the existing grid can accept up to 65MW of wind and solar capacity without the need for storage or supply-and-demand controls. The study examined scenarios, which included 15–45MW of distributed solar PV, 0–20MW of central solar PV, and 10–15MW of wind. BL&P concluded that 20MW of distributed PV, 20MW of centralized PV, and 15MW of wind capacity can be added to the grid under current operating conditions with mitigation measures. Under the study's favored scenario, around 130GWh—equal to 12 percent of total load—would be produced by wind and solar capacity.[27]

BL&P indicated that in the examined scenarios its production costs were reduced by between BB$19million and BB$62.5million per year, equal to 5–15 percent of its energy production costs. It also stated that wind and solar capacity as part of the overall energy mix will act as a natural hedge against volatility on the oil market and in the currency exchange rate. Adding renewables to the grid would reduce the country's oil consumption by 66,000–225,000 barrels of oil per year.[28]

As of summer 2015, BL&P indicated that it would be adding up to 55MW of renewable energy capacity to the grid over the next two years alone. Of this, 38MW will come from solar power, 15MW from wind, and 2MW from thermal and heat recovery. BL&P aims to convert to 100 percent clean energy generation between 2029 and 2045 and phase out over 200MW of existing "legacy generation" capacity consisting of low-speed diesel and steam turbine generation.[29]

Barbados' per capita consumption of electricity stands at 3407kWh, roughly 60 percent more than the Latin American and Caribbean average and about 10 percent higher than the world per capita average. Relatively low electricity costs, high consumption in the tourism and hospitality sector, and a high level of development help to explain the above-average level of electricity consumption per capita.

Figure 23 Electricity Use per Capita, 2013



Source: BL&P, 2014a; UN, 2014; World Bank, 2014a

[27] BL&P, 2015.
[28] BL&P, 2015.
[29] Hoyos, 2015.

Secondary Balance and Consumption

Secondary energy balance

Barbados does not have any refining capacity and thus imports all liquid fuels from Trinidad and Tobago.

Final consumption by sector

Energy consumption in 2011 totaled 5780 boe/day. The transportation sector dominated the use with 2920 boe/day representing 50 percent, followed by the industrial sector with 740 boe/day representing 13 percent, the residential sector with 710 boe/day also representing 13 percent, and other (including agriculture) with 1410 boe/day representing 24 percent.

Figure 24 Energy Consumption by Sector, 2011

Source: United Nations Statistics Division, 2013

Institutional Organization of the Energy Sector and Legal Framework

Institutional Structure

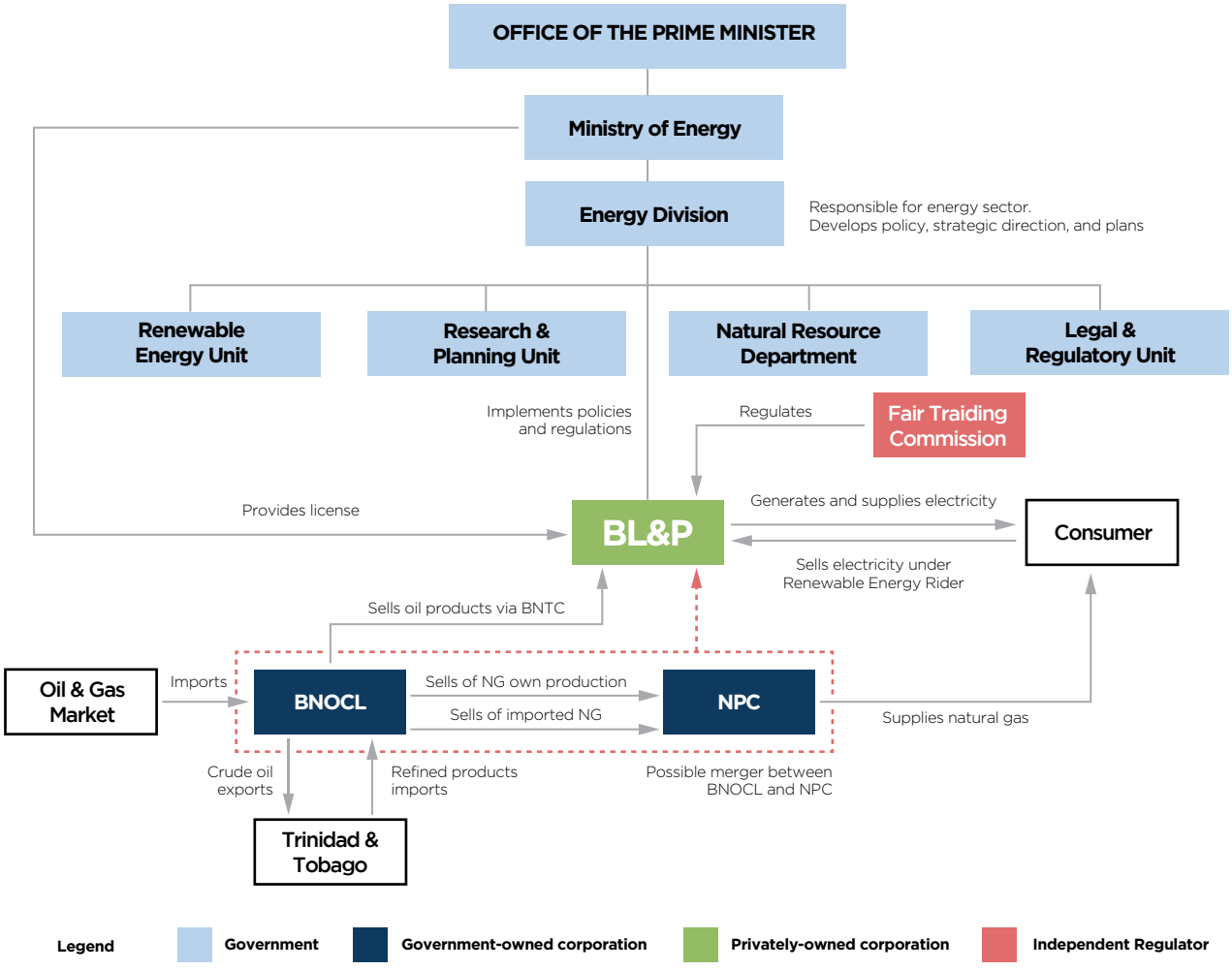
The Energy Division within the Office of the Prime Minister is responsible for monitoring and regulating the overall energy sector.[30] It was established in 1978 as part of the Ministry of Trade and it has since merged with the Energy Conservation Unit and expanded into a diverse organization "responsible for oil and gas, alternative energy and energy conservation."[31] It consists of an Administrative Unit, the Legal and Regulatory Unit, the Natural Resources Department, the Renewable Energy and Energy Conservation Unit, and the Research and Planning Unit.[32]

[30] Government of Barbados, 2014b.
[31] Government of Barbados, 2014a.
[32] Ibid.

Table 5 Institutions and Responsibilities of the Energy Sector

System Size	Installed Capacity, MW	Committed Applications, MW
Energy Division/ Office of Prime Minister	Government ministry	Develop and monitor policies, provide strategic direction for energy sector
Fair Trading Commission (FTC)	Government agency	Regulate the electricity sector, set rates and standards, monitor fair trade policies
Barbados Light & Power Company Limited (BL&P)	Vertically integrated private utility company	Production, transmission, and distribution of electricity
Barbados National Oil Company Limited (BNOC)	Government-owned corporation	Production of crude oil and natural gas, both onshore and offshore
Barbados National Terminal Company Limited (BNTC)	Government-owned corporation	Exporting of crude oil, importing of refined oil products, and storing of oil products. Subsidiary of BNOC
National Petroleum Corporation (NPC)	Government-owned corporation	Purchases natural gas from BNOC and supplies gas to residential, commercial and industrial customers

Figure 25 Organization and Functioning of the Energy Sector, 2015



Source: Author's own work based on information from Government of Barbados, 2014b; Government of Barbados, 2015; Samuel, 2013

Table 6 Institution and Governance Structure of the Energy Sector

Key Legislation	Regulator	Utility	Ownership structure
National Energy Policy, 2006	Fair Trading Commission	Barbados Light & Power	Privately owned, 100%
Electric Light and Power Act 2013			
Offshore Petroleum Act 2007			
Fair Trading Commission Act 2001			

Energy Division

The Energy Division was established in 1978 as part of the Ministry of Trade. Today it is part of the Office of the Prime Minister. The Division is responsible and sets policy for oil and gas, renewable energy, energy conservation, and the electricity sector. It is tasked to ensure the efficient and reliable functioning of the sector and coordinate with the CARICOM Secretariat and OLADE on regional energy issues. The Division monitors the activities of BNOCL, responsible for exploration and production of oil and gas; the Barbados National Terminal Company Limited (BNTC), responsible for the terminalling and storage of crude oil and its derivatives; and the NPC, responsible for the distribution of natural gas. It also monitors petroleum price movements. The Division is comprised of an Administrative Unit, a Legal and Regulatory Unit, a Natural Resource Department, a Renewable Energy and Energy Conservation Unit, and a Research and Planning Unit.[33]

Research and Planning Unit

The Research and Planning Unit within the Energy Division advises the Ministry on the economic and financial aspects of energy production, imports, exports, consumption, distribution, related infrastructure investments, pricing, and fiscal issues. Some of its key responsibilities are: (i) collecting and compiling of energy sector–related data; (ii) conducting economic and financial analyses to inform sector policy; (iii) devising and formulating strategies to ensure efficient production, consumption, and pricing of energy products and services; and (iv) coordinating between the government and energy sector stakeholders including BNOCL, BNTCL, NPC, BL&P, and the University of the West Indies.

Natural Resource Department

The Natural Resource Department is responsible for promoting the exploration and development of all onshore and offshore natural resources, including oil and gas reserves and industrial minerals such as sand, clay, and limestone. Some of its key objectives are: (i) identifying and quantifying the country's natural resources, (ii) designing programs to exploit said natural resources, and (iii) fostering a regulatory framework, ensuring an orderly and sustainable development of resources in a manner which provides the largest benefit to the country.

Formulation of policies in the energy sector

The Energy Division develops, implements, and monitors energy policy. It is responsible for the issuing of licenses and leases for all oil exploration and production, it promotes the use of renewable energy, and it advises on the pricing of petroleum products.[34] Apart from these functions, it coordinates with entities such as the CARICOM Secretariat and OLADE on Caribbean energy issues and works with other ministries and agencies.

[33] Government of Barbados, 2015.
[34] Government of Barbados, 2014a.

National Energy Policy

Barbados' energy sector is changing; in particular, the 2013 Electric Light and Power Act (ELPA) charts a new course for the electricity sector and should support greater use of renewable energy. The eventual adoption of the National Sustainable Energy Policy (NSEP) promises to transform the sector further.

Barbados published a draft National Energy Policy (NEP) in 2006; however, it was never formally adopted. The NEP defined a broad set of goals for the energy sector, including maximizing efficient use of energy, reducing dependence on and consumption of fossil fuels by expanding energy from renewable sources, and allowing competition in the sector to reduce energy costs. To achieve these broad goals the NEP defined six key objectives. It aimed to: (i) improve the efficient production, storage, distribution, and use of energy; (ii) promote research and development for energy efficiency, renewables, and oil and gas; (iii) increase oil and especially gas production to ensure that natural gas can provide 70 percent of energy needs; (iv) increase oil and gas reserves and manage exploration in such a manner to ensure a transfer of at least 50 percent of reserves to the next generation; (v) promote competition within the petroleum and electricity sector by adjusting regulation and economic sector policy; and (vi) include stakeholder inputs in energy sector policy and increase participation of the private sector.[35]

The NEP also suggested a number of specific measures to improve efficiencies in the petroleum sector, including the construction of a new oil terminal and infrastructure for the storage and distribution of oil products. Furthermore, the policy planned to introduce competitive bidding for the exploration of offshore oil and gas resources and the deregulation of oil imports and distribution in the retail market. The government, through BNOCL and BNTCL, would maintain control over onshore exploration and the storage and terminaling.[36]

Sustainable Energy Framework

The Sustainable Energy Framework (SEF) was published in June 2010 and aims to develop sustainable energy scenarios. The framework proposes and analyzes a number of energy scenarios and issues a set of policy recommendations to support their development. A number of suggested measures have been implemented, including the liberalization of the electricity sector by allowing independent power producers (IPPs), the issuing of interconnection standards, appliance labeling standards, and the introduction of distributed renewable energy.[37]

Regulator

In Barbados there is no agency dedicated to regulating the whole energy sector. The FTC regulates the electricity subsector. In the hydrocarbon subsector, the main agency in charge of regulation is the Energy Division within the Office of the Prime Minister.

Description of the Electricity Subsector

The country's sole utility-scale electricity provider is BL&P. BL&P is a vertically integrated electric utility company responsible for the generation, supply, and distribution of electricity; it provides electricity to 125,991 customers. The company operates under a non-exclusive license valid until 2028. Although IPPs are permitted, there have not been any market entrants in either generation or transmission and distribution. BL&P is regulated by the FTC, which was established in January 2001 following the Fair Trading Commission Act. Regulatory oversight was previously in the domain of the Public Utilities Board.

The legal and regulatory framework in Barbados recently underwent a reform process, opening the electricity sector to IPPs and ending BL&P's legal monopoly with the passing of the ELPA on December 18, 2013.[39] The changes in the regulatory structure aim to achieve a more favorable investment climate for private power providers and a more open framework for IPPs.

[35] NREL, 2015.
[36] Castalia, 2010.
[37] NREL, 2015.
[38] NREL, 2015.
[39] Government of Barbados, 2013.

The legislative and regulatory framework of the energy sector is organized around four laws and regulatory acts: the Electricity Act, the Electric Light and Power Act (ELPA), the Fair Trading Commission Act, and the Utilities Regulation Act.[40]

Electricity Act

The Electricity Act of 1936 is the primary set of rules and technical guidelines related to the electric system and electricity. The act describes the power and duties of the electrical engineer, states that alterations or changes to any electric installations shall not take place without the permission of the electrical engineer, and sets basic fees for installations and inspections. It also provides a pathway for appeals to the Minister of Energy if an applicant is dissatisfied with the decision of the electrical engineer.[41]

Electric Light and Power Act (ELPA)

The revised Electric Light and Power Act of 2013 is the principal set of rules regulating the supply of electricity in Barbados. The ELPA formalizes competition in electricity generation, aims to promote the generation of electricity from renewable energy sources at utility scale, and seeks to increase the security and reliability of the supply of electricity. Under the ELPA, BL&P no longer holds an exclusive license for the generation, transmission, and distribution of electricity but it will continue to hold an official mandate for generation, transmission, and distribution of electricity. Its current license will expire at the end of 2028.

Prior to 2013, the law provided an exception only for residential self-generation and consumption; the operation of renewable generation connected to the grid by anyone other than BL&P required an act of parliament. Under the new law, renewable energy systems of up to 5kW for residential purposes and up to 50kW for other/commercial purposes will be allowed without the prior need to obtain a license. For facilities larger than 50kW, the newly established Electric Light and Power Advisory Committee will make a recommendation to the Minister of Energy regarding the granting of license as an IPP. The recommendation of the committee will take into account the projected and future demand and the total capacity, as well as technical aspects. The overall goal is to promote the generation of electricity from renewable energy and increase supply security and reliability. Facilities need to be safe and adequate and applicants for licenses need to have the financial capacity to build and maintain facilities and the technical expertise to operate them safely, reliably, and efficiently.

If the planned generation capacity exceeds 1MW, the license application must be published in newspapers and a wait period of three months is enforced to ensure that all objections by the public or other parties can be heard. If those conditions are met, the Minister may grant a non-exclusive license for the supply of electricity within a specified geographic area for a period deemed appropriate by the Minister. The license may specify if or what share of electricity needs to come from renewables and if and how much of the electricity is provided to consumers or for self-consumption at a different location in the grid.[42]

BL&P is one of the top-performing electricity utilities in the Caribbean and operates 239.1MW of oil-fire generation capacity and employs a workforce of 420 people. The company operates under a cost-of-service model providing a "reasonable" return on investment set by the regulator at 10 percent for the year 2015. Fluctuations in fuel costs are recovered through a pass-through mechanism, with price adjustments calculated and approved by the FTC on a monthly basis.[43]

Apart from changes in shareholder structure and corporate organization, BL&P has remained unchanged since 1909. The long-standing relationship with Leucadia National Corporation, forged in the early 1980s, ended in 2010, and Emera, a Canadian-based company, acquired 38 percent interest in BL&P's parent company, Light and Power Holdings Limited. Later that same year, Emera made an offer to shareholders to purchase all issued and outstanding common shares. The offer was accepted by most of the shareholders and on January 25, 2011, Emera acquired a controlling stake in Light and Power Holdings. By the end of 2011, it held 79.7 percent of the shares of Light and Power Holdings with the remaining shares held by the National Insurance Board and approximately 1,700 other shareholders.[44] In 2014, Light and Power Holdings was renamed Emera Caribbean and Emera held an 80 percent stake in it. In addition to full ownership of BL&P, Emera Caribbean also wholly owns

[40] FTC, 2012; Government of Barbados, 2013.
[41] Government of Barbados, 1936.
[42] Government of Barbados, 2013.
[43] Emera, 2015.
[44] BL&P, 2014b.

Emera Caribbean Renewables Limited and has a 52 percent stake in Dominica Electricity Services Limited and a 19.1 percent stake in Saint Lucia Electricity Services Limited. Emera also holds an 80 percent interest in the Grand Bahama Power Company.[45]

Renewables and Energy Efficiency in Barbados

Government continues to support public and private sector EE and RE through (respectively) the Energy Smart Fund and the Public Sector Smart Energy Program (PSSEP). Both programs aim to increase the penetration of energy efficient technologies saving government, households, and businesses money. The PSSEP has met its eligibility requirements to receive funding and should begin procuring EE retrofit projects in 2014. A first disbursement of US$200,000 is expected for the procurement process of streetlight retrofits. The PSSEP is considering a pilot electric vehicles program and financing ocean power studies. The Smart Fund has launched all lending facilities except for a lighting facility and an air conditioning facility. Thirty percent of the loan facility's funds have been committed through contract signing. The Executing Agency estimates that over 80 percent of funds will be committed by June 2015.

Barbados has the potential to increase its use of renewable energy sources for electricity generation as well as further promote energy efficiency and energy conservation. The island has exploitable renewable energy resources including wind, solar, waste, and biomass (primarily crop residue such as sugarcane bagasse). Until recently, little attempt was made to exploit these resources, but a combination of higher energy costs and declining prices for renewable energy technologies have made these sources more attractive. In terms of energy efficiency (EE) and energy conservation (EC) there still much space to develop demand side management programs to promote EE and EC measures.

Solar Water Heaters

In the 1970s, Barbados introduced tax exemption for the import and sale of solar water heating equipment while simultaneously increasing taxes on electric water heaters. It also mandated the use of solar water heaters in new public housing. Today the country ranks fourth in per capita deployment of solar water heaters with a penetration of more than 40 percent. The combined heating capacity of Barbados' solar water heaters is estimated at around 88MW, more than half of BL&P's peak electricity demand in 2014.[46]

Renewable Energy Rider

In 2009, BL&P proposed the introduction of a Renewable Energy Rider (RER) program to allow distributed solar PV capacity to be supplied to the grid. The program began on a pilot basis in August 2010 for a period of two years. In July 2012, BL&P made a request that the program be made permanent, which was granted by the FTC in August 2013.[47]

During the pilot phase the program was limited to 200 customers on a first-come, first-served basis or a maximum installed capacity of 1.6MW, whichever were to occur first. Individual installations were limited to 5kW or 1.5 times the customer's average monthly usage for customers paying the residential, general service, or employee tariff and 50KW for customers paying the secondary and large power tariff. Customers were billed according to the buy all/sell all billing arrangement and were compensated at 1.8 times the Fuel Clause Adjustment (FCA) or BB$0.315/kWh, whichever was greater.

When the program was made permanent, the FTC considered two different types of billing arrangement: buy all/sell all and sale of excess. Under buy all/sell all, customers sell all their produced electricity to the grid. Under sale of excess, customers only sell the difference between self-consumption and production. Under buy all/sell/ all customers do not realize the benefits related to reduced consumption in contrast to sale of excess which can translate to lower-tier tariffs and reduced customer chargers, and permits customers to store generated electricity in batteries, thus creating a sense of independence vis-à-vis the national producer.

In its August 2013 decision, the FTC stated that 78 percent of RER customers opted for the sale of excess billing arrangement and decided that the sale of excess billing arrangement was to be used going forward. In December 2013, BL&P filed a motion with the FTC to review and vary the decision to use the sale of excess billing arrangement for all RER customers. BL&P invited the FTC to consider two alternative options: (i) let all customers choose their preferred billing arrangement (buy all/sell all or sale of excess) or (ii) let customers with systems up to 2kW choose their billing arrangement and require customers with systems above 2KW to use the buy all/sell all arrangement.

[45] Emera Caribbean, 2015.
[46] NREL, 2015.
[47] FTC, 2013b.

In August 2014, the FTC altered its original stance following the motion from BL&P. Under the new rules all new domestic, general service, and employee RER customers with a capacity of less than 2kW will be able to choose between sale of excess and buy all/sell all billing arrangements. Once the choice is made it cannot be changed. Existing RER customers can remain with their current billing arrangements or switch from sale of excess to buy all/sell all within three months. All new domestic, general service, and employee RER customers with capacity above 2kW as well as all secondary and large power tariffs will be billed under buy all/sell all.[48]

When the program was made permanent in August 2013, the rate at which customers were compensated was reduced from 1.8 times the FCA to 1.6 times the FCA for electricity fed into the grid; the amount fed into the grid was limited to 1.5 times the customer's average monthly consumption. Any electricity supplied to the grid above that limit is only compensated at the monthly FCA rate. The size of individual installations remained limited to 1.5 times the customer's consumption, but the upper limit was increased from 5kW and 50kW to a maximum of 150kW.

With the decline in oil prices and the subsequent decrease in the FCA, the rate at which customers were compensated under the RER became less competitive and installations were deemed to no longer be economically viable by suppliers and installers. The FTC began consultation in April 2016 to review the RER compensation and to either establish a fixed credit or a credit floor. BL&P made a motion to create fixed rates to compensate RE suppliers and suggested the resource cost approach to determine the rate at which customers should be compensated. It suggested BB$0.378/kWh for solar PV installations and BB$0.298/kWh for wind power for system sizes up to 500kW.

The FTC largely followed BL&P's recommendations by establishing a fixed rate based on the resource cost approach, albeit at slightly higher rates. In July 2016, the FTC issued its decision, establishing a temporary credit of BB$0.416/kWh for solar PV and BB$0.315/kWh for wind power for suppliers up to a capacity of 500kW. Hence, the previous limit of 150kW, which was previously raised from 5kW and 50kW, is no longer valid.[49]

The RER program has been increasingly popular and the FTC has increased the maximum allowed installed capacity on three occasions. In 2013, BL&P reported that the 2MW limit was nearly exhausted and there existed a total of 271 installed solar PV systems. This led the FTC to increase the maximum allowed installed capacity to 7MW in August 2013, stipulating that the last MW be reserved for residential customers. In the first three months of 2014, the FTC recorded 424 customer subscriptions representing 3.4MW of capacity. In September 2014, the FTC again increased capacity from 7MW to 9MW with the additional 2MW available on a first-come, first-served basis. Following the submission of BL&P's Intermittent Renewable Energy Penetration Study to the FTC and BL&P's recommendation that it could accommodate additional distributed capacity, the FTC further increased the limit to 20MW in February 2015. The FTC calculated that 7MW of installed capacity under the RER program equates to around BB$2.3 million in lost revenue for BL&P.[50] In 2014, distributed capacity under RER stood at 6.8MW increasing to 10.4MW in 2015. Over the same period BL&P compensated customers for 5.3GWh and 18.7GWh of electricity produced under RER.[51]

Table 7 Renewable Energy Support Policies, 2013

Feed-In Tariff	Net Metering	Renewable Portfolio Standard	IPPs Permitted	Tax Credits	Tax Reduction/ Exemption	Public Loans/ Grants
In Development	✓	—	✓	✓	✓	✓

Source: Auth et al., 2013; FTC, 2014f; NREL, 2015

Regulator

The FTC, established under the Fair Trading Commission Act of January 2, 2001, is an independent government entity responsible for administering the Utilities Regulation Act (URA). The FTC is an independent regulator of the supply and distribution of electricity as well as domestic and international telecommunications services and natural gas.[52] It is responsible for, among other things, regulating electricity rates, stipulating the standards of service, competition law and consumer protection, monitoring general business conduct, educating and informing businesses and consumers about their rights and responsibilities, and enforcing

[48] FTC, 2014c.
[49] FTC, 2016.
[50] FTC, 2014b; FTC, 2014c; FTC, 2015a; FTC, 2015b.
[51] BL&P, 2016a.
[52] FTC, 2014a.

regulations where needed. It receives budgetary support from the government as well as from fees levied on the entities it regulates.[53]

The Utility Regulation Department within the FTC is in charge of overseeing two utility companies: BL&P and Cable & Wireless (Barbados) Ltd. In both instances the division's primary function is "establishing principles for arriving at the rates to be charged."[54] The overall sector policy, the ELPA, guides the FTC in this process as it seeks to "protect consumers by setting fair and reasonable rates," encourages investments, and promotes efficient use of the utility service.[55]
The URA outlines the functions of the FTC as the following: (i) establish principles for arriving at the rates to be charged, (ii) set the maximum rates to be charged, (iii) monitor the rates charged to ensure compliance, (iv) determine the standards of service applicable, (v) monitor the standards of service supplied to ensure compliance, and (vi) carry out periodic reviews of the rates and principles for setting rates and standards of service.[56]

The FTC protects the interests of consumers by way of ensuring electricity supply is safe, adequate, efficient, and reasonably priced, and it is responsible for hearing and determining complaints by consumers related to billing and standards of service.[57]

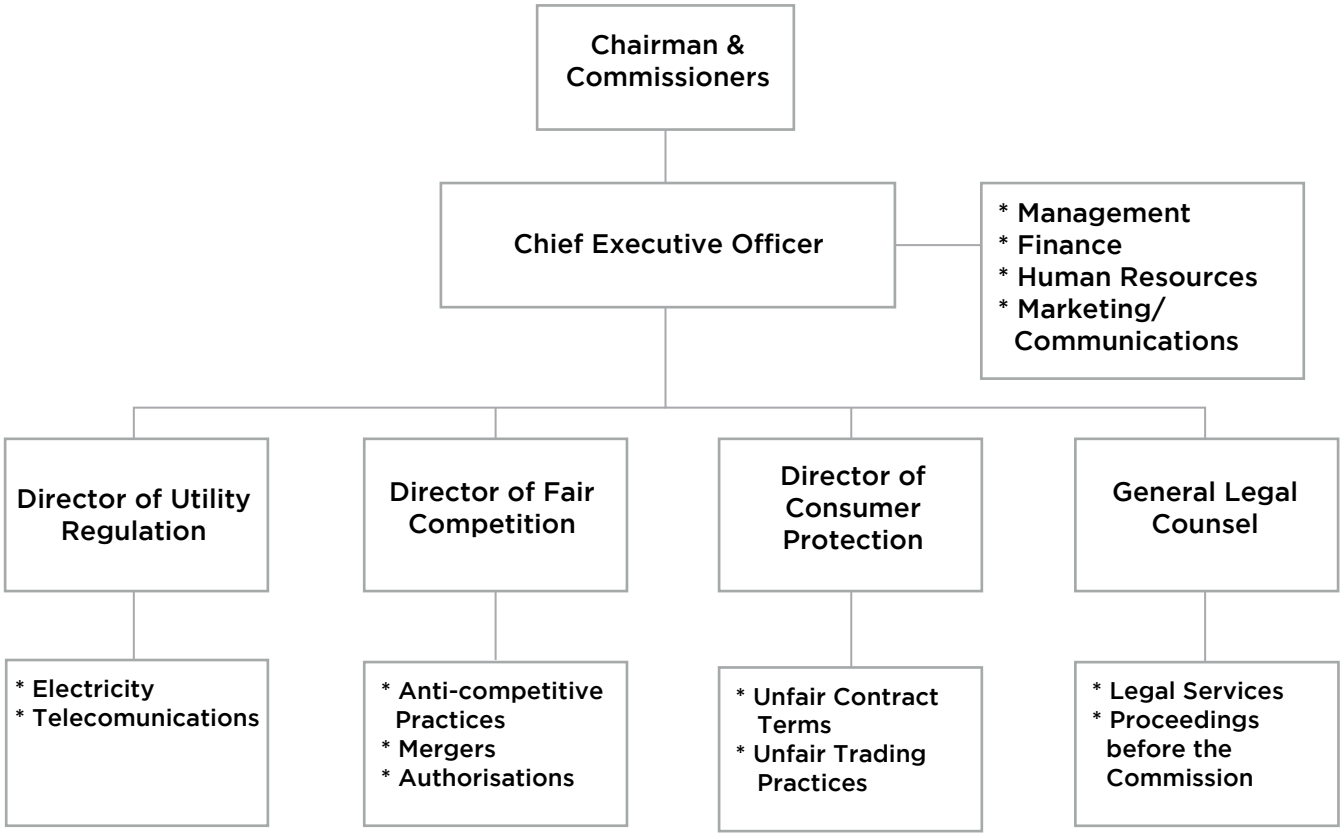
The FTC's operating structure and procedures ensure that it operates independently. According to a recent World Bank study of regulatory authorities, the FTC received excellent marks "due to its mechanisms and procedures for guaranteeing its autonomous administration."[58] The FTC's precursor was the Public Utilities Board, which was in charge of regulating public utilities from 1955 to 2001.[59]

Figure 26 Regulatory Framework of the Electricity Sector

Source: Author´s own work

[53] Ibid.
[54] Ibid.
[55] Ibid.
[56] Government of Barbados, 2002.
[57] Ibid.
[58] Guasch et al., 2007.
[59] Castalia, 2010.

Figure 27 Organizational Setup of the Fair Trading Commission



Source: FTC, 2013a

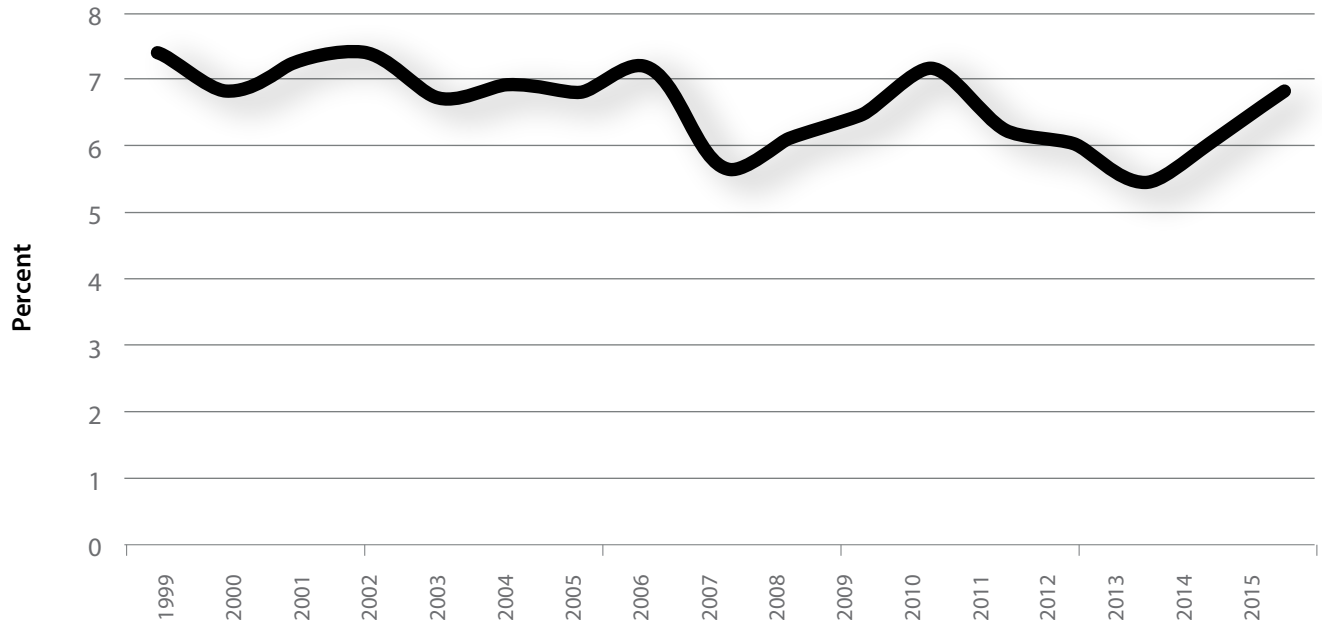
Transmission and Distribution

Barbados Light & Power operates an extensive electricity grid, with few homes being further than 30 meters from the main service lines. It owns 82 kilometers of transmission lines and 1,743 kilometers of distribution facilities and operates 14 substations. Electricity is transmitted at either 24.9Kv or 69kV from the generation plants to a number of substations throughout the island. At the substations the voltage is stepped down to 11kV and further distributed to feed circuits in the residential and commercial neighborhoods. Exceptions are the Pine, Wildey, and Sergeant Village areas, where electricity is distributed at 24.9kV rather than 11kV. The voltage is then further stepped down by means of pole- or pad-mounted transformers and supplied to customers at either 115V or 230V. Electricity is supplied at a frequency of 50 Hertz.[60]

BL&P's technical and non-technical loss rates are among the lowest in the Caribbean, due to mostly well-maintained infrastructure and low incidences of theft or non-payment. Over the past almost two decades loss rates have hovered between 5 and 7.5 percent. The utility recorded loss rates below 6 percent in 2007 and 2013. Since then loss rates have increased to 6.9 percent in 2015, reaching the highest level in five years.[61]

[60] Emera, 2015.
[61] BL&P, 2016a.

Figure 28 BL&P Losses as Share of Net Generation, 1999-2015



Source: BL&P, 2004; BL&P, 2005; BL&P, 2006; BL&P, 2007; BL&P, 2008; BL&P, 2009; BL&P, 2010; BL&P, 2011; BL&P, 2012; BL&P, 2013; BL&P, 2014a; BL&P, 2014c; BL&P, 2014d; BL&P, 2016a

Electricity Rate

Electricity tariffs are high around US$0.32 per kWh. This is due to the high cost of fuel oil, used for nearly all electricity generation. The high dependence on oil products for energy needs leads to high and volatile energy prices, which negatively impacts the economy, particularly sectors that consume large amounts of energy.

However, despite hydrocarbon-based generation of electricity, Barbados has, in comparison to other Caribbean states, relatively moderate electricity prices.[62] The prevalent use of low-speed diesel generators allows for better-than-average efficiency rates. As a result, Barbados' rates are below even those of St. Vincent and the Grenadines and Dominica, which both feature more efficient hydropower in the electricity mix.[63] Also, Barbados' distribution losses of below 6 percent—the lowest in all of the Caribbean and rivaling those of most industrialized countries—contribute to lower-than-average costs.[64] Relatively low electricity costs and a high level of development help to explain the above-average level of electricity consumption per capita. However, as with most oil import–dependent electricity generation, prices fluctuate according to world market prices. About two thirds of BL&P's operating expenses are directly related to the cost of imported oil products.[65]

BL&P sells electricity at four main rates: Domestic Service, General Service, Secondary Voltage Power, and Large Power. In addition it has specialized rates for BL&P employees and street lighting customers.

The domestic service tariff "applies to single phase services to residential customers for lighting, cooking, heating, refrigeration and incidental domestic power in individually metered dwelling houses and apartments occupied by a person or household and used only and entirely as their own personal fixed place of abode for long periods of time or altogether". The tariff cannot be used for rooming houses, hotels, or guest houses, or if the primary purpose is commercial, industrial, or non-domestic activities.

The general service tariff is used for lighting and power to non-residential customers to which none of the other tariffs apply.

[62] Williams, 2010
[63] Williams, 2010
[64] Castalia, 2010
[65] Ibid.

The secondary voltage power tariff applies to customers whose demand exceeds 5kVA and requires single or three-phase supply. Customers will be billed for the "maximum measured demand" in a given month; a minimum of 5kVA applies. Alternatively, the demand can be measured in kW as well, depending on the customer's "character of service." If demand is measured in kW, a "correction factor of 0.85 for conversion to kVA for billing purposes" is applied.

The large power tariff is for customers with at least 50kVA of billing demand who own and operate their own transformation equipment and receive "primary voltage" of 24.9kV or 11kV. Customers "connected under this rate shall be metered as to demand and the billing demand shall be the maximum measured demand of the current month or 50 kVA, whichever is greater." As with the secondary voltage power tariff, demand may be measured in either kW or kVA "at the option of the Company depending upon the character of the service" and a conversion factor of 0.85 is applied "for conversion to kVA for billing purposes."[66]
BL&P employees don't pay the monthly customer charge and receive a subsidized base energy charge, paying between BB$0.15 and BB$0.224 per kWh. Street lighting service is billed based on the wattage of the light and assessed a customer charge and a reduced FCA, but no base energy charge.

In addition to the tariff rates described above, BL&P also offers two innovative rate structures as part of demand-side management strategies in the form of a time-of-use rate and an interruptible service rate. Both rates aim to better manage demand from large customers. With the time-of-use rate, BL&P offers participants the possibility to shift their demand from peak demand hours to off-peak hours at the benefit of a lower per-kWh rate. The interruptible service rate gives permission to BL&P to temporarily interrupt electricity services during times of very high system demand. The rate is aimed at commercial consumers who are willing to have their service temporarily interrupted given a certain notice and limited to a specific number of hours over the course of a year. Both rates were introduced on a two-year pilot basis in 2010 but have been extended until September 2015 under existing terms and conditions due to limited customer resonance.[67]

On top of the base tariffs, BL&P adds an FCA rate. The FCA is meant to pass along both reductions and increases in the price of fuel oil to the customer. Revenue collected through the fuel clause does not add to BL&P's rate of return; all revenue collected through the fuel clause is used to pay oil suppliers. The FTC is responsible for checking the level of the adjustment on a monthly basis.[68] BL&P does not use derivatives to manage the changes in market price of HFO and its fuel pricing is based on the three-day average market price.[69] The FCA hovered around BB$0.40–0.50 during 2011–2014 before beginning to decrease in late 2014. By mid-2015 the FCA stood below BB$0.20.

In April 2016, BL&P notified the FTC of its intention to engage in fuel hedging and requested permission to apply the results and costs of the hedging program to the FCA calculation. According to the notification, BL&P would hedge 80 percent of its HFO requirements, with up to 90 percent of requirements possible if market conditions are very favorable. The hedging would be administrated by Emera Energy Services at an annualized cost of BB$600,000. BL&P requested said administrative costs and the results of fixed price swaps to be applied to and become part of the FCA calculation.[70]

[66] BL&P, 2014e
[67] FTC, 2014d
[68] BL&P, 2014f
[69] Emera, 2015, BL&P, 2016b
[70] BL&P, 2016b

Table 8 BL&P Electricity Tariffs, 2015

Tariff	Customer Charge	Demand Charge	Base Energy Charge, per kWh	Fuel Charge
Residential	1-150kWh $6.00 151-500kWH $10.00 >500kWh $14.00	n/a	1-150kWh $0.15 151-500kWH $0.176 501-1500kWh $0.20 >1500kWh $0.224	FCA on all units
General Service	1-150kWh $8.00 151-500kWH $11.00 >500kWh $14.00	n/a	1-100kWh $0.184 101-500kWH $0.217 501-1500kWh $0.259 >1500kWh $0.29	FCA on all units
Secondary Power	Each Service $20.00	Per kVA $24.00	All kWh $0.1380	FCA on all units
Large Power	Each Service $300.00	Per kVA $22.00	All kWh $0.1170	FCA on all units

Source: FTC, 2010

Table 9 Matrix of the Electricity Sector

Generation		Transmission		Distribution	
BL&P	Ownership	BL&P	Ownership	BL&P	Ownership
	79.7% Emera Caribbean 20.3% National Insurance Board, approximately 1,700 other shareholders		79.7% Emera Caribbean 20.3% National Insurance Board, approximately 1,700 other shareholders		79.7% Emera Caribbean 20.3% National Insurance Board, approximately 1,700 other shareholders

Description of the Hydrocarbon Subsector

Offshore Petroleum Act

The exploration and production of hydrocarbons is regulated by the Offshore Petroleum Act and the Offshore Petroleum (Taxation) Act, both passed in 2007, and their amendments. The laws set out the permitting and licensing procedures for entities carrying out reconnaissance, exploration, or production activities. The Offshore Petroleum (Taxation) Act establishes a tax rate of 25 percent on hydrocarbon production for offshore licensees. The Storage of Petroleum Act of 1882 governs the storage and importation of petroleum products. With the Offshore Petroleum Act, the government vested all petroleum and natural gas in the Crown, but invites foreign companies to apply for exploration licenses.[71] Following a discovery of new reserves, companies can apply for production licenses after submitting development and decommission plans. The act requires "[applicants to] follow best industry

[71] Government of Barbados, 2007.

practices, establishes environmental protection duties and health and safety standards, and it requires the use of Barbadian workers".[72]

The act also gives the government the power to require a percentage interest in a license and to take over operations. Following considerable interest at the launch of the bidding round for oil and gas exploration licenses, Barbados offered twenty-six offshore blocks up for auction on 2008,[73] but it ended up only awarding two blocks: the 2,498-square-kilometer Carlisle Bay block and the 2,506-square-kilometer Bimshire block. Both blocks went to BHP Billiton. As of April 2015, BHP Billiton had not conducted operations in the very deep waters and the potential remained unclear. The only previous deep-water well, drilled seventy miles south of the west coast by ConocoPhillips in 2001, came up dry.[74]

Barbados National Oil Company Limited (BNOCL)

The Barbados National Oil Company Limited (BNOCL) was created in June 1982 following the government's buy-out of Mobil Oil at Barbados' Woodbourne facilities. BNOCL is 75 percent government owned, with the remaining 25 percent owned by the NPC. BNOCL activities include both upstream and downstream operations and it is tasked with exploration, production, and procurement of oil and gas. The company operates under a Mineral Lease Agreement issued by the government for exploration and production in the 16,438 acres (6,652.2 hectares) of the Woodbourne, Scotland, and Fisher Pond areas.[75] Proven natural gas reserves are only 0.004 trillion cubic feet (tcf).[76]

The produced crude oil is stored in tanks before it is piped to facilities at the BNTCL, from where it is exported to Trinidad for refining at the Petrotrin refinery. Revenue from the sales of these refined products is used to purchase HFO from Trinidad and Tobago. About 80 percent of fuel oil purchased from these funds is used for electricity generation by BL&P, and the rest is used in the industrial and transportation sectors.[77] Esso also imports HFO. Additional gasoline, diesel, and kerosene is purchased by BNTCL as needed from Petrotrin.[78] Gasoline and diesel is sold by ESSO, Texaco, and Shell, who operate a network of modern petrol stations on the island.[79]

In 1996, the Barbados government and BNOCL decided to bring on a partner to assist in the further development of oil and gas resources. The decision was made to select a small, independent company with experience in developing the challenging reservoirs found in Barbados. A twenty-five-year production sharing agreement was signed with Waggoner (Barbados) Ltd. of North Texas. As part of the agreement, Waggoner was to receive the majority of future incremental production increases as a result of the cooperation and "an equal voice in developing and implementing the venture's operating plans."[80] As the agreement failed to deliver sustainable production levels, the agreement was terminated in 2002. In 2008, Barbados opened its economic zone for offshore oil exploration and production to qualifying companies.[81]

National Petroleum Corporation (NPC)

The National Petroleum Corporation (NPC) is the national distributer for all gas produced by BNOCL.[82] The NPC is a statutory body responsible for the management of the distribution of national gas supply for domestic, commercial, and industrial use. Its main goal is to provide and maintain "an adequate, reliable, competitive, safe and efficient gas service to customers at a reasonable cost."[83] The corporation's activities are the production of crude oil, natural gas, and liquefied petroleum gas and "are permitted by statute and carried out by an associated company, the Barbados National Oil Company Limited (BNOCL)."[84] All natural gas consumed in Barbados is produced domestically. In 2012, production and consumption were 0.71 billion cubic feet (bcf), down from a peak of 1.13 bcf in 2010.[85]

[72] Clarke, 2014.
[73] *Oil and Gas Journal*, 2009.
[74] Bryan, 2013.
[75] BNOCL, 2014a.
[76] EIA, 2015.
[77] BNOCL, 2014a.
[78] BNOC, 2014a.
[79] Williams, 2010.
[80] Government of Barbados, 2014c.
[81] Invest Barbados, 2010.
[82] Government of Barbados, 2014a.
[83] NPC, 2014.
[84] Ibid.
[85] EIA, 2015.

Barbados National Terminal Company Limited (BNTC)

Barbados National Terminal Company Limited (BNTCL) is a fully owned subsidiary of BNOCL and was incorporated in February 1998. This company manages the importation, supply, and distribution of gasoline, diesel, and fuel oil. It is also responsible for the export of crude oil to Trinidad and Tobago and provides storage for the local crude oil to facilitate shipping to Trinidad. The BNTCL temporarily operated at the former Mobil Oil site at Needham's Point but has since moved to its permanent location at Fairy Valley, Christ Church. All fuels are stored at the Fairy Valley facility except for HFOs, which are stored at Esso's Holborn terminal. BNTCL is also responsible for the importation, storage, and distribution of aviation fuel "on behalf of major oil companies, SOL, Esso, and Chevron" and the imported jet fuel is "transferred to the joint venture facility at the airport" for use on airplanes.[86]

Table 10 Matrix of the hydrocarbon sector

Production	Imports	Transformation	Commercialization
BNOCL	BNTC	n/a	BNTC NPC Sol Esso Chevron

Government Priorities and Plans

Once passed, the draft NSEP will define the government's priorities for the energy sector. The NSEP is rooted in Barbados' macroeconomic situation and the government's fiscal position. The government's current plans for the energy sector are to fully implement the ELPA; these plans will grow upon approval of the NSEP.

The government's three principal objectives in the energy sector are reducing energy costs, achieving greater energy security, and improving environmental sustainability. The 2010 SEF describes these goals, specific targets for renewable energy, and some steps needed to achieve these goals. The SEF outlines goals for energy efficiency and renewable energy for Barbados to produce 29 percent of electricity from renewable sources by 2029. The study concluded that Barbados has the renewable energy potential to meet these goals while reducing the cost of electricity.

The government is close to adopting an NSEP that would formalize these goals. The NSEP would provide specific policy guidance to the FTC. The FTC could then pursue certain policy objectives without the need for legal changes.

The SEF proposed policies that would aim to increase renewable energy use to 29 percent of all electricity consumption by 2029.[87] The SEF recognizes that the electricity sector is one of the best in the region and has some of the lowest tariffs. However, the sector is almost completely dependent on fuel oil, and tariffs are still high relative to many residents' incomes. There are three core principles of the SEF:

1. Reducing energy costs,
2. Achieving greater energy security, and
3. Improving environmental sustainability.

The SEFB found that many renewable energy resources are economically and commercially viable. Specifically, the SEFB mentions solar water heaters, biomass co-generation, wind energy, and waste-to-energy as immediately viable options. Since the SEFB was completed, declining technology costs are likely to have made solar PV and other technologies viable as well.

[86] BNOC, 2014c.
[87] Sustainable Energy for All, 2014.

To achieve the three goals listed above, the government outlines an approach that identifies energy sources that are both more sustainable and cheaper than imported oil. Such an approach will focus on the least-cost technologies available, without favoring any particular technologies. In general, the government will avoid high-cost sustainable energy options, unless the positive externalities from sustainability would exceed the economic cost of higher energy.

Natural gas is one of the identified potential energy sources, and the government is exploring options to import natural gas as LNG to meet local demand. Initial efforts are targeted towards the residential, commercial, and industrial sectors, while the power generation and transport sectors would be addressed later. BNOCL already installed a micro LNG unloading facility at the Woodbourne Terminal with capacity to handle ISO containers to supply around 0.5 mmcfpd. However, there is a need to expand its capacity in order to satisfy total demand of 3 mmcfpd and avoid costly natural gas shortages.

In addition to meeting current demand, the government is planning steps that could eventually enable the use of natural gas for power generation. BL&P has already shown interest in using natural gas in some of their facilities. To this end, NPC is planning the process of establishing a Public-Private Partnership (PPP) to import LNG for power generation.

Substantial initial investment will be needed to pursue many of the renewable energy resources identified as commercially and economically viable. This means accessing all concessional finance, regional initiatives, and other international opportunities that are available.

In particular, this means that BL&P should continue to operate efficiently, and that the FTC should continue to effectively regulate the sector.

The government plans to pass the NSEP in the near future. The NSEP will clearly set out the government's policies and targets in the energy sector, build on the 2010 SEF, and more fully define the government's plans for the sector. A draft NSEP has not been released to the public.

The government plans to continue its reform of the electricity sector, including by fully implementing the ELPA. Implementing the ELPA will open up the electricity sector to third-party generation. The goal of allowing third-party generation is to reduce prices and increase the portion of generation from renewable sources. Implementing the ELPA includes the following steps:

- The government will establish and operationalize the Electric Light and Power Advisory Committee ("the Committee"), which the ELPA creates. The Committee's main role will be advising the minister responsible for energy on the issue and renewal of licenses, and will also advise the minister on "any other matter relevant to the administration" of the ELPA. Until the Committee is operational, the ELPA cannot be implemented.
- The minister has the power to set minimum and maximum targets for renewable energy on the public grid, and may wish to do so to meet the government's policy objectives for renewable energy (29 percent of electricity generation by 2029). Viable targets should consider grid stability when covering intermittent generation, as well as prices to end users and the financial health of the electric utility.

The government has signed an agreement with Cahill Energy to construct and operate a US$240 million plasma arc waste-to-energy plant in Vaucluse, St. Thomas.[88] The declared installed capacity of the plant is 30–35MW.[89]

The government has expressed interest in opening up second phases for both the Energy Smart Fund to promote RE and EE in the private sector as well as continuing a second phase of the Public Sector Smart Energy Program for the public sector. Second phases of each of these programs would allow more retrofits to be completed, benefiting both the public and private sectors.

A 2–3MW solar PV plant would allow BNOCL to meets much of its energy demand and possibly save on its overall electricity expenditure. Excess generation could be sold back onto the utility's grid.

Nationally Appropriate Mitigation Action (NAMA)

The Government of Barbados is in the process of developing and registering a Nationally Appropriate Mitigation Action (NAMA) in the energy sector under the United Nations Framework Convention on Climate Change (UNFCCC). The objective of the NAMA is to further the sustainable development and greenhouse gas emissions reduction efforts in the energy sector of Barbados. It aims to achieve this goal through the reduction of the

[88] Cahill Energy, 2014
[89] Bloomberg, 2014.

dependency on fossil fuels and the increase in the use of renewable energy and energy-efficient technologies in both the electricity sector and end-use consumption, including transportation.

The NAMA is designed taking into account the characteristics of Barbados as an island nation and its significant reliance on fossil fuels for its energy mix. As such, the NAMA will take into account the key characteristics of Barbados' energy needs and capabilities. The NAMA follows in line with the energy policy of Barbados, as guided by the Sustainable Energy Framework for Barbados (SEF) and the resulting NSEP, which aim at policy changes to minimize the use of fossil fuels throughout the energy supply chain.

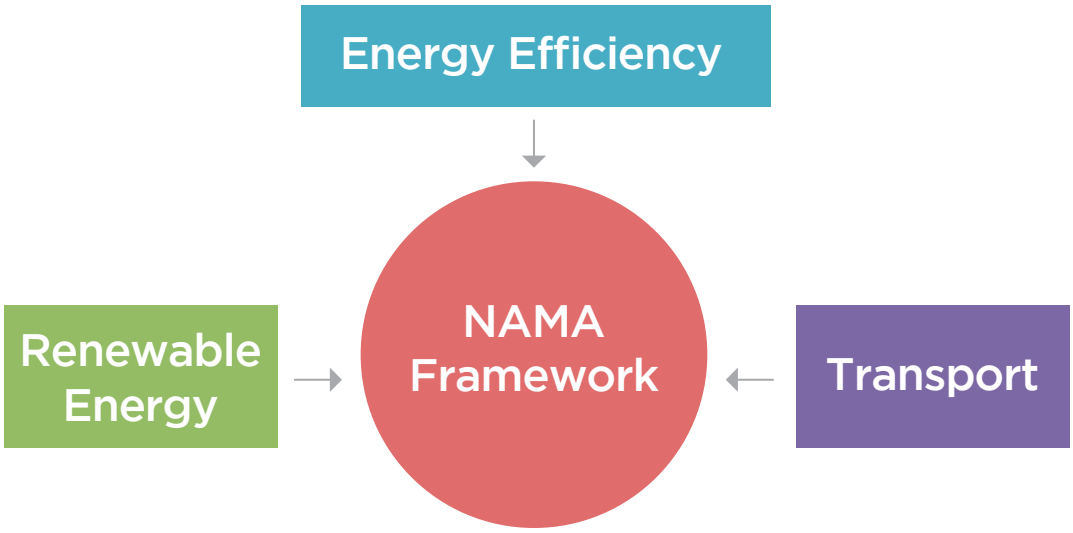
The NAMA has three specific objectives and associated metrics. First, increase the share of renewable energy as part of Barbados' energy mix to 29 percent of all electricity consumption by 2029; second, achieve savings of 22 percent in the country's consumption of electricity as compared to the "business as usual" scenario by 2029; third, avoid 7.1 million tons of CO2 emissions as a result of RE and EE measures.

Individual projects implemented as part of NAMA will be in the sectors of energy efficiency, renewable energy, and transport and are intended to be supported by a number of policies and financial instruments. The NAMA Framework will make an important contribution to improving overall economic stability through the diversification of energy supply and the subsequent reduction of the heavy reliance on fossil fuels, primarily derived from imports.

The projects that can be enrolled in the NAMA Framework must be aligned in one of the three areas:

- Renewable energy projects connected to the grid.
- Energy efficiency projects for both demand-side management and the operation of power generation.
- Improvements in public and private transportation energy use.

Figure 29 NAMA Areas



Source: Author's own work

As of 2015, the NAMA comprises fourteen projects in these three areas, including a tentative project for energy storage whose implementation will depend on the installed solar and wind capacity as well as development in the energy storage technologies sector. The NAMA Framework is designed flexibly and allows for the inclusion of future projects that fall under these three categories of mitigation efforts. The time frame for the implementation of the NAMA began in 2014 with a duration of fifteen years until 2029.

Depending on financing needs and opportunities for implementation, the prioritization methodology suggests three classifications. Projects will be categorized as either priority projects, viable projects, or long-term projects.

Priority projects
Priority projects are those designated as a priority for Barbados stakeholders and attractive for international finance mechanism and in need of new sources of financing.

Viable projects
Projects designated as economically viable are relatively secure based on existing sources of financing and/or expected market value, but could be expanded or enhanced with additional financing. Projects in this category are further divided in two subcategories based on financing sources. Projects A are already moving forward, having secured existing sources of financing, while Projects B require key non-financial assistance or are subject to obstacles that international assistance is not likely to overcome.

Long-term projects
Projects designated as long-term lack immediate technical or economic viability and while potentially attractive in the long-term, they are unlikely to attract international finance in the short-term.

In addition to the reduction of greenhouse gas emissions, the Barbadian economy will see a number of co-benefits from NAMA, including:

- Enhanced energy security through the reduction of Barbados' need for imported fossil fuels;
- Improved economic efficiency and cost reductions in the energy sector;
- Improved quality of life and attractiveness of the island for international visitors in the tourism sector as the result of reduced emissions and local air pollutants;
- Enhanced business opportunities and the creation of new jobs; and
- Development of a sustainable energy sector model serving as a blueprint for the larger Caribbean region.

The successful implementation of EE finance mechanisms and large-scale RE projects, an area in which Barbados' government and private sector have limited experience, will require reforms of existing business models for financial instruments, the use and application of new technologies, and overall market capacity building for mitigation-related services.

A key aspect of NAMA projects will be their complementary nature. The preparation and successful implementation of projects will rely on the improvement and creation of local capabilities in the areas of technology, finance, and policy.

The use of state-of-the-art technologies may have to be adapted to local and island conditions and is likely to require the participation of foreign experts in the near-term to identify appropriate transferrable products and techniques and required modifications. International experts will also be key in creating capacity among local technicians and engineers, which will allow for long-term cost reduction and completion of advanced stages of the projects. Such measures will also allow for maintenance, and most measuring, reporting and verification (MRV) activities to be carried out with little or no foreign support.

The process will be similar in the design and negotiation of the projects' financing mechanism. Local financial institutions and project developers will in part rely on support during the beginning stages of the NAMA by a range of organizations, such as the IDB and other potential donor institutions, to create and reinforce local capacities. Such steps will expedite and simplify the implementation of future projects under NAMA.
The existing policy frameworks as well as policies under development will play a critical role to increase the share of RE in the energy matrix and support the implementation of EE measures on the island. Furthermore, due to the diversity of technologies applied and actors involved, the expedited development of policies will be key to maximize the important benefits expected for the country.

NAMA is structured as an umbrella framework for projects covering the areas of RE, EE, and transport. The large-scale use of renewable energy will allow for the reduction of fossil fuel consumption in electricity generation, which currently accounts for around 50 percent of fossil fuel consumption. EE measures address waste and overconsumption on both the energy generation and end-use side, and the transport sector, often neglected in energy policy, accounts for around 33 percent of fossil fuel consumption and is likely to see dramatic shifts in technology over the coming decades.

Due to the particular structure of the energy sector and the size of Barbados, efforts to change the energy mix, improve efficiencies, and reduce energy consumption in the transport sector are interconnected and have reciprocal effects on each other. The reduction of electricity consumption as the result of efficiency measures has a direct net positive effect on efforts to reduce the dependence on fossil fuels and changes in electricity generation positively affects energy efficiency projects.

The development and highlighting of specific projects under NAMA emphasize capital expenditure investment opportunities. However, to ensure a long-term enabling environment for public infrastructure projects and

private sector-led investments into the country, the development and implementation of required policies, the enhancement of regulatory and financing mechanisms, and the creation of specific capabilities will be key. To address this need, the NAMA Framework aims to facilitate these areas of policy, regulatory, financing advancement, and capacity building in an effort to overcome some of the existing barriers.

Description of the Historic Development of the Energy Sector

History of the Fair Trading Commission (FTC)

The FTC evolved from its predecessor, the Public Utilities Board, which was responsible for the regulation of electricity and telephone services between 1955 and 2001. As the Barbadian economy expanded, so grew the need for a more all-encompassing regulatory agency. The FTC was thus established on January 2, 2001, through the Fair Trading Commission Act.

History of Barbados Light & Power Company (BL&P)

The origin of BL&P goes back to the Barbados Electric Supply Corporation (BESC), which was established in 1909 based on the 1899 Electric Light & Power Act. After slow beginnings, BESC reached a total capacity of 7,044kW in 1955, more than triple its capacity of 1940. BL&P was established in 1955 and took over all "local assets" of the BESC. By 1965, BL&P had grown to supply close to 30,000 customers and supplied a peak capacity of 11,500kW. By 1969, the customer base had grown by 30 percent to 40,249 and peak capacity stood at 20,500kW. During the 1970s, BL&P ran into financial difficulties and, following a number of share offers to the public and the government's purchase of 300,000 ordinary shares, Barbadians owned 52 percent of the company by 1980. By 1997, after the original BL&P Company was absorbed by the new BL&P Holdings parent company, Barbadians owned 63 percent of the shares. The remaining 37 percent were held by Canadian International Power Co. Ltd. and its parent company, Leucadia National Corporation of the USA. After the installation of numerous new plants BL&P's capacity reached 185.5MW in 1999, giving it a highly adequate reserve capacity when compared to an average load of 89MW and a peak demand of 125MW. In 1999, the company posted a profit of US$12.8 million on revenue of US$191.5 million. Following the rapid increase in crude oil prices, BL&P applied to the FTC to secure an increase in electricity rates, the first such increase since 1983, and the new rates went into effect in March 2010, increasing average bills by around 5 percent.[90] Leucadia's role at BL&P ended in 2010 when Emera acquired the 38 percent stake in the electricity company and over the coming year increased its share in BL&P to 79.7 percent. The remaining 20.3 percent stake is held by approximately 1,700 other shareholders.[91]

History of Barbados Light & Power Company (BNOCL)

Commercial exploration of hydrocarbon products began in the mid-1800s in the Scotland district and the first oil exploration took place between the 1870s and 1890 by the Lloyd's Oil Company. This was followed by the West India Petroleum Company (1896–1915) and then British Union Oil Company (1919–1940) and the first natural gas exploration in 1946. Between 1950 and 1955, Gulf Oil Caribbean operated in Barbados, drilling wells up to 16,000 feet deep, but with little success. The Woodbourne oilfield, which continues to supply crude oil today, was first tapped by the General Crude Oil Company between 1960 and 1970 and led to the first sustained drilling and production operation. In 1979, Mobil Explorations Incorporated took over operation and continued until 1982 when the Government of Barbados bought all its assets and formed BNOCL. Between 1982 and 1986, both Petro-Canada and PEDVSA provided technical and financial assistance and in 1996 BNOCL entered into a production-sharing agreement with Waggoner (Barbados) Ltd. In 1998 and 1999, twenty-three wells were drilled under the agreement. As the agreement failed to deliver sustainable production levels, the contract was terminated in 2002. Furthermore, the BNTCL was founded in 1998 to manage the processing agreement between Petrotrin and BNOCL. Over the past twenty-five years, BNOCL has produced 10 million barrels of crude oil, 22.8 billion cubic feet of associated natural gas, and 274,000 barrels of liquefied petroleum gas (LPG) with 107 wells currently in production.[92]

[90] Castalia, 2010.
[91] BL&P, 2014d.
[92] BNOCL, 2014b.

History of the National Petroleum Corporation (NPC)

The Barbados Gas Company Ltd. was formed in 1873, but the number of supplied consumers was and remained very limited for the coming decades. By the 1940s, the number of consumers still hovered around 500. The Natural Gas Corporation was created in 1950 and was tasked with production and transmission; it also took over the distribution of natural gas from the Barbados Gas Co. Ltd. in 1955. The National Petroleum Corporation was established by an act of parliament in 1979 but did not start operation until 1982 when it took over all functions of the National Gas Corporation, including the sale of natural gas to domestic, commercial, and industrial customers through its pipeline network.

Methodolgy

The matrix was constructed using data from the United Nations Energy Balances.[93]

Appendix A: Energy Demand/Supply Projections

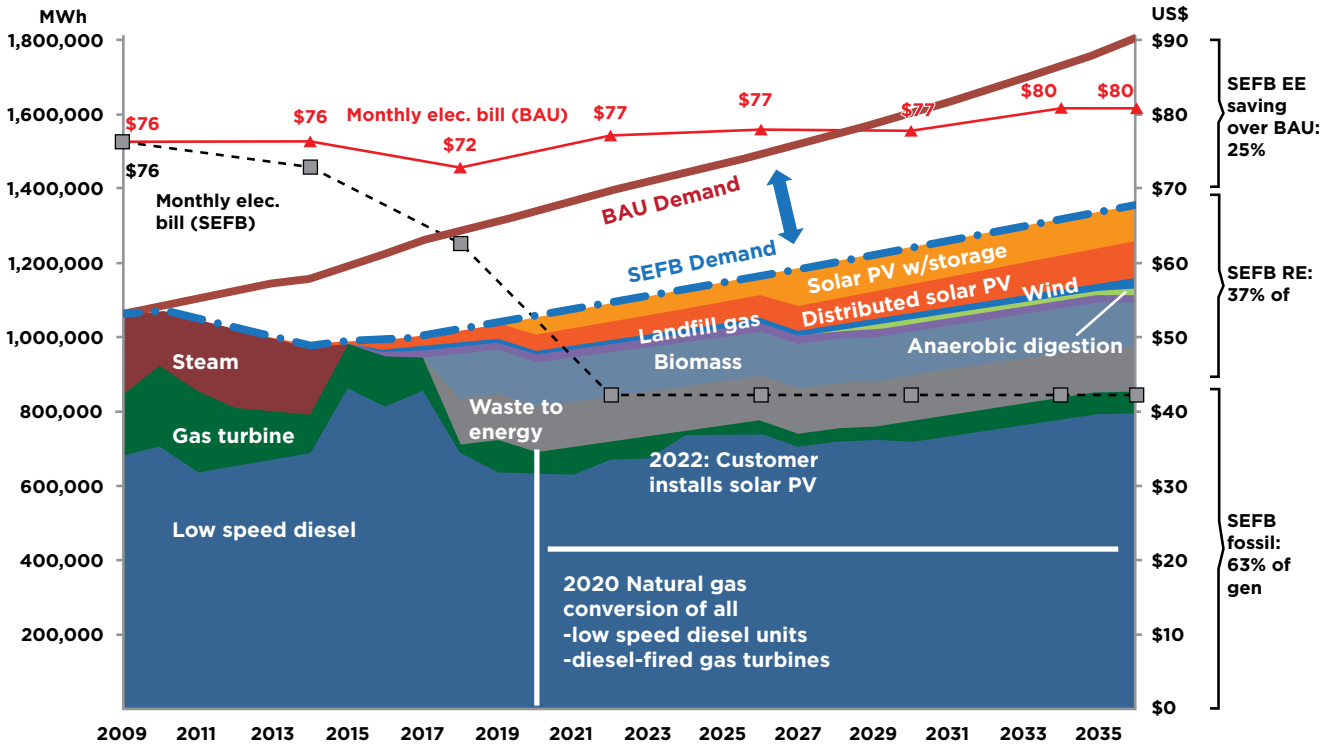
Implementing an SEF in Barbados would have the following effects between 2014 and 2036 compared to a business-as-usual scenario:

- Cut total electricity expenditure for Barbadian consumers by US$685 million (net effect in present value terms of higher capital costs but lower fuel costs);
- Reduce consumer electricity bills by 40 percent, and up to 50 percent for those with solar PV systems;
- Reduce reliance on fossil fuels from 98 percent to 63 percent of electricity generation (while converting the remaining 63 percent of liquid fossil fuel generation to lower-cost natural gas);
- Reduce electricity sector greenhouse gas emissions by 76 percent; and
- Save the government US$45 million (in net present value terms, 5 percent discount rate).

Figure 30 below summarizes the costs and benefits of sustainable energy in Barbados:

[93] BNOC, 2014b

Figure 30 Electricity Supply by Source and Reduction in Average Residential Bills



Note: Supply and demand projections are based on BL&P's Integrated Resource Plan, and modified by the Authors based on their assessment of EE and RE potential.

Figure 30 is based on the following renewable energy and energy efficiency assumptions:

- Waste-to-energy: a 35MW plasma arc plant comes online in 2018.
- Biomass: a 15MW biomass plant fired with locally produced biomass comes online in 2018.
- Landfill gas: a 1.5MW plant comes online in 2016; a second 1.5MW-generating unit is added to the plant in 2017.
- Wind: 2MW of wind are added in 2016, and a further 1MW of generating capacity is added in each of the years 2018, 2021, 2025, 2029, and 2032; 3MW are added in 2036.
- Large-scale (utility or large commercial installation) solar PV with storage: 25MW added in 2020; an additional 25MW added in 2027.
- Distributed PV: grows gradually from 2.6MW in 2014 to 55MW by 2036.
- Anaerobic digestion: 1.25MW of generation come online in 2029.
- Energy efficiency: implementation of energy efficiency measures reduces demand by 25 percent compared to business as usual.

The figure also accounts for expansion of fossil fuel generation capacity, as well as switching fossil fuel capacity to use natural gas instead of liquid fuels in 2020.

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