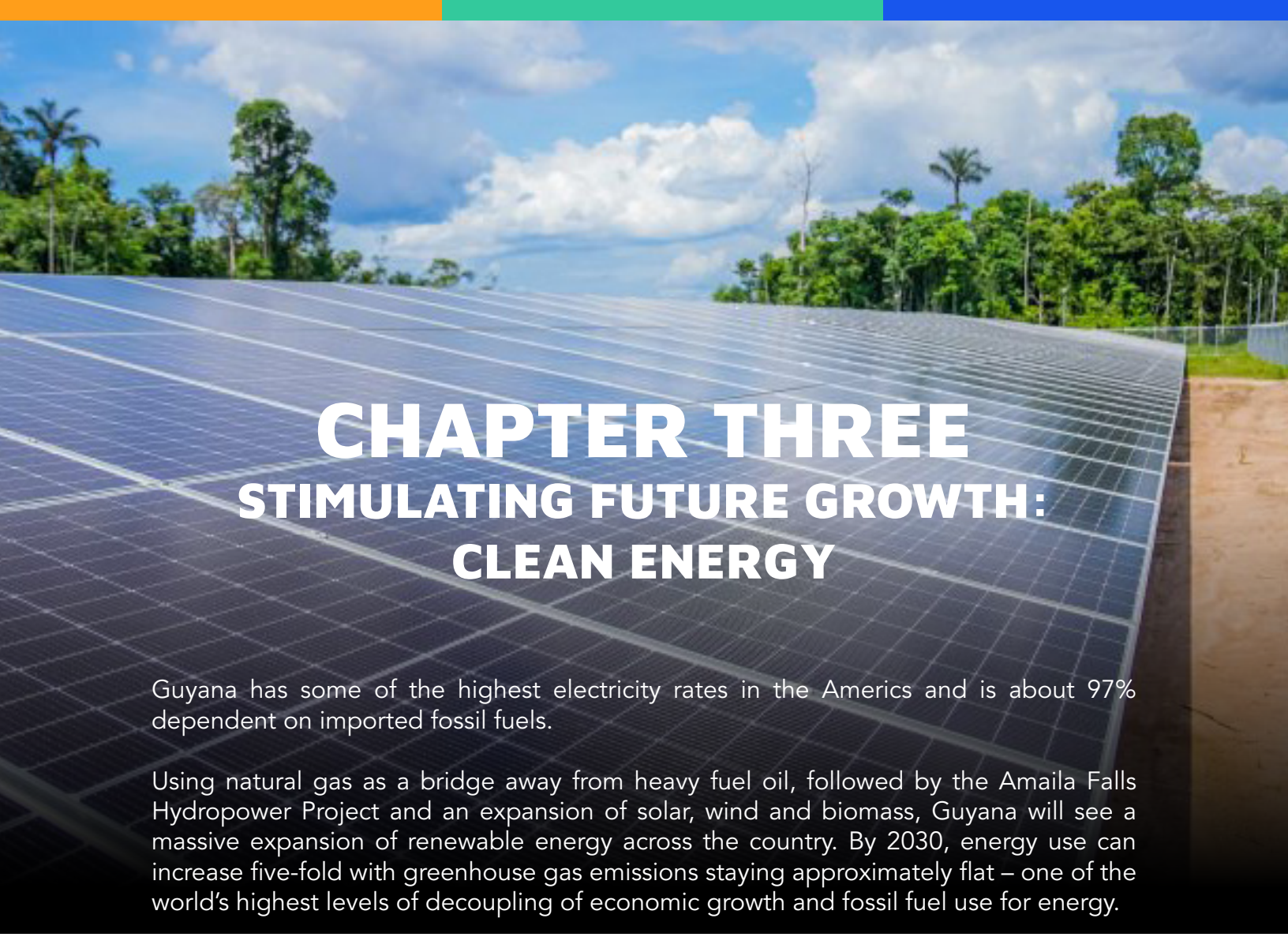


CHAPTER THREE
STIMULATING FUTURE GROWTH: CLEAN ENERGY

Guyana has some of the highest electricity rates in the Americs and is about 97% dependent on imported fossil fuels.

Using natural gas as a bridge away from heavy fuel oil, followed by the Amaila Falls Hydropower Project and an expansion of solar, wind and biomass, Guyana will see a massive expansion of renewable energy across the country. By 2030, energy use can increase five-fold with greenhouse gas emissions staying approximately flat – one of the world's highest levels of decoupling of economic growth and fossil fuel use for energy.

Without this transition away from today's energy sources, both greenhouse gas emissions and consumer costs will stay very high because of a reliance on imported Heavy Fuel Oil (HFO) and diesel for electricity generation in the 12 public grids operated by Guyana Power and Light (GPL) and Hinterland Electrification Company Inc (HECI). Expenditure on these fuels was approximately US$ 150 million in 2021.

The Demerara Berbice Interconnected System (DBIS) is the largest of the public grids and accounts for 78% of the total cost. The DBIS peak power was 135.7 Megawatts (MW) in 2021 and it is estimated that the peak load by 2025 will be 407MW. The DBIS has currently 205MW of firm capacity. However, some of that capacity is from aged generators with low reliability. It has been estimated that a new 300MW of firm capacity will be needed to cover the demand increase, the retirement of aged generators and to improve the grid's reliability.

In the original LCDS, it was foreseen that the Amaila Falls Hydropower Project would have been completed before 2020, delivering cheaper, cleaner electricity. However, its development was not progressed by the 2015-2020 Government. The Government now intends to return to a strategy of decoupling economic growth from using fossil fuels for

electricity by developing low-carbon energy resources (Solar, Hydro, Wind, Biomass, and Natural Gas) to meet rapidly rising demand and keep greenhouse gas emissions low.

This is being done through a combination of: (i) investment in transformational energy infrastructure across the generation and transmission systems; (ii) fiscal incentives and government policies to support the use of renewable energy at the level of households and businesses; (iii) investments to improve energy efficiency.

TRANSFORMATIVE INFRASTRUCTURE DEVELOPMENT

Infrastructure development will be funded by the regular national budget, private sector investment and increased revenues from forest climate services, and can be seen as three phases:

- In the period 2022 to 2028, a near tripling of electricity demand will be met mainly through a combination of natural gas and the Amaila Falls Hydropower plant on the DBIS, coupled with a major expansion of solar power for the main coastal urban areas and with batteries for off-grid areas.
- From 2028 to 2032, further increases in electricity demand will be met by continued replacement of HFO, expansion of wind and solar power and the commissioning of Guyana's second hydro plant, the site of which will be identified before 2025.
- From 2032 onwards, expansion will be determined by prevailing market conditions, but it is likely that battery and hydrogen technology will be sufficiently advanced to enable solar and wind plants to provide most new capacity increases while contributing to further downward pressure on electricity prices.

Figure 3.1 shows how renewable energy will grow to dominate Guyana's electricity supply, while Figure 3.2 shows how a ten-fold increase in electricity demand by 2041 will be see greenhouse gas emissions stay essentially at 2018 levels. This level of decoupling of economic growth and fossil fuel use for energy is among the highest in the world.
More details of how investment in transformative infrastructure will propel the energy transition are set out in the remainder of this section – showing the energy transition for:

- Demerara-Berbice Interconnected System (DBIS)
- Isolated Grids: Linden, Essequibo Coast, Bartica, Lethem, Kwakwani, Mabaruma, Port Kaituma, Mahdia, Leguan, Wakenaam, Matthews Ridge with Essequibo Coast, Linden, Leguan and Wakenaam being integrated with DBIS by 2027
- Unconnected Communities

Details are also provided for the other major investment in a modernised Transmission and Distribution (T&D) System.

Figure 3.1 Energy Mix to 2041

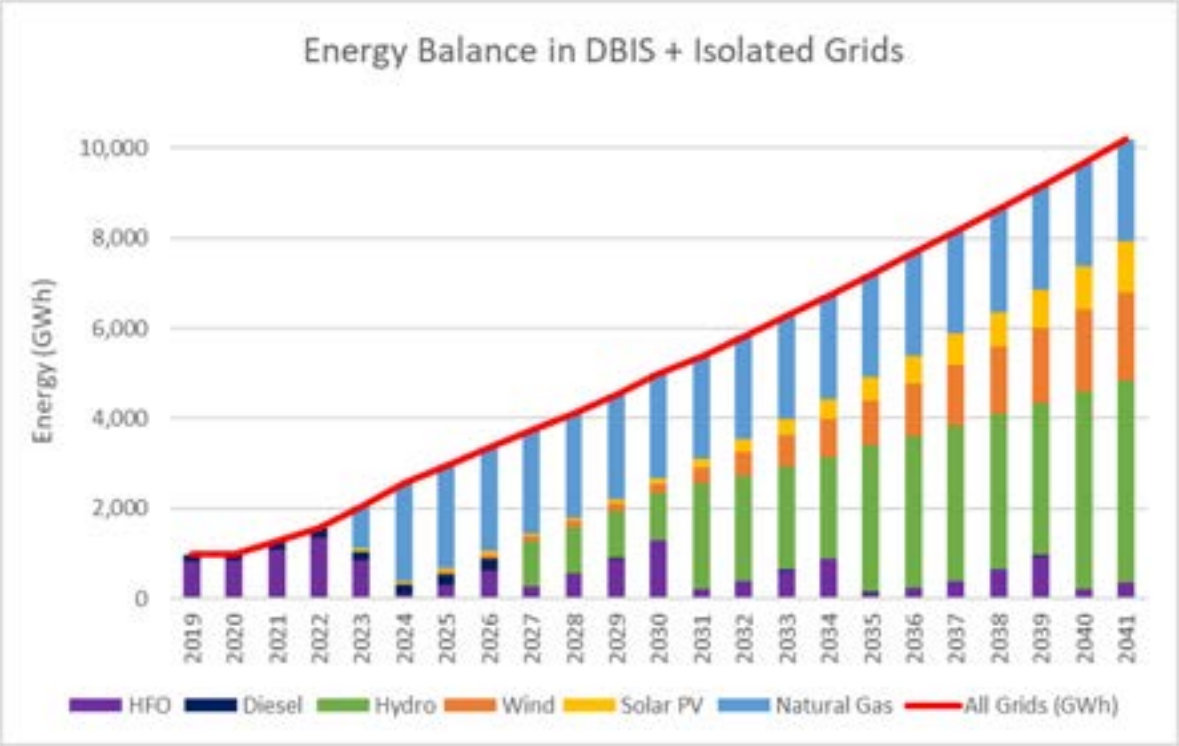
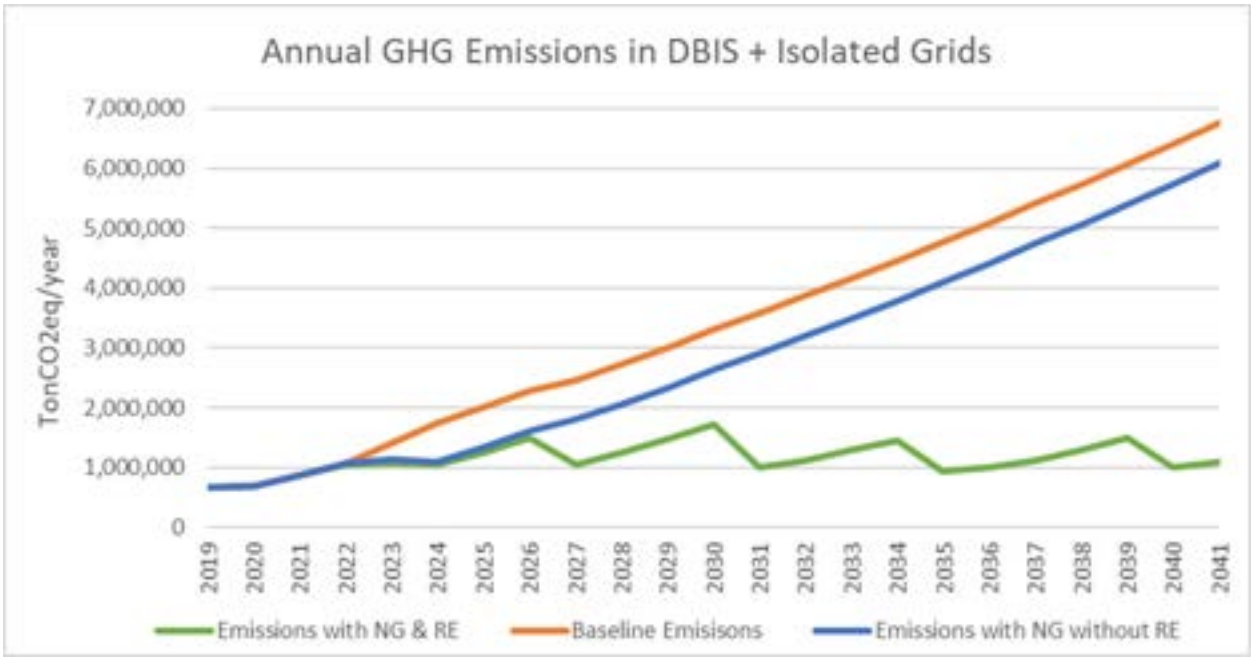


Figure 3.2 Greenhouse Gas Emissions to 2041



Demerara-Berbice Integrated System

Today, almost 100 percent of the power supplied by GPL on the DBIS comes from Heavy Fuel Oil and diesel. In the short term, these sources will be largely displaced by natural gas which will provide the needed firm capacity at a significantly lower generation cost compared to the other indigenous renewable energy options available in Guyana.

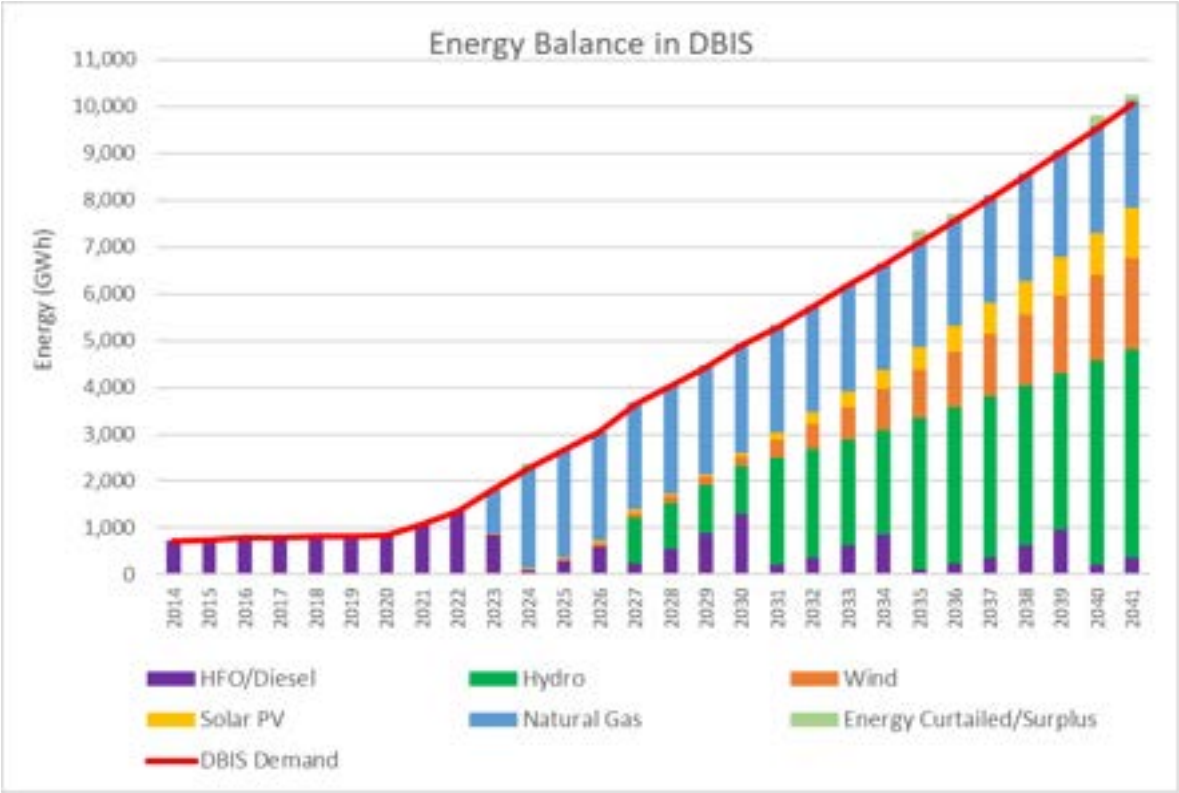
With natural gas providing the means to achieve the early stages of the energy transition in Guyana, over the medium and long term, the most sustainable and resilient energy mix in Guyana will see natural gas augmented by solar, wind, hydro and biomass power plants. Within the renewable energy resources available in Guyana, hydro will be important to provide firm capacity and short-term energy storage to compensate for daily and weekly fluctuations form solar and wind. Hydro will also provide, in the long-term, a cheaper solution than any other technology, due to its long lifespan.

In Guyana, solar energy, wind and hydropower are good complementary resources. Solar energy is available during daylight hours, peaking at noon, while wind is stronger during evening hours and at nights. Wind is lower during the wet seasons, while hydropower is fully available. Through this combined approach utilising complementary lower carbon and renewable energy systems, the DBIS will see the emergence of lower electricity prices and very significant greenhouse gas emissions savings. This is summarised in Figures 3.3 and 3.4, with greater detail about each energy source on the following pages.

Year	Peak Load (MW)	Back-up HFO or Diesel (MW)	Natural Gas (MW)	Solar (MW)	Wind (MW)	Hydro (MW)	HFO share (%)	Natural Gas share (%)	RE Share (%)
2021	161	203	0	5	0	0	99	0	1
2022	211	203	0	5	0	0	99	0	1
2023	283	192	250	15	0	0	47	52	1
2024	341	182	250	20	25	0	4	94	2
2025	414	182	250	25	25	0	11	86	4
2026	459	157	250	30	25	0	20	76	4
2027	506	132	250	35	35	165	7	62	31
2028	561	107	250	40	45	165	13	57	30
2029	620	82	250	45	55	165	20	52	29
2030	685	57	250	50	65	165	26	47	27
2035	989	47	250	300	315	585	1	32	67
2040	1,326	47	250	550	565	785	2	24	74

Figure 3.3 Evolution of the DBIS energy transition

Figure 3.4 Energy Mix on DBIS to 2041



Natural Gas in DBIS

To use natural gas for power generation, the following investments are needed: a pipeline to bring the natural gas to shore, a processing plant to separate the Liquefied Petroleum Gas (LPG) and the natural gas, and a gas-fired power plant. Studies confirmed that the natural gas option would significantly reduce the cost of generation.

A 300MW gas-fired power plant will be constructed and in operation by 2025. Besides the natural gas-fired power plant, and to provide the necessary firm capacity, new reciprocating 46MW dual fuel (HFO/NG) engines were added to the DBIS grid in 2021. By 2025, with the addition of 300MW of new firm capacity provided with Natural Gas, the reliability of the DBIS grid will increase while the Green House Gas (GHG) emissions associated with electricity generation will be reduced by half.

As part of the Natural Gas Programme, the LPG consumed in the country would be provided by the new separation plant and LPG production facility, avoiding the current importation. The planned offshore pipeline is designed to provide larger amounts of gas. In case new discoveries are made, the natural gas could be used for other industrial activities.

Utility Scale Hydropower in DBIS

Hydropower has the potential to provide Guyana with both utility-scale and small-scale capacity. Small-scale is discussed under "Isolated Grids" below.

Guyana has a potential for 8.5 Gigawatt (GW) of hydropower on 33 hydropower plants (including storage capacity and run-of-river). It is anticipated that Guyana will build two hydro plants over the next 20 years: Amaila Falls and another which is still to be identified. Of the potential 33 sites, many were assessed in the 70s and 80s, when environmental and social standards were lower. It is anticipated that the new site will be identified by 2025, with the goal of providing 350MW of capacity by 2030 and a further 250MW of capacity by 2035. In the meantime, Amaila Falls will be the focus of the hydropower programme.

Amaila Falls - Background

The Amaila Falls Hydropower Project (AFHP) was first identified in 1976 during an extensive survey of the hydroelectric power potential in Guyana, carried out by the Canadian company Montreal Engineering Company (Monenco). A total of 67 sites were identified as technically feasible solutions. From 1974 to 1976, a prefeasibility study was carried out to assess Amaila Falls, which suggested an installed capacity of 200MW. The Guyana Power Study done in 1982 included Amaila Falls as part of Guyana's power generation systems development.

In 1997, a review of the pre-feasibility study and Guyana's electricity demand was done, and it reduced the size to 165MW. Subsequently, in 1998, the Government of Guyana (GoG) signed a Memorandum of Understanding (MoU) with Synergy/Harza for the development of the Amaila Falls Hydropower Project. A feasibility study was submitted to the Government in 2001. In 2007, Sithe Global entered as a potential investor in the Project. The Government of Guyana and Sithe Global established a special purpose company, Amaila Falls Hydro Incorporated (AFHI), to develop the AFHP. The AFHI, after a competitive bidding in 2008, selected China Railway as the Engineering, Procurement and Construction (EPC) Contractor. In 2009, Synergy/Harza, the original holder of an Interim Development Licence and a subsidiary of Synergy Holdings (Guyana) and Harza International, transferred all rights and interests, obligations, and liabilities under its licence to AFHI. The Environmental and Social Impact Assessment (ESIA) was completed in 2011. A draft Power Purchase Agreement (PPA) with GPL was negotiated in 2011. Agreements with China Development Bank and the Inter-American Development Bank (IDB) for debt financing were negotiated and the project was structured as Build, Own, Operate and Transfer (BOOT), in which the asset will be transferred to GPL at zero cost after 20 years of operation.

In 2013, Opposition APNU/AFC Parliamentarians did not support the project and it did not advance.

The Engineering, Procurement, and Construction (EPC) contractor negotiated with Sithe Global and the Government of Guyana to take the role as sponsor and to purchase the shares, assets and rights in AFHI from Sithe Global. However, negotiations were interrupted after the then Government took office following elections in 2015.

In 2016, the APNU/AFC Government, with support from Norway, hired an independent consultant (Norconsult) to review the project. The report, published in December 2016, recommended the development of AFHP as the best option for Guyana to achieve affordable, low-carbon electricity.

A public procurement process is being undertaken to advance this project. The goal is for this project to come on stream in the latter part of the decade.

[2] The average lifespan of a hydropower system is 100 years, over this period, replacement of the mechanical and electrical parts is required, but those account for less than 30% of the initial cost. The lifespan of solar, wind and natural gas power plants are 25 years and after that the refurbishment will be close to 100% of the initial cost. For example, if the hydropower finance model is planned with a transfer of the asset after year 20, the generation cost after, from year 21-100 can be as low as US$20/MWh.
[3] Arco Norte Electrical Interconnection Study – Pre-feasibility study, 2016

Solar Voltaic (PC) - DBIS

Solar photovoltaic (PV) is close to being established as a mature technology in the country. Local prices are in-line with developed countries and local technology providers have the capacity to supply, install and operate on-grid and off-grid.

The Government has secured US$97 million in funding – including US$85 million in payments for forest climate services earned under the Guyana-Norway partnership.This will see the implementation of a 33MWp capacity of solar PV farms at eight different locations.

By 2024, GPL will have its first solar on-grid PV farm in Berbice with a total capacity of 10 megawatts-peak (MWp) financed by the Guyana-Norway Partnership.

The current distributed generation capacity is about 6.5 MWp of rooftop Solar PV. The Government will promote its expansion by implementing a net billing scheme and improving the distribution network to accommodate larger amounts of distributed generation without compromising the grid stability.

GPL will update its grid model regularly with the actual and forecasted demand growth, the actual generation capacity and the latest generation technologies, and costs to assess the amount of utility-scale solar that are technical and economically feasible.

In the current DBIS model with the base demand forecast, it is estimated that 100MWp of Solar PV capacity would be in operation by 2030. That capacity would be for Distributed Generation solar rooftops and Utility-scale solar farms.

Wind – DBIS

Wind measurements have been conducted in different locations across Guyana to assess the country's wind energy potential. A favourable wind regime was observed along the Coastland, which is exposed to the steady Northeast trade winds, with speeds averaging 7 metres per second.

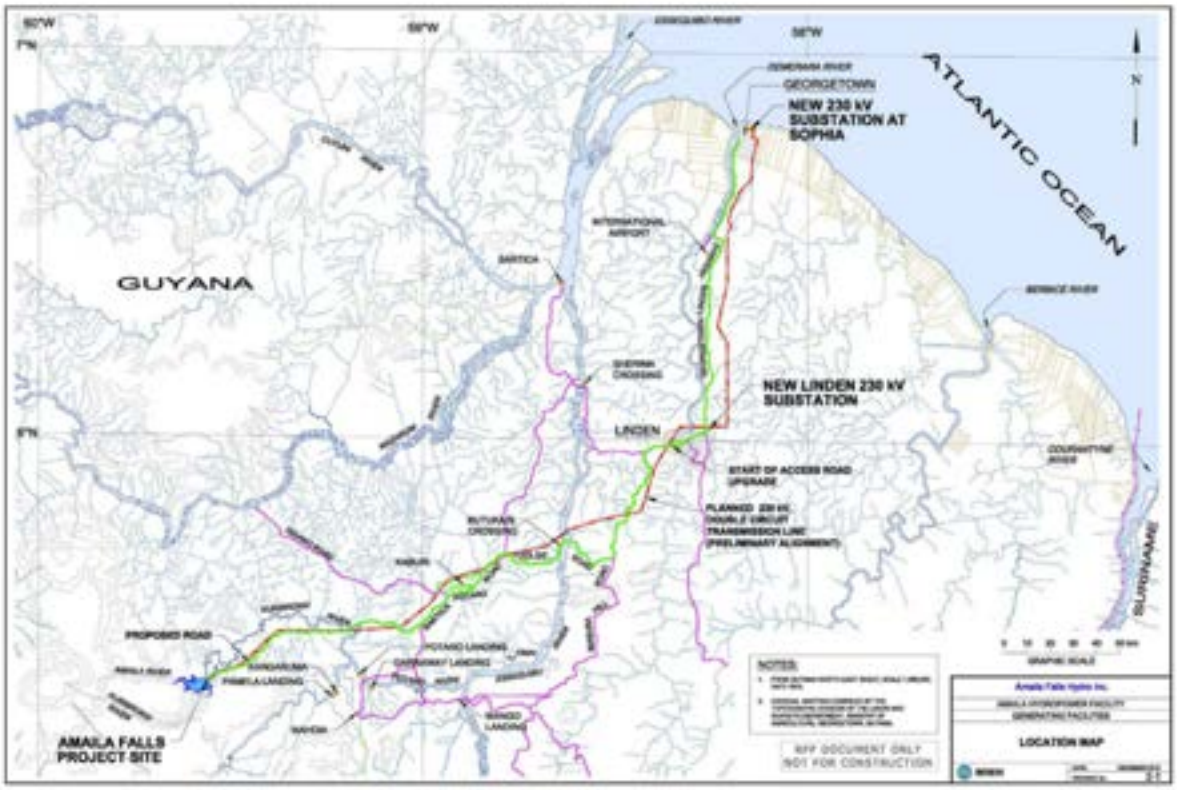
A private developer has concluded measures and studies, including the Environmental and Social Impact Assessment, for a 25MW wind farm at Hope Beach. The Government has recently conducted wind speed measurements at Onverwagt, and it is exploring other locations along the coast. The development of wind farms on Guyana's shores will mitigate GHG emissions, reduce the energy generation cost, create green jobs, and in some cases can also support adaptation to climate change by fortifying the sea defence infrastructure.

The wind speed measures taken along the coast will inform the design of the future wind programme. Based on the advances of offshore wind technology and the lowering of costs, its potential would also be explored. In the current DBIS model with the base demand forecast, it is estimated that 105MW of wind capacity would be in operation by 2030.

Biomass – DBIS

There is some practical experience in the use of biomass as an energy resource for self-consumption like rice husk in the rice mills, the use of the distillate waste to produce biomethane at Demerara Distillers Limited (DDL), or the use of bagasse for co-generation at Skeldon and Albion Sugar Estates.

The Skeldon co-generation plan for 30MW of electricity generation using bagasse from the sugar process was designed to produce excess power that would be exported to the grid. The plant is no longer working as a co-generation system due to the closure of the sugar factory. Albion co-generation plant is still in operation for self-consumption.
The Government will continue to research and encourage the utilization of waste biomass resources for energy generation when demonstrated to reduce GHG emissions.



Isolated Grids

Solar PV – Isolated Grids

By 2024, revenues earned under the Guyana-Norway partnership and other funding will see investment at 8 different sites. By then, Essequibo Coast, Linden, Bartica, Lethem, Mabaruma, Mahdia, Leguan and Wakenaam grids will have an average of 30 percent of their electricity consumed generated by solar PV.

In the second and third phases of the programme for the Isolated Grids, there is a planned increase of the Renewable Energy share to an average of 50 percent by 2027 and 70 percent by 2030. Solar PV with battery storage will be the main renewable energy resource on the regional grids.

Small Hydro – Isolated Grids

Guyana is currently implementing three small hydropower projects: a 150kW in Kato, the rehabilitation of Moco-Moco hydropower site, which would increase the capacity up to 0.7MW and a new 1.5MW hydropower plant in Kumu. Moco-Moco and Kumu hydropower projects will provide energy to Lethem grid. It is expected those two projects, in combination with an ongoing solar PV project, will provide the Lethem grid with 100% renewable energy in 2024. Other small hydro projects will be pursued to provide energy to the regional grids as well as Hinterland villages.

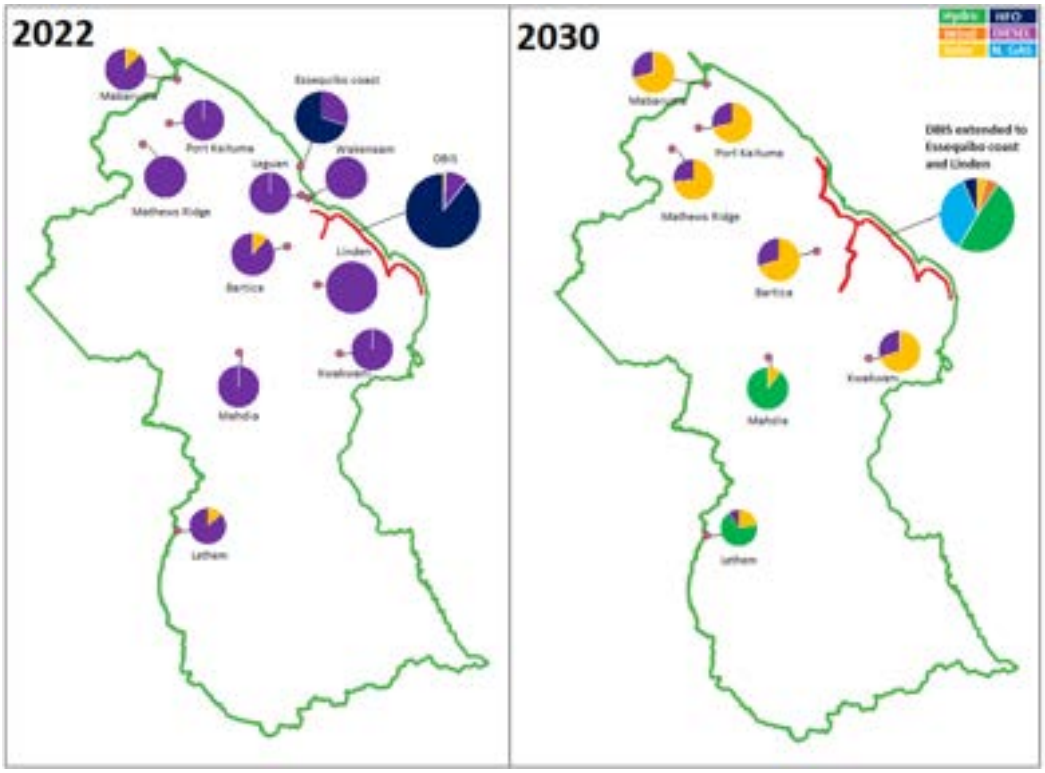


Figure 3.5 Energy Transition on Isolated Grids

Unconnected Communities

Guyana has approximately 218 Hinterland communities with a total population of 98,500 people which are off-grid (i.e., outside of the 12 public grids). Most of those villages are in remote areas, difficult to reach by road, and in many cases only accessible by boat. The cost of diesel in off-grid villages can be up to three times the cost in Georgetown.

Since 2012, through different programmes, the Government has provided Solar Home Systems for households, and small solar PV systems for schools, public buildings, and water pumps. These have included:

- The Guyana REDD+ Investment Fund (GRIF) funded project "ICT Access and E-Services For Hinterland, Poor and Remote Communities" is installing ICT Hubs in all 200+ Hinterland Villages between 2022 and 2023. The project includes the installation of an average of four-kWp solar PV system to power each ICT Hub.
- In 2020, the Guyana Energy Agency (GEA) installed a 72KW micro-grid at Moraikabai.
- A combined five kilowatts of solar PV was installed under the Rural Energy Project in Moraikobai, Powaikoru and Shulinab.

In 2021, HECI completed the installation of 9 solar-powered mini-grids at Yarakita and Hotoquai, Region 1, Akawini, Bethany and Kabakaburi, Region 2, Chinoweng and Phillipai, Region 7, Monkey Mountain, Region 8 and Achiwib, Region 9.

- Installation of 9 Solar photovoltaic systems was completed in Region 1, during 2022, at the following locations: Arakaka Health Centre, Mabaruma Radio Station, Barima Kariabo Health Centre, Arakaka Primary School, Wauna Primary School, Red Hill Health Post, Santa Rosa Secondary School, Hobodiah Health Post and Moruca Health Centre.
- Installation of a solar PV system for the Quebenang Health Centre, Region 7 was completed in 2022 and 2 other installations at Kamwatta Primary School, Region 1 and Sand Creek Primary School, Region 9 will be completed in 2022.

Other work is in progress:

- Under the planned Solar Home System Project, with support from the Government of India, thirty thousand (30,000) 150-watt systems are expected to be installed in 2024.
- As part of the 2021 public budget, the Government approved the installation of 19 solar PV mini-grids for public and community buildings at Sebai, Karaburi, Kwebanna, Haimacabra, Baramita and Canal Bank of Region One; Wakapao, Capoey Mission, St. Monica and Tapakuma, of Region 2; Waramadong, Paruima and Jawalla of Region 7; Kurukubaru of Region 8; Annai, Karasabai, Aishalton and Kraudarnau of Region 9; and Riversview of Region 10.

- In 2021, Guyana signed a grant agreement with the International Solar Alliance for a solar demonstration project in Orealla, Region Six. This will see the installation of a 9kWp grid-tie solar photovoltaic system at the Orealla Health Centre and will be accompanied by a battery energy storage system of 37kWh.
- 13 solar PV installations were awarded in 2022 for the following locations: Ulele Primary School, Hackney Primary School, Mashabo Health Centre in Region 2; Santa Aratack Nursery/Primary Schools, Santa Aratack Health Centre and Saxacalli Health Centre in Region 3; Karrau Primary School, Batavia Primary School in Region 7; Sand Creek Nursery School and Teacher's Quarters, Village Office and the Youth Multi-purpose Hall in Region 9; Falmouth Nursery/Primary School in Region 10.

The learnings during the implementation of those solar PV projects in the Hinterland will support the development of a larger programme to electrify all Hinterland villages. The electrification will be with the most technical and economically feasible solution (interconnection to a larger grid, solar PV and/or mini-hydro). The programme will include the enhancement of the productive usage of the energy to increase the long-term sustainability of the mini-grids.

It is estimated such a programme would cost US$313 million and could be implemented between 2023-2028. Work has now commenced on how to fund this programme including through the emerging carbon markets to support off-grid renewable energy.

Modernisation of T&D network (Smart Grid)

The Transmission and Distribution (T&D) network plays a critical role in power evacuation from power plants and delivery of electricity to customers across Guyana. The electricity service provided to Guyana Power and Light (GPL) customers does not meet the reliability and quality requirements of utilities in developed countries. The low reliability is due to the low capacity of generation, the lack of redundancy in key lines, and the low remote supervision and control of the T&D network.

The utilities have been increasing their generation capacity at the same pace as the demand has been growing, keeping a low reserve and excess capacity that is inadequate to cater for downtime in their generators. The expansion of the firm capacity that is planned in the next decade with new power plants using natural gas and renewable energy will increase the reliability and resilience to generate the electricity demanded at a much lower cost than currently; but besides that, all the public grids will need important improvements in their T&D which have been developed in a radial way and built with single lines, meaning that a failure in any of those single lines will disconnect customers connected downstream of the faulty line.

To increase reliability in the transmission network to world-class utility requirements, the new transmission lines and substations will be designed to comply with 'N+1 redundancy criteria' (with at least one backup component). The transmission network will also be expanded to form a real network, avoiding radial configurations where possible. As part of the T&D improvement programme, the existing lines and substations will be progressively upgraded to meet the new redundancy requirements.

GPL's Development and Expansion Programme estimates the need for an investment of US$600 million over the next five years to upgrade, expand and equip the power system to take off and manage the forecasted electricity demand, and provide services, and operate at the required reliability levels of a modern power utility company.

POLICIES AND INCENTIVES TO ENCOURAGE CONSUMER CHOICE

Along with investments in transformational infrastructure, Government policy is to encourage individual consumers and businesses to invest in, and use, renewable energy, through fiscal incentives and policies including:

- **Self-Generation:** Self-generation is allowed as per Guyana's legislation. Any consumer who wishes to interconnect their solar PV system into the public grids to eliminate the need for battery storage (solar PV on-grid) must submit an interconnection request and comply with the Interim Interconnection Requirements set by GPL. As part of the roof-top solar PV for Government buildings programme, about five megawatts were installed at 291 buildings across the ten Administrative Regions during the period 2012-2020.

- **Grid Feed-In Mechanism:** A grid feed-in mechanism is being advanced by GPL to establish the regulatory framework for consumers to supply excess energy to the grid, from renewable energy sources.

- **Fiscal Incentives:** Machinery and equipment imported for the purposes of generating and utilising renewable energy are eligible for Customs duty and Value-Added Tax Exemptions under existing laws. This includes solar panels, solar lamps, deep-cycle batteries, solar generators, solar water heaters, solar cookers, direct current (DC) solar refrigerators, direct current (DC) solar freezers, direct current (DC) solar air-conditioners, wind turbines, water turbines, and power inverters; and energy-efficient lighting, including compact fluorescent lamps and light-emitting diode (LED) lamps. There is also a one-off tax holiday of two years for corporation tax to importers of items for wind and solar energy investments.

ENERGY EFFICIENCY MEASURES

A significant reduction of the total energy consumed can be achieved through sustainable energy efficiency programmes and strategies. The Government will promote conservation and efficient use of energy, provide information to encourage behavioural changes for sustainable energy consumption, and encourage the use of energy-efficient technologies based on performance standards.

Since 2006, the Government has supported the replacement of incandescent bulbs with energy-saving bulbs, with special programs for hinterland households. Compact fluorescent lamps (CFLs) and light-emitting diode (LED) lamps have been fully exempted from import duties and the Value Added Tax (VAT) has been zero-rated to make energy-efficient lighting technologies more affordable and accessible.

28,390 LED lights were installed in households and commercial businesses in the Hinterland regions of Kwakwani, Lethem, Mahdia, Mabaruma, Port Kaituma and Matthew's Ridge and government buildings across Guyana. During 2022 and 2023, an additional 34,450 LED lights will be installed for residents and businesses of Bartica, Linden, Wakenaam, and Leguan.

In 2013, a program was started to improve the efficiency of the streetlights, repairing defective photocells, and replacing inefficient bulbs with LED. Energy audits in public buildings have been carried out, which resulted in reduced energy bills by installing LED bulbs, occupancy sensors, and inverter-type A/C units.

A Regional Energy Efficiency Building Code (REEBC) was adopted as a national standard to foster energy-efficient building designs to reduce energy consumption in the built environment. The codes focus on the building's envelope, cooling system, ventilation, pumping, lighting, and the service water heating systems in buildings. Several other standards have been adopted, including energy labelling standards for CFLs and LEDs (GYS 577 – 2021) and Air Conditioners (GYS 578 – 2021) and a standard for energy management systems (GYS 503: 2019) all to promote energy efficiency and conservation of energy.

The incorporation of Energy Efficiency measures will be improved and enhanced to:

- Continue with the program to replace inefficient bulbs with LEDs for households and streetlights.
- Promote Energy Labelling standards for appliances.
- Adopt low carbon building codes for the residential and commercial sectors, which will include the designing and testing of solutions adapted for the local environment accompanied by capacity building for building designers, material

and equipment suppliers, contractors, surveyors and regulators. The codes would promote the incorporation of passive and active systems which are used for optimizing energy and water consumption as well as occupant comfort. Initially, the code would be voluntary for the residential sector, but consideration will be given to making it mandatory for commercial buildings.

- promote the use of energy efficiency and climate-friendly cooling equipment for the residential, commercial and industrial sectors, including the development of a plan to phase-down the use of hydrofluorocarbons (HFCs) gases in refrigeration equipment.