

ENERGY TRANSITION ROADMAP FOR GUYANA

Abstract

This document presents the suggested energy transition roadmap for Guyana with a focus on achieving 100% renewable energy penetration in the electric sector. Tasks have been identified together with specific projects and responsible parties. Natural gas is suggested as the transitional energy source. Funding for the Road Map is predicated on the monetization of recently discovered offshore gas and oil resources, plus private public partnerships, local financial institutions, international donor resources and national government resources.

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Contents

List of Acronyms and Abbreviations	2
1 Introduction	4
2 SCOPE OF WORK	4
3 EXISTING SITUATION TO THE POWER SECTOR	4
3.1 Legal and Institutional Framework	4
3.2 Existing Grid Constraints	6
3.3 Existing Grid Generation	7
3.4 CURRENT GUYANA POWER CAPACITY EXPANSION ACTION PLAN	7
4 ENERGY TRANSITION ROAD MAP	9
4.1 Justification	9
4.1.1 Load Forecasting	9
4.1.2 Costs and Benefits.....	10
4.1.3 Policy Commitments	12
4.2 List of Actions.....	13
4.3 Financing Action Plan (5 Year, 10 Year)	18
5 Annex I – Detailed Actions from Guyana Draft National Energy Policy	21

List of Acronyms and Abbreviations

AFHI	Amaila Falls Hydro Inc.
AFHP	Amaila Falls Hydropower Project
ASHRAE	American Society for Heating, Refrigeration and Air-conditioning Engineers
boe	Barrels of Oil Equivalent
BOOT	Build, Own, Operate & Transfer
CARICOM	Caribbean Community
CCREEE	Caribbean Centre for Renewable Energy and Energy Efficiency
CDB	Caribbean Development Bank
CRFG	China Rail First Group
CROSQ	Caribbean Regional Organisation for Standards and Quality
DAI	Direct Area of Influence
DBIS	Demerara/ Berbice Interconnected System
DO	Dissolved Oxygen
DRIFT	Downstream Response to Imposed Flow Transformations
EFR	Environmental Flow Requirement
EIA	Environmental Impact Assessment
EnMS	Energy Management Systems
ESCO	Energy Services Company
ESIA	Environmental & Social Impact Assessment
ESRA	Electricity Sector Reform Act 1999
EPC	Engineering / Procurement/ Construction
GDS	Green Development Strategy
GDP	Gross Development Product
GEF	Global Environment Facility
GHG	Greenhouse Gases
GIS	Geographical Information Systems
GL	Generation Licence
GOG	Government of Guyana
GPL	Guyana Power & Light
GSEC	Ground Structures Engineering Consultants Inc.
GUYSUCO	Guyana Sugar Corporation
HECI	Hinterland Electrification Company Inc.
HFO	Heavy Fuel Oil
IA	Implementation Agreement
IAI	Indirect Area of Influence
IAST	Institute of Applied Science and Technology
IDB	Inter-American Development Bank
IE	Independent Engineer
INDC	Intended Nationally Determined Contribution
IPED	Institute of Private Enterprise Development
IPP	Independent Power Producer

IRENA	International Renewable Energy Association
Kboe	Kilo (thousands) Barrels of Oil Equivalent
LCSD	Low Carbon Strategy Document
LFO	Light Fuel Oil
MEF	Minimum Environmental Flow
MEPS	Minimum Energy Performance Standards
MoF	Ministry of Finance, Cooperative Republic of Guyana
MoPI	Ministry of Public Infrastructure, Cooperative Republic of Guyana
MW	Megawatt
REETA	Renewable Energy and Energy Efficiency Technical Assistance
SECBI	Sustainable Energy Capacity Building Initiative
SECCI	Sustainable Energy and Climate Change Initiative
SEI	Skeldon Electricity Inc.
SWERA	Solar and Wind Energy Resource Assessment

1 INTRODUCTION

The Government of Guyana through the Ministry of the Public Infrastructure (MoPI) has retained the Consultant to prepare the Guyana Energy Transition Road Map. This effort is aided by funding from the Inter-American Development Bank (IDB) Guyana, and is managed by the Hinterland Electrification Company Inc..

2 SCOPE OF WORK

The scope of work addresses a renewable energy power expansion plan inclusive of a transition strategy based on natural gas for Guyana for the period 2017 – 2035. Further, the road map is based only on existing information and studies and incorporate both on-grid and off-grid energy generation.

3 EXISTING SITUATION TO THE POWER SECTOR

This section gives an overview of the institutional and legal arrangements for the power sector, plus a description of the national electric grid. This section also identifies a number of gaps.

3.1 Legal and Institutional Framework

The legal and institutional framework for the power sector of Guyana comprises of the following institutions: The Ministry of Public Infrastructure, the Guyana Energy Agency (GEA), the Public Utility Commission (PUC) and the National Industrial and Commercial Investment Limited (NICIL).

The Ministry of Public Infrastructure is responsible for: energy, hydropower, utilities, hinterland electrification and electrical inspection. Its departments include: Guyana Energy Agency (GEA), Guyana Power and Light (GPL), the Hinterland Electrification Company Inc. (HECI) and the Electrical Inspectorate. The Public Utilities Commission (PUC) is an autonomous regulatory agency acting under its own Act.

The Guyana Energy Agency Act of 1997 (and as subsequently amended), established the GEA to: (i) advise and make recommendations to the Minister regarding efficient use of energy resources; (ii) Upon the request of the Minister, develop a national energy policy and secure its implementation, directly or through other persons; (iii) Secure the efficient use of energy; (iv) develop and encourage the development and utilisation of sources of energy other than sources presently in use; (v) to carry out research into all sources of energy including those sources presently used in Guyana for the generation of energy, and securing more efficient utilisation of energy and sources of energy; (vi) to monitor the performance of the energy sector in Guyana, including the production, importation, distribution and utilisation of petroleum and petroleum products; (vii) to disseminate information

relating to energy management, including energy conservation and the development and utilisation of alternative sources of energy.

The Electric Sector Reform Act 1999 (ESRA) established the Guyana Power Light and Inc. as the main national electric grid infrastructure service provider. GPL is a state owned vertically integrated utility. GPL generates most of the electricity in Guyana with its own power plants. It operates three girds, the Demerara/Berbice Interconnected System (DBIS), the Essequibo system and the Bartica system. It also buys wholesale electricity from a bagasse fired cogeneration plant collocated with a diesel plant at the Skeldon Sugar Factory to assist in the supply of electricity to the DBIS system. GPL also operates a mini grid in the Essequibo region that utilises diesel generation. Under its license GPL is permitted to purchase electricity from hydro facilities under the terms of a power purchase agreement (PPA). The license also requires that GPL undertakes a tendering process for the acquisition of all new non-hydro generating plant.

There are several other smaller minigrids/microgrids that serve isolated communities which are owned by the Hinterland Electricity Company Inc. (HECI) which in turn is a wholly owned by the Government of Guyana. The subsidiaries are in Table 1 following:

Table 1: Subsidiaries of HECI

Company	Description	Installed Capacity	Peak Demand (KVA)	Peak Demand (KW)	No. of Customers
Linden Electricity Company Inc. (LECI)	Transmits, distributes and supply electricity to the bauxite mining town of Linden, and purchases all its electricity from Bonsai Bauxite Company (owned 70% China Bonsai and 30% Government of Guyana)	18 MW		11200	4,597
Kwakwani Utilities Inc. (KUI)	Generates, transmits, distributes and supply electricity and water to Kwakwani and surrounding areas	3.375 MVA	837.5	670	1098
Lethem Power Com. Inc. (LMPCI)	Generates, transmits, distributes and supply electricity to areas within the boundaries of Quarrie Creek in the South, Manari Creek in the North, Kanuku Mountain Range in the East and Takatu River in the West of Region 9.	2.125 MVA	950	760	1200
Mahdia Power Company	Supplies electricity to the Mahdia community and surrounding communities in Region 8.	1.463 MVA	440	352	580
Port Kaituma Power & Light	Supplies electricity to the Port Kaituma community	1.463 MVA	400	320	635
Matthew's Ridge Power & Light	Serves Matthew's Ridge, a small mining community within the Barima-Waini region of Guyana (Region 1). This area also has a significant number of self-generators.	218 KVA	60	48	67
Mabaruma Power & Light Co. Inc	Supplies electricity to the Mabaruma community	750 KVA	575	460	720

The HECI's mission is to maintain the steady extension and upgrade of electricity supply systems across the hinterland, progressively improving operations and merging isolated services as appropriate. It currently manages the Government's Hinterland Electrification Programme and the Global Environment

Facility (GEF) – Sustainable Energy Programme for Guyana with loan support through the Inter-American Development Bank (IDB), to promote renewable energy development in Guyana.

The Public Utilities Act (PUCA) authorises the Public Utility Commission (PUC) to provide economic regulation for public services including electricity, telecommunications, water supply, and transportation. In relation to the electricity sector, the PUC shall be bound by, and shall give effect to, the GEA Act and the Electricity Sector Reform Act 1999 (ESRA). The PUC is a corporate body with members appointed by the Minister for a three-year term period.

The PUC administers the regulatory framework of the power sector as follows:

- i) The main regulatory elements for the power sector are defined in the four Acts: 1) the GEA Act, which defines the scope of energy policy; 2) the Electricity Sector Reform Act, which defines the scope of the electricity public services, the procedures and conditions for granting of licenses to Independent Power Producers and provisions for the operations of the utility within served and unserved areas. The license also sets out the 5 years rolling Development and Expansion plan as Schedule 3 to the license; 3) the Hydro Electric Power Act, which defines the scope of licenses for hydro generation. The Minister responsible for the energy sector is responsible for issuing licenses under the Hydro Power Act; and finally, 4) the PUC Act, which defines the procedures for approval of plans and tariffs and enforcement of standards and targets.
- ii) The 1999 GPL's license, includes power generation, except hydropower generation). GPL's License stipulates: (i) the Rates and Adjustment mechanisms, (ii) Operational Standards and Performance targets, (iii) Development and Expansion Plan, (iv) Standard Terms and Conditions; (v) Customer Service Standards in Schedules I, ii, iii and iv of the license respectively; and (vi) Rules related power acquisition prices and rates.
- iii) Institutional capabilities: The essential institutional arrangements for the power sector already exist in Guyana. However, there are several gaps in national capabilities that have now been emphasised as a consequence of the new aspirational goal of 100 percent renewable energy for electricity generation by the year 2025 and the need to reduce national energy intensity to a nationally determined target. The enhancements to remove these gaps are given in Annex 1.

3.2 Existing Grid Constraints

The constraints faced by the transmission and distribution system of GPL that limit the incorporation of mid-scale hydro power production and grid tied distributed generations are as follows:

- i) Transmission:
 - a. Lack of a substation and transmission intertie between geographic areas for prospective mid-scale (150 – 180 MW) hydropower development to serve both Linden and the Demerara/Berbice Interconnected System (DBIS).

- ii) Distribution:
 - a. Lack of feed-in tariff and regulatory regime to govern the pricing, service standards and mandate concerning the interconnection of roof top and commercial scale distributed generation (of less than 1.5 MW) to the distribution grid.
 - b. Lack of an operational protocol for GPL to manage the integration of high level of intermittent renewable energy integration.
 - c. Lack of a grid modernisation plan and investments aimed at high levels of penetration of intermittent renewable energy and the deployment of smart grid concepts.
- iii) Generation:
 - a. A significant number of large industrial companies are self-generating off the national grid.
 - b. There is a lack of clarity concerning the generation licensing issues for distributed generation.
 - c. High levels of penetration into the national grid of intermittent renewable energy generated from distributed systems are likely to cause integration problems such as stability, inadequate ramping and voltage impacts. There is a lack of planning for this eventuality.

3.3 Existing Grid Generation

This section summarises the generation capability of GPL in the DBIS System, plus the Essequibo region (but excluding Linden) which are operated by GPL.

- i) DBIS System: Currently, the installed capacity of the DBIS is 139.89 MW with only 122.19 MW available. This total combines 117.49 MW in Demerara and 22.4 MW in Berbice. Generation plants comprise of relatively old high-speed diesel units fueled by light fuel oil (LFO), and relatively new medium-speed diesel units fueled by heavy fuel oil (HFO). In addition, there is a generation plant comprising 2x15 MW steam turbines fired by sugar cane bagasse that are owned and operated by the Skeldon Electricity Inc. (SEI). SEI also owns a total of 10 MW in HFO fired reciprocating engines. The steam turbines and reciprocating engines support a Power Purchase Agreement (PPA) with GPL.
- ii) Essequibo: There are generation power plants at Anna Regina 8.2 MW), Wakenaam (0.9 MW), Leguan (1.28 MW), and Bartica (4.8 MW).
- iii) Linden. Installed Capacity of 18MW with Peak Demand of 11.2 MW.

3.4 CURRENT GUYANA POWER CAPACITY EXPANSION ACTION PLAN

The power generation expansion plan recommended in the Guyana Power Generation System Expansion study 2016 is given in Table 2 below. While the plan is intended to pursue the least cost expansion plan as analysed and recommended in 2016, the plan would have to be adjusted to fit the full range of contemporary policy goals of the Government of Guyana plus the state of implementation to date. The Plan is divided in ten (10) phases—Phase 1 to Phase 10 — and seventeen (17) tasks, each task representing the development of certain infrastructure (e.g. generation project including renewables, transmission line, gas infrastructure) or an action to be taken (e.g. energy efficiency program, regulatory

reform). Phase 10 relates to Institutional Strengthening of GPL and the GEA to better enable adjustments to the Plan as demand and technology innovation unfolds.

Specific adjustments of the plan to meet current national policy goals include:

1. The expansion of Phase 6 to include studies for the re-development of the planned transmission line to Linden as a potential transmission backbone to accommodate the interconnection of other mid-scale hydro power sites (150 – 180 MW) as well as northern Brazil.
2. The advancement of the timeline for Phase 9 from 2025 to 2020. This phase relates to energy efficiency and distributed generation.

Table 2: GPL Action Plan

Phase	Year	Task	Project
1 Engines	A 2017	Engines HFO	HFO 17.4 MW
	B 2018	Engines LFO	LFO 22 MW
	C 2032/33/35	Engines Natural Gas	2032 - 2035 HFO w/natural gas 3x11 MW
2 Wind	2017	Hope Beach	Wind 26 MW Hope Beach
3 Solar	A 2018	Solar - Phase I	Solar 3 MW - Phase I
	B 2019	Solar - Phase II	Solar 3 MW - Phase II
4 Biomass	A 2019	Wood	Wood 0.7 MW
	B 2020	Skeldon	Bagasse 7.5 MW Skeldon
	C 2025	Albion	Bagasse 9.8 MW Albion
	D 2027	Enmore	Bagasse 5.7 MW Enmore
5 Hydro	2021	Mid-size Hydro	Mid-size Hydro 165 MW
6 Linden interconnection	2021	Linden	Linden interconnection to DBIS
7 Natural Gas	2027	Natural Gas Infrastructure	Natural gas infrastructure for power generation
8 Policy & Regulation	2018	Regulatory Reforms	Energy policy & Power sector regulation reforms
9 Energy Efficiency & Distributed Generation	2025	Energy Efficiency	Energy Efficiency measures and distributed generation
10 Institutional strengthening	A 2017	Institutional strengthening	Strengthen GPL
	B 2017		Strengthen GEA

Source: Guyana's Power Generation System Expansion Study – Final Report June 2016

4 ENERGY TRANSITION ROAD MAP

The justification for the transition is motivated by the forecast of electricity demand, the cost and benefits of renewable energy and the national and international policy commitments of the Government of Guyana.

4.1 Justification

This Road Map points the way towards the aspirational goal of 100 percent renewable energy in the power sector. The existing Guyana generation expansion plan would not achieve this goal as it considers only a single mid-scale hydro plant and the introduction of natural gas as a transitional energy source (albeit natural gas being a cleaner energy source). This section therefore review the peak load forecast for GPL, the indicative cost and benefits of renewable energy, and the policy commitments that guide this transition road map. A series of actions are also identified to guide the orderly development of the transition and to identify the financial requirements that would be necessary.

4.1.1 Load Forecasting

The forecast of peak demand on GPL systems and installed capacity is given in Figure 1 below. The capacity additions include a mid-scale hydroelectric project. The forecast does not take into consideration of potential new loads based on the MoU with Brazil under the Arco Norte Project. GPL will need to be guided on the types of anticipated loads to be met as a result of the MoU implementation. It is anticipated that new loads will require an additional generation capacity, and further renewable energy resources will be considered at that time. Figure 1 also illustrates that the projected installed capacity exceed the projected peak load by a significant amount. While significant over capacity is typical of small isolated utilities, there is the potential to reduce this through interconnection with other grids as contemplated under the Arco Norte Project (which seeks to interconnect Guyana, Suriname, French Guyana and northern Brazil).

Figure 1: DBIS Power Generation Capacity (MW)



Source: GY Generation Expansion Study and Annexes (2016)

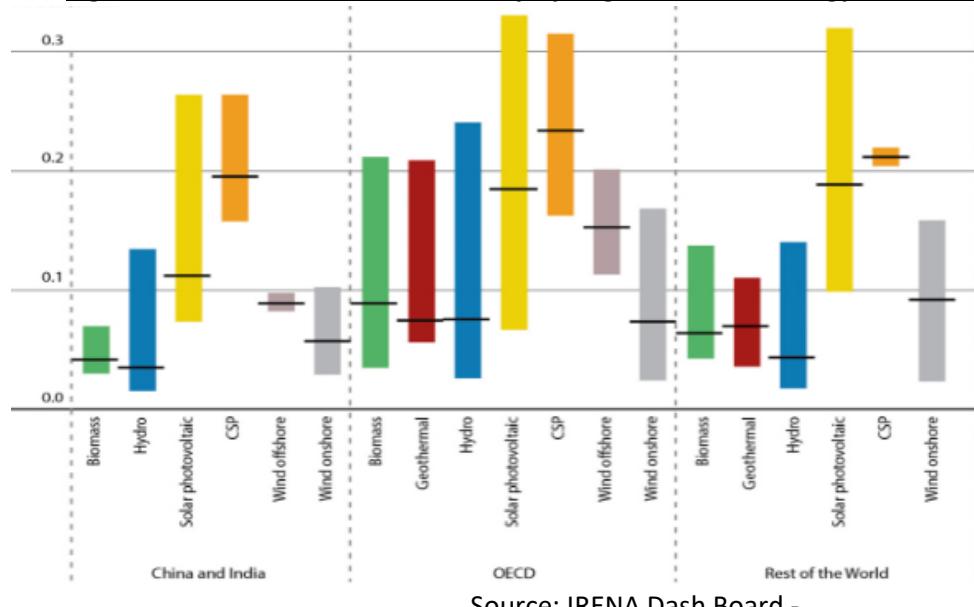
4.1.2 Costs and Benefits

A guide to the world-wide costs of renewable energy is given by reports of the International Renewable Energy Agency, IRENA. Historical levelised costs and average installed costs for various technology types are given below. This is followed by a list of benefits for renewable energy within the context of Guyana.

4.1.2.1 Costs

The publications of the International Renewable Energy Agency give historical levelised costs (2014) and projected cost reductions (2025) in Figure 2 and Figure 3 respectively, as well as average installed costs in Figure 4 below. While these indicative costs trend downwards, the level of cost are to be determined for Guyana. Typically, renewable energy costs in relatively smaller countries like Guyana tend to be the high end of the international averages. Hence the IRENA data is to be used for reference purposes only.

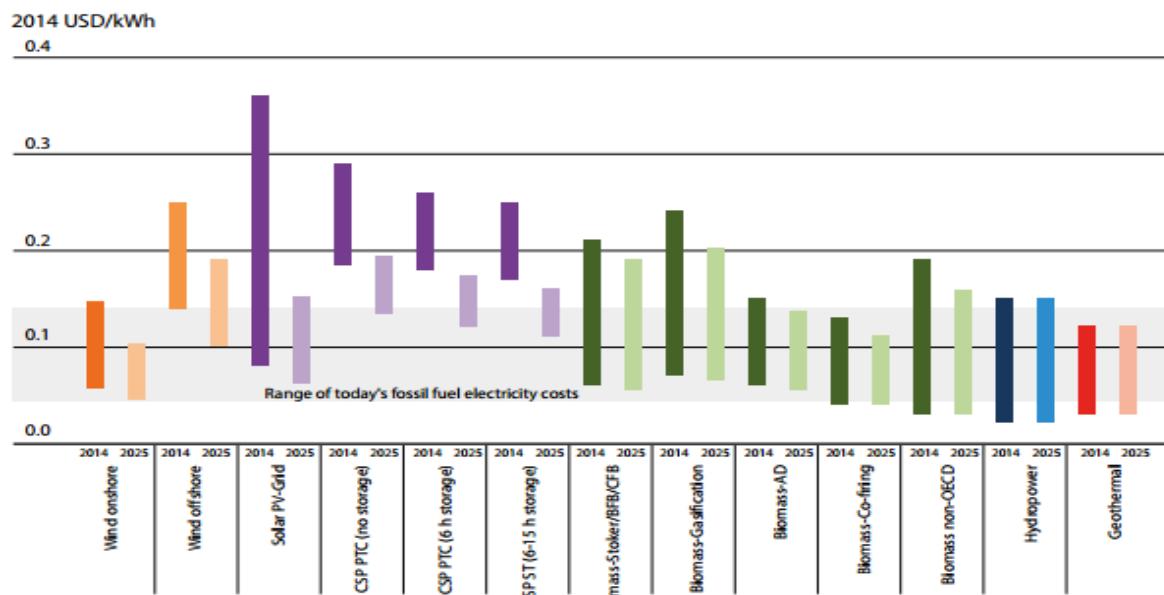
Figure 2: Levelised Costs of Electricity by Region and Technology and their Weighted Average



Source: IRENA Dash Board -

<http://resourceirena.irena.org/gateway/dashboard/?topic=3&subTopic=1057>

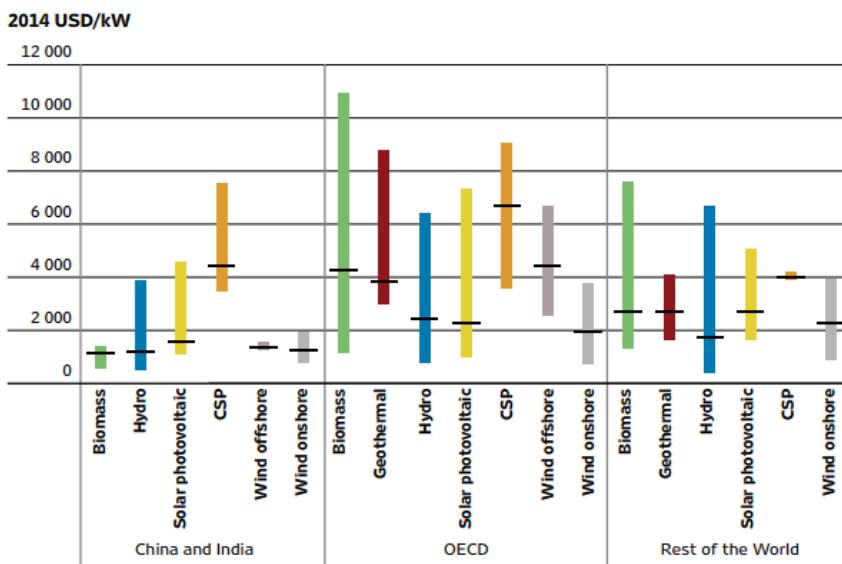
Figure 3: LCOE ranges by renewable power generation technology, 2014 and 2025



Source: Renewable Power Generation Costs in 2014 (page 146)

http://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Power_Costs_2014_report.pdf

Figure 4: Typical Ranges and Weighted Averages for the Total Installed Costs of Utility-Scale Renewable Power Generation Technologies by Region, 2013/2014



Source: IRENA Renewable Cost Database.

Note: Ranges and weighted averages are calculated for 2013 and 2014 to ensure representative ranges for biomass, CSP and offshore wind. Weighted averages for solar PV, CSP and onshore wind would be lower if only data for 2014 was used.

Source: Renewable Power Generation Costs in 2014 (page 18)

http://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Power_Costs_2014_report.pdf

4.1.2.2 Benefits

The benefits of this energy transition road map to Guyana are motivated by the Draft Guyana National Energy Policy (December 2016) and are as follows:

1. Reduced energy consumption and costs to end users and the economy as a whole;
2. Greater inter-sectoral linkages between energy and agriculture;
3. Reduced costs of factor inputs into manufacturing and other economic sectors;
4. Reduced climate change impacts;
5. Reduced local environmental impacts;
6. Use of a cleaner transitional fuel in the form of indigenous natural gas;
7. Greater utilization of natural resources and renewable energy;
8. Greater deployment of clean energy and green in the Hinterland Communities, River Islands and off-grid locations;
9. Increased trade with neighbouring countries;
10. Reduction in transmission and distribution losses due to local production and use of grid tied distributed renewable energy generation;
11. Enhancement of the eco-tourism product of the country through the use of renewable energy;
12. Greater sustainability and self-reliance in rural electrification schemes;
13. Enhanced energy productivity through energy conservation and efficiency;
14. Enhancement of the research capacity of local institutions and personnel;
15. Enhancement of local institutional and individual capacity to manage complex infrastructure projects and the transition to a sustainable energy future;
16. Better utilisation of waste biomass for productive purposes.

4.1.3 Policy Commitments

The suggested goals of the National Energy Policy are reflected in the regional and international commitments of the Government of Guyana. These are:

1. By 2025, working towards 100 percent renewable energy in the power sector, as adopted from the Nationally Determined Contribution of Guyana to the United Nations Framework Convention on Climate Change (UNFCCC) (2015) and the Paris Agreement (2016).
2. A reduction in energy intensity, as adopted from the Caribbean Sustainable Energy Road Map and Strategy (CSERMS) (2015) as proposed by the Caribbean Community (CARICOM) Secretariat.

The December 2016 Draft National Energy Policy of Guyana also identifies several detailed goals that have been adapted from the United Nations Sustainable Development Goals. These goals together with the national policy objectives are to be used to develop a measurement and evaluation protocol to gauge the success in the implementation of the National Energy Policy.

The international and national policy commitments and the objectives of the National Energy Policy may be achieved through the following actions in respect of the power sector.

4.2 List of Actions

The section provides a list of actions to be undertaken by the Government of Guyana and key stakeholders in order to move towards the aspirational goal of 100 renewable energy in the power sector by the year 2025 and beyond. The actions are guided by these two reference documents

- (a) The Guyana's Power Generation System Expansion Study (June 2016);
- (b) The Draft Guyana National Energy Policy (December 2016).

In respect to the Guyana's Power Generation System Expansion Study (June 2016) as reproduced in Table 2 above, modifications are necessary to the list of actions here in order to reflect progress to date. The modified Guyana Generation Action Plan is given in Table 3 below. The Action Plan identifies time lines, tasks and projects.

Table 3: Guyana Energy Transition Action Plan

Phase #	Start Year	End Year	Task	Project
1. Engines	2017	2018*	Engines on HFO	HFO – 17.2 MW (Garden of Eden)
	2017	2018*	Engines on LFO	1. LFO – 2.4 MW (Bartica) 2. LFO - 51 MW (Essequibo Coast) 3. LFO 5.5 MW (Cane Field)
	2018/23/24	2020/25/26	Engines on Natural Gas	Dual Fuel HFO with Natural Gas – 3x11 MW
2. Wind	2018	2020*	Hope Beach (to be confirmed)	Wind up to 10 MW – to be confirmed
	2018	2022	Other sites	Wind up to 16 MW – site selection, sizing, interconnection studies, tendering, construction and commissioning
3. Solar PV	2017	2018	1. Solar Phase I GPL	1. Solar 3 MW (WCB)
	2018	2019	2. Solar Phase II GPL	2. Solar 3 MW (EBD)
	2017	2018	3. Solar (Essequibo Coast) GPL	3. Solar 3 MW
	2017	2019	4. Mabaruma Power & Light Co. Inc (HECI)	4. Solar 400 KW using a BOOT arrangement
	2020	2025	5. Kwakwani Utilities Inc. (HECI)	5. Solar with storage 2.7 MW, BOOT

Phase #	Start Year	End Year	Task	Project
	2020	2025	6. Lethem Power Company Inc. (HECI)	6. Solar with storage 3.0 MW, BOOT
	2020	2025	7. Mahdia Power Company (HECI)	7. Solar with storage 1.4 MW, BOOT
	2020	2025	8. Port Kaituma Power and Light (HECI)	8. Solar with storage 1.3 MW, BOOT
	2020	2025	9. Mathew's Ridge Power and Light (HECI)	9. Solar with storage 0.192 MW
4. Biomass	2018*	2020	Wood (GPL)	Wood 0.7 MW
	2018	2020	Skeldon (GPL)	Bagasse 7.5 MW
	2023	2025	Albion (GPL)	Bagasse 9.8 MW
	2025	2027	Enmore (GPL)	Bagasse 5.7
5. Hydro	2017	2025*	Mid-scale Hydro #1 (MoPI)	150 – 180 MW (tendering in 2020)
	2023	2031	Mid-scale Hydro #2 (MoPI)	150 – 350 MW
	2018	2024	Small Hydro	1 Moco Moco Hydro Power Project (0.5 MW – 1.0 MW), 2. the Kato Hydropower Project (320 KW) 3. Tumatumari Hydropower project (3MW)
6. Linden Interconnection	2017	2021	Linden Interconnection (MoPI, GPL)	1. GPL to study the Linden Interconnection to DBIS contingent upon the commissioning of mid-scale hydro. 2. GPL expects to complete construction of a 69kv/13,8 substation at Kuru Kururu on the Linden Highway in 2018
7. Natural Gas	2020	2027	Natural Gas Infrastructure (MoPI)	Natural Gas infrastructure for power generation
8. Policy and Regulation	2017	2018	Regulatory Reforms (MoPI)	1. Energy policy and power sector regulation

Phase #	Start Year	End Year	Task	Project
				2. Feed-in Tariff regime 3. GPL and PUC to develop and publish a standardized PPA by 2017
9. Energy Efficiency	2017	2035*	Energy Efficiency	1. GPL DSM programme 2. GEA Energy Efficiency Programmes
10. Distributed Generation	2017	2035*	Distributed Generation using renewable energy (GEA, HECL)	1. Grid tied distributed generation 2. Off-grid distributed generation
11. Institutional Strengthening	2017	2018*	Energy sector institutional strengthening – 1 Strengthen GPL 2. Strengthen GEA 3. Strengthen MoPI 4. Strengthen HECL 5. Strengthen PUC	1. GPL has retained a Management Consultant firm under the IADB/EU Power Utility Upgrade Programme for 36 months (into 2019). The consultancy is a Management Strengthening programme targeting GPL's Executive and Senior management 2. GPL to retain consultants to develop technical and commercial framework for renewable energy (RE) integration 3. GPL and the PUC to operationlise the recent grid code which is aimed the integration of RE projects greater than 1.5 MW 4. GPL to develop and operationlise a grid code for RE projects less than 1.5 MW
12 Grid Modernisation	2018	2023	Grid modernization (GPL) 1. Operational changes and investments for high penetration of RE	1. GPL extend the SCADA (currently managing the transmission network) to the distribution network and generation.

Phase #	Start Year	End Year	Task	Project
			2. Smart Grid	2. GPL to replace approximately 79,000 meters with Advanced Metering Infrastructure (AMI) compatible meters and to establish AMI operability using programmable logic controllers (PLC) and existing radio frequency (RF) communications by the year 2020
13. Renewable Energy Resource Mapping and Potential Site Identification	2018	2022	SWERA solar and wind energy resource mapping (GEA)	1. Wind resource map 2. Solar resource map 3. Identify candidate sites for wind farms
14. Research	2017	2035	Market Research – Technical potential, economic potential, market barriers, baseline, programme design, programme tracking database, and process and impact evaluations (GEA, HECL)	1. Hinterland RE programmes 2. GEA's RE and EE programmes
	2017	2022	Resource research (MoPI, HECL, GEA)	1. Mid-Scale Hydro – detailed resource assessments and environmental and social impact 2. Run-of-River Hydro - resource and social impact assessment
	2017	2022	Technology research (IAST, University of Guyana)	3. Rice Husk – combustion research 5. Wood – combustion research
15. Public Awareness	2018	2035	Public Awareness (GEA)	1. Public education 2. Behavioral modification

Phase #	Start Year	End Year	Task	Project
				programmes for EE and conservation
16. Capacity Building	2019	2035	Capacity building (GEA)	1.Trades persons 2. Bankers and financiers 3. Programme implantation contractors 4. Engineers, Architects 5. Students
17. Community Consultation	2018	2021	Stakeholder Consultations (MoPI, GEA, HECL)	1. Government and Institutional 2. Hinterland and River Island 3. Regional Stakeholders and Funding Agencies 4. International Stakeholders and Funding Agencies

*Note – Dates updated from original GY Generation Expansion Plan to reflect current progress and realities

Source: Adapted from Guyana's Power Generation System Expansion Study – Final Report (June 2016) and expanded from Phase 9 to Phase 17

The Action Plan is supplemented by detailed actions as illustrated in Annex 1. The details in the Annex 1 are motivated by the Guyana National Energy Policy (December 2016).

4.3 Financing Action Plan (5 Year, 10 Year)

This energy transition road map for Guyana requires significant levels of funding. There are several sources of funding identified in the Draft Guyana National Energy Policy (December 2011). The most relevant of these are highlighted in Table 4 following:

Table 4: Financing Action Plan

Source	Start Date	End Date	Action	Projects
5 Year Action Plan				
Memorandum of Understanding between Norway and Guyana (09 November 2009) in support of the Low Carbon Development Strategy (LCDS)	2017	2020	Draw down on a portion of the \$80 million currently managed by the Inter-American Development Bank on the behalf of the Government of Norway. Funds to be replenished from the monetization of the gas and oil resources of Guyana.	1. Project identification and preparation for mid-scale hydro, wind, solar, and biomass 2. Regulatory Reforms 3. Feed-In Tariff study 4. Production costs analysis, grid modelling for stability studies 5. Linden Interconnection study 6. Market research for RE and EE programmes for HECL and GEA 7. Programme design for RE and EE for HECL and GEA 8. Review and update of Guyana's Hydropower Inventory and prioritization of sites for development 9. Prepare selected hydro project for EPC tendering 10. Equity investment in two mid-scale hydropower plants
Oil companies currently engaged in oil and gas exploration e.g. Exxon	2018	2022	Replenish drawn down from Norway resources using financial resources resulting from hydro carbon production	Equity investment in two mid-scale hydropower plants
Solar and Wind	2017	2022	Request technical	1. Country wide wind and solar

Source	Start Date	End Date	Action	Projects
Energy Resource Assessment, SWERA			assistance from the World Bank's ESMAP programme. ESMAP = Energy Sector Management Assistance Programme	resource maps 2.Identification of potential wind energy sites
International funding agencies e.g.: Inter-American Development Bank (IDB) - the Guyana Country Strategy	2017	2022	GoG programmes	1. Project identification and preparation for mid-scale hydro, wind, solar, and biomass (MoPI, GPL, GEA, HECI) 2. Grid integration studies for RE (GPL, GEA)
REETA – CARICOM Secretariat	2017	2019	REETA programmes	1. Research on biomass combustion 2. EE labelling, building performance standards, minimum performance standards for appliances, Government procurement policy for EE 3. Preparation of a small hydro project at Hosororo 4. Institutional strengthening of the GEA through the provision of salary for an in-house technical expert. 5. Technical assistance to the Hope Beach wind energy project through the provision of an international expert
Public Private Partnerships	2017	2025	Hinterland Electrification (HECI)	1. Mabaruma Power & Light Co. Inc. 2. Linden Electricity Company Inc. (LECI) 44.8 MW 3. Kwakwani Utilities Inc. (KUI)

Source	Start Date	End Date	Action	Projects
				4. Lethem Power Com. Inc. (LMPCI) 5. Mahdia Power Company 6. Port Kaituma Power & Light 7. Matthew's Ridge Power & Light
ESCOs	2018	2022	GoG programme aimed at Energy Services Companies (ESCOs) to use their own capital and/or that of their lenders to engage in performance based contracting to pursue energy conservation and energy efficiency projects in the public and private sectors. (GEA)	1. GEA to issue tender for ESCOs.
10 Year Plan				
Royalties and other revenue from oil and gas resources and sales	2023	2035	GoG programmes	GEA, GPL, HECL
Public Private Partnerships, BOOT	2022	2035	GoG programmes, HECL programmes	1. Mid scale hydropower 2. Small scale hydropower 3. Solar PV micro and mini grids in hinterlands areas

5 Annex I – Detailed Actions from Guyana Draft National Energy Policy

In respect to the Draft Guyana National Energy Policy (December 2016), the scope extends well beyond the Guyana national grid. It includes the Hinterland and River Island Communities, end user energy conservation and efficiency, and international trade of electricity. The general approach to action will be that of programmatic intervention. Such programmes will incorporate well defined activities such as: Policy target setting; identification of funding; determination of technical and economic potential; market barrier research; market baseline research; application of fiscal incentives; programme design, monitoring, implementation, evaluation; programme data tracking; and supporting programmes for electric utility demand side management (DSM) where applicable. Detailed action as required by the Guyana National Energy policy are given is given in Table A1 following.

Table A1: Guyana Energy Transition Action Plan

Actions		Start Date	End Date	Responsible Parties
Policy				
Residential	1. Increase the use of solar hot water heaters. Commission a programmatic approach that includes actions such as: Policy target setting; determination of technical and economic potential; fiscal incentives; programme design, monitoring, implementation, evaluation; and electric utility demand side management	2017	2035	Minister of Public Infrastructure, GEA, MoPI, MoF, GPL, HECL
	2. Residential: Increase small scale grid tied and off grid electricity production from solar energy and wind energy. Actions include demonstration projects, pilot programmes, private sector participation, fiscal incentives	2017	2035	Minister of Public Infrastructure, GEA, MoPI, MoF, GPL, HECL
Agriculture	1. Increase small scale grid tied and off grid electricity production from solar energy and wind energy.	2017	2035	Minister of Public Infrastructure, GEA, MoPI, MoF, GPL, HECL
	2. Foster the production of electricity for on grid and off grid applications from new biomass resources such as rice husk and wood waste	2017	2035	Minister of Public Infrastructure, GEA, MoPI, MoF, GPL, HECL
Hydro	1. Government will consider options for	2017	2018	Minister of

Actions		Start Date	End Date	Responsible Parties
<p>development of a mid-scale hydropower project with political consensus and understanding with all stakeholders.</p> <p>2. A BOOT type public private partnership model be maintained for the project implementation.</p> <p>3. A Special Purpose Vehicle will be created to execute the project.</p> <p>4. Consideration is to be given to the upgrade of the proposed T&D transmission line into Linden to serve as the backbone for all hydro projects rather than a project specific line. Considerations will include the ownership structure throughout the life time of the line, and the most suitable arrangements for construction and operation. Options to include ownership of the line by the SPV throughout the life of the BOOT arrangement, then the transfer of ownership to GPL.</p>				Public Infrastructure
Legal				
Institutional Capacity	<p>1. Review with a view to amend the Electricity Sector Reform Act, CAP 56:01, Section 65 (Duties of the Minister) to make explicit reference to:</p> <ul style="list-style-type: none"> a. The interconnection and integration of intermittent renewable energy resources into the public electric grid; b. The introduction of markets for electric energy, capacity and ancillary services supplied the public electric utility; c. The introduction of markets to facilitate the reduction of the environmental impact of the public electric utility and the non-utility deployment of renewable energy, energy conservation and energy efficiency resources; and d. The modernization of the national electric grid (meaning the implementation of Smart Grid concepts) to facilitate integration of very high penetration levels of intermittent renewable energy. 	2017	2018	Minister pf Public Infrastructure, GEA, MoPI, GPL, PUC
Community Projects in	1. Establish and operationalize the legislative and institutional mechanisms	2017	2017	Minister pf Public

Actions		Start Date	End Date	Responsible Parties
River islands and the Hinterland	necessary to facilitate community based projects;			Infrastructure, GEA, MoPI, GPL, PUC
Regulation				
Central Grid	1. Develop a licensing procedure aimed at independent power producers (IPPs) to produce bulk power from renewable energy and feed into the national electric grid.	2017		GEA, MoPI, GPL
	2. Develop a competitive tender or auction process to procure services to develop and construct solar and wind farms	2018		Minister of Public Infrastructure, GEA, MoPI, GPL, PUC
	3. Mandate GPL with collaboration from the GEA and the private sector to implement an electric utility demand side management (DSM) programme;	2017	2019	GPL, GEA, ESCO, PUC, private implementation contractors
	4. Set policy guidelines for the Public Utilities Commission (PUC) to require that GPL develop and publish a grid code inclusive of an interconnection policy, and a standardised power purchase agreement (PPA) for IPPs to interconnect and integrate into the national grid	2017	2017	Minister of Infrastructure, GEA, GPL, PUC
	5. Set guiding operational policies for GPL to conduct: <ol style="list-style-type: none"> Integration resource planning procedures and studies including production cost analysis and grid modelling to determine the limits to penetration of intermittent renewable energy; Power factor studies; Impact studies on grid stability due to interconnections of intermittent renewable energy resources; Loss studies for each region or sub grid including technical and commercial losses, billing and metering errors, and electricity theft; 	2017	2020	GPL, GEA, OUC,

Actions		Start Date	End Date	Responsible Parties
	e. Demand and load forecasting for the central grid, as well as at each major substation; f. Wind and solar energy measurement and forecasting at each major substation; and g. Quality of service evaluations for each region or sub-grid			
	6. Provide policy guidance to the Public Utilities Commission in respect to: a. Interconnection and integration of intermittent renewable energy resources into the public grid; b. Markets for electric energy, capacity and ancillary services supplied by the public electric utility; c. Markets to facilitate the reduction of the environmental impact of the public electric utility. d. Grid modernisation meaning the implementation of Smart Grid concepts into the public grid; and e. The imposition of cost effectiveness criteria on the public utility when making decisions on the development and expansion of facilities or services.	2017	2019	
	7. Facilitate the Guyana Power Company (GPL) in undertaking least cost expansion planning every five years and implementing the plan.	2017	2020, 2025, 2030, 2035	GPL, GEA, PUC
Distributed Generation	1. Set policy guidelines for Public Utilities Commission to require the GPL to develop and publish a feed-in tariff mechanism for grid tied distributed renewable energy technologies; 2. Set policy guidelines for Public Utilities Commission to require the GPL to develop and publish interconnection policy for small scale and commercial scale distributed renewable energy systems; 3. Set policy guidelines to determine an appropriate market share for distributed generation versus IPP's versus GPL in respect to the generation of renewable energy. 4. Encourage a net billing approach to	2017	2018	GEA, PUC, MoPI

Actions		Start Date	End Date	Responsible Parties
	reconciling revenue and costs to customers through the decisions of the Commission.			
Hinterland Communities	1. Introduce fixed price feed-in tariff mechanisms for rural mini and micro grids. These mechanisms are aimed at cost effective renewable energy resources. The cost effectiveness criterion will ensure that only least cost renewable technologies are employed, while providing a reasonable return to householders and investors.	2017	2018	HECI, GEA
Eco-Tourism	1. Examine fire safety issues in lodgings in respect to the installation of solar electric systems on thatched roof. The aim is to address technology issues and develop installation guidelines that address the fire safety issues in lodgings that use fire prone building materials.	2018	2019	GEA, HECI
Hydro Power	1. Support the EPA and the GEA to develop a life cycle environmental management process for hydro projects. The scope would include: planning; construction; decommissioning; human health and safety impacts; water quality impacts; flow rules that impact other water users; fish passage for migratory species; conservation and the protection of biodiversity; reservoir sedimentation and reservoir debris; monitoring and evaluation of mitigation measures.	2017	2019	EPA, GEA
	2. Require a social action plan framework and a watershed management plan for projects that may not have significant impacts	2017	2019	EPA, GEA
	3. Require that developers offset any loss of natural terrestrial habitat where there is need to enhance the productivity and sustainability of aquatic resources within the reservoir and its tributaries;	2019	2021	EPA, GEA
	4. Require the application of the ISO 14001 standard of the International Organization for Standardization (ISO) which	2019	2021	EPA, GEA

Actions		Start Date	End Date	Responsible Parties
	specifies the actual requirements for an environmental management systems. It aims to reduce the environmental footprint of a business and to decrease its pollution and waste generation			
Energy Conservation and Efficiency	1. Implement energy labeling for lighting, appliances and equipment. The Government will encourage retailers to provide public display of information that will improve customer decision-making at the point of sale for appliances. Retailers will be encouraged to import appliances that are been subject to energy labeling requirements in other jurisdiction. Labelling of appliances provides information to buyers which supports informed decision-making and promotes a gradual shift in market demand to more efficient appliances	2017	2019	GEA
	2. Implement Codes and Minimum Energy Performance Standards (MEPS). The Government will encourage real estate developers and building code officials to adopt codes and MEPS for buildings. Government will undertake pilot projects in public sector buildings to showcase successful energy efficiency projects and provide guidelines on best practices. Codes and standard MEPs in the private sector will be encouraged on a voluntary basis. This allows time for market adoption before transitioning to compulsory mandates	2018	2020	GEA
	3. Introduce relevant regulations and legislations. Government will subsequently develop regulations and legislation for standards and labelling of lighting, appliances and equipment.	2017	2018	GEA
	4. Collaborate with Member States of CARICOM through the CARICOM Regional Organisation for Standards and Quality (CROSQ), to implement lighting, appliance and	2017	2020	GEA

Actions		Start Date	End Date	Responsible Parties
	equipment standards, as well as labels and testing procedures;			
Organisational Reform and Strengthening				
	1. The GEA should acquire the skills to oversee a programmatic approach to the planning, evaluation and implementation of energy conservation and efficiency activities.	2017	2019	GEA
	2. GEA should acquire the skills to provide the policy, planning and regulatory oversight (of technical issues) aimed at the power sector in respect to the high penetration of intermittent renewable energy.	2017	2019	GEA, GPL
	3. GPL should acquire the skills to the design and implementation of a utility demand side programme aimed at peak load reduction, energy efficiency and energy conservation.	2017	2021	GPL, GEA
	4. GPL should acquire the skills necessary to design and implementation a feed-in tariff programme, including a grid code aimed at the safe and orderly interconnection of renewable energy systems into the transmission and distribution grid.	2017	2018	GPL, MoPI, GEA
	5. GPL should acquire the skills to design and implement an operational plan aimed at mitigating the impacts due to the integration of high levels of intermittent renewable energy into the transmission and distribution grid.	2017	2019	GPL, GEA
	6. The PUC should acquire the skills necessary to oversee the economic regulation of a feed-in tariff programme aimed at renewable energy.	2017	2018	PUC, MoPI
Research				
Hinterland	1. Market barrier research aimed at designing new programmes and improving existing programmes for rural electrification	2017	2020	HECI

Actions		Start Date	End Date	Responsible Parties
	2. Programme impact and process evaluations aimed at refining existing programmes	2019	2020	HECI
	3. Identify and carry out feasibility studies on micro/minи hydro sites and other sources to provide power to mini-grids in remote areas. The management of these schemes will be done by local rural communities or local entrepreneurs	2017	2020	HECI, GEA
Biomass	1. Support the GEA in further examination and research in resolving the problems associated with the precipitation of silica and coal tar in combustions chambers and tubes of furnaces that burn rice husk	2017	2022	GEA, IAST
	2. Support the GEA and GUYSUCO in investigating the outdoor storage of bagasse following earlier research findings in Belize	2017	2019	GEA, GUSUCO
	3. Support the IAST in its continuing work to research energy efficient stoves which utilize the briquettes developed tested at the IAST	2017	2022	IAST
	4. Support the IAST in the continued development and deployment of mobile technology to convert wood waste and rice husk waste into energy briquettes	2017	2022	IAST
	5. Support the continued involvement of the GEA in developing the potential of rice husk and wood waste as sustainable biomass fuels for generating electricity. The GEA will continue its work to use a geographical information system to map the locations of resource sites and quantify the availability of biomass in order to aid sector planning. In the near term, the GEA will guide local stakeholders in the installation of a demonstration 20 to 30 kW rice husk to energy plant	2017	2022	GEA
	6. Support collaboration between the GEA and the EPA in implementing sustainable waste management practices for wood waste. The GEA/EPA will identify specific sites for the aggregation of wood waste from the surrounding areas	2019	2022	GEA, EPA
Wind	1. Identify potential Wind Energy Zones to be earmarked for wind farm development.	2017	2022	GEA

Actions		Start Date	End Date	Responsible Parties
	The potential zones will be investigated to firmly characterize the wind resource for investment purposes in accordance with international best practice. Preliminary transmission interconnection planning will also be undertaken. While these sites will be restricted to wind farm development, integrated land use activities will also be considered			
	2. Collaborate with GPL to define the wind farm zoning process. This process will comprise of resource assessment, geotechnical and environmental impact assessment, securing of land rights, social impact assessment, preliminary transmission planning, development of a tailored power purchase agreement, and the release of a wind farm development request for proposal (RFP) to potential developers	2019	2022	
	3. Facilitate the GEA to conduct wind resource measurements at wide variety of sites across the country to support the development of wind farms and other purposes	2017	2022	GEA
	4. Facilitate GEA to conduct a country wind and solar resource mapping using the methodology and resources available through SWERA.	2017	2022	GEA
Hydro	1. Support the GEA to continue providing all reasonable support for the assessment of likely hydroelectric sites with an aim of development to the point of commercial acceptance by a developer. For example in the short run, the GEA will conduct a feasibility study for hydroelectric projects at Kumu Falls in Region 9, Hosororo in Region 1, the Ikuribisi Falls in Region 7, and Tiger Hill in Region 10.	2017	2020	GEA/HECI
	2. Government will pursue the development of other small hydropower projects such as the rehabilitation of the Moco Moco Hydro Power Project (0.5 MW – 1.0 MW), the Kato Hydropower Project (320 KW), and Tumatumari Hydropower project (3MW)	2017	2020	GEA/HECI
Energy	1. Support the GEA to establish a data	2018	2035	GEA

Actions		Start Date	End Date	Responsible Parties
Conservation and Efficiency	tracking systems that would regularly collect programme data on indicators for conservation and efficiency			
Project Identification				
Hinterland-River islands, Eco-Tourism	1. Explore new and proven methodologies for financing of rural electrification. The aim is to examine methodologies for both public sector and private sector financing	2017	2019	GEA, HECI
	2. Support the development of independent micro grids by hinterland communities. Programme support will prioritize electrification for productive uses and key social services. The main sectors include health, education, water supply and agriculture	2017	2035	GEA, HECI
	3. Encourage community owned projects on the river islands that deploy solar-diesel hybrid systems, or other hybrids based on locally available biofuels, or off-grid and on-grid solar PV systems with battery back-up	2017	2035	GEA, HECI
	4. Support the development of independent hybrid micro-grids by hinterland communities. Programme support will prioritize electrification for productive uses and key social services. The main sectors include health, education, water supply and agriculture	2017	2035	GEA. HECI
	5. Encourage residential customers to install off grid and on grid solar photovoltaic (PV) systems with battery backup	2018	2035	GEA, HECI
	6. Introduce a technical assistance and or financial assistance programme to assist the tourism sector in retaining the services of technical experts. The aim would be to increase the use of renewable energy and energy efficiency	2017	2019	GEA
Biomass	1. Support GUYSUCO in collaboration with the GEA and other agencies to determine feasibility of deploying bagasse fired steam cogeneration systems at all sugar cane estates. The analysis should consider the feasibility of year-round storage of bagasse, so that power plant capacity could be downsized and thus operated continuously throughout the year	2017	2019	GEA, GUYSUCO

Actions		Start Date	End Date	Responsible Parties
Hydro Project Cycle (Identification, Preparation, Construction, Operation)				
Mid-Scale Hydro – Government action	1. GoG to consider two mid-scale hydropower projects. The first will be considered beginning in 2017 and the second in 2023. GoG to clarify any property rights issues associated with any past identified mid-scale hydropower project in respect to hydro resources data, environmental and social impact assessments, technical plans and project documentation and any remaining rights and licenses.	2017	2017	MoPI
	2. Consider the merits of taking a 100% ownership position versus being a part owner in any special purpose vehicles (SPV). The SPVs will own and operate the two identified mid-scale hydro projects. Funding for purchasing shares in the SPV will be considered under the USD \$80 million presently deposited with the IDB under the Norway Agreement (if agreed by Norway to be within the statute for use of the money). GoG will also seek funding derived from the early monetisation of natural gas resources in the short run, and the sale of both gas and oil in the medium to long term.	2017	2017	Minister of Public Infrastructure, MoPI
	3. Request lenders to projects to issue a Mandate Letter that specifies the lender's conditions for support of hydro projects.	2017	2017	Minister of Public Infrastructure, MoPI
	4. Government to investigate / review any private interest in any project with a view of clarifying and settling outstanding property rights issues in a fair and equitable manner.	2017	2017	Minister of Public Infrastructure, MoPI, Sponsor
	5. Consider whether export credits including debt financing should be part of the EPC tender processes.	2017	2017	Minister of Public Infrastructure, MoPI
	6. Retain a Technical Adviser/Independent Engineer to: (a) undertake the technical and environmental preparations of projects; (b) support the GOG in defining its positions on questions relating to conflict interests between GPL as the perpetual power off-taker and final long term owner & operator of hydropower projects, versus the main sponsor as the owner,	2017	2017	MoPI

Actions	Start Date	End Date	Responsible Parties
operator and seller in a long term BOOT project; (c) serve as a mediator in potential conflicts between GOG/GPL and the main sponsors/owners of the hydropower projects; (d) serve as an Independent Engineer during the project preparation and construction period, and throughout the period of any project agreements.			
7. Undertake a technical review of any and all existing and future hydropower projects to consider and to prepare or update of the associated "Owner's Requirement" for the projects	2017	2018	MoPI
8. Require that all hydro power project undertake Field Investigations to include (but not be limited to): (a) seismic profiling along the entire dam base and along selected portions of any tunnel alignment; (b) daily water flow measurements at the project site to improve the input for simulating the potential energy production and reduce the uncertainties related to the PPA. This in turn will provide a more reliable basis for preparing back up power capacity; (c) sediment sampling over at least a whole year cycle of varying seasons to provide a better basis for assessing future sedimentation and life span of any reservoir	2017	2022	MoPI
9. Require all Environmental and Social Impact Assessments to include (but not be limited to): (a) the development of a stand-alone road access management plan to address activities such as mining and logging along any access road built for a specific hydropower project; (b) update any existing environmental and social management plan that may exist for any project; (c) Implement a consultation program to garner feedback and buy-in from affected local communities; (d) Elaborate on the Environmental Flow Requirement (EFR) for all projects to better justify any proposed minimum environmental flow (MEF) requirements.	2018	2020	MoPI, EPA
10. Consider whether the construction of a transmission line into Linden should be a	2017	2020	MoPI

Actions	Start Date	End Date	Responsible Parties
part of a EPC Contract in order to safeguard the completion of construction and commissioning of the line.			
11. Prepare or update EPC tender documents for hydro projects	2018	2020	MoPI
12. Undertake tendering for a new EPC contractor	2019	2020	MoPI
13. Negotiate Generation Licenses for hydropower projects	2018	2020	Minster of Public Infrastructure, MoPI
14. Negotiate PPA's	2018	2020	MoPI
15. Negotiate a new Implementation Agreement with SPV e.g. BOOT arrangements.	2017	2020	Minster of Public Infrastructure, PoPI
16. Conduct a least cost development study among the other promising mid-scale hydro candidates. Based on the outcome the <u>second</u> hydropower project for implementation should be selected	2023	2025	MoPI
19. Assess the impact of the Arco Norte transmission interconnection project on the costs of implementing mid-scale hydro projects at Tumatumari, Tiger Hill, Kamaria and Kumarau, and Amaila	2023	2025	MoPI